Grid Generator

Grid Generator for MIKE 21C

User Guide

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The grid generator contains three main properties: Grids, Polylines and Bit-maps. A typical project encompass the following activities:

- Import a Bitmap file as background image for orientation
- Generate Polyline describing bank lines based on background image
- Generate grids based on polylines
- Add data items to the generated grid

There are four basic functions for grid generation:

- New Grid
- Merge Grids
- Add Grid
- Options for grid

The functions are activated by selecting Grids with the mouse and right-click.

Addition functions (Grid Operations) are available for each grid in the project. These functions are activated by selecting the relevant grid with the mouse and Right-click.

1.1   Introduction

The MIKE 21C Grid generator is used to create and modify data defined in curvilinear grids with the following file formats: *.dfs2, and *.dt2 (ie - 2D binary data files in association with DHI Software). These files typically contain the model bathymetry, bed resistance data, etc. A brief introduction to grid generation is provided in this section:

The difference between a rectilinear and a curvilinear grid is depicted in Figure 1.1.
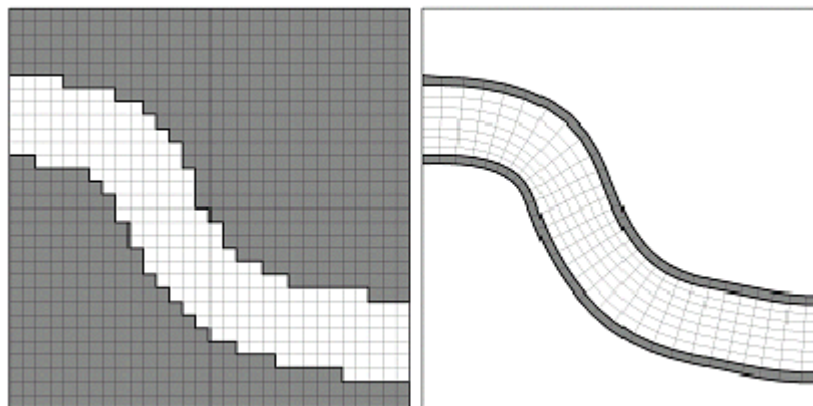
Figure 1.1   Left: A rectilinear (standard) MIKE 21 model. Right: A curvilinear MIKE 21C model

In contrast to a rectilinear MIKE 21C 2-D data file, an additional 2-D file with the position of the grid points (in the following referred to as the grid file) must supplement the curvilinear MIKE 21C 2-D data file. Both files are based on the dfs2 or the dt2 format meaning that the usual MIKE 21 tools such as the Grid Editor can be applied to the curvilinear files as well.

Input for the MIKE 21C Grid generator is background images showing the study area, text files with position of e.g. bank lines (x,y data) and text files with bed elevation at discrete points (x,y,z data). Output from the MIKE 21C Grid generator is

- A grid file *.dfs2 with the position of all grid points (x,y)
- A bathymetry file or data file *.dfs2 with the value in each grid point (z)

A curvilinear grid is generated to cover the entire model area, i.e. the area where information about bathymetry is available and model results are required. The MIKE 21C model bathymetry is in a matrix format with each value representing the mean bed level within a grid cell, see Figure 1.2. The four corner points define the grid cells. The dimensions of the grid matrix will, therefore, be one higher in each direction than the corresponding bathymetry matrix. If for instance the bathymetry matrix has the dimension 100x100 the corresponding curvilinear grid will have 101x101 grid lines.
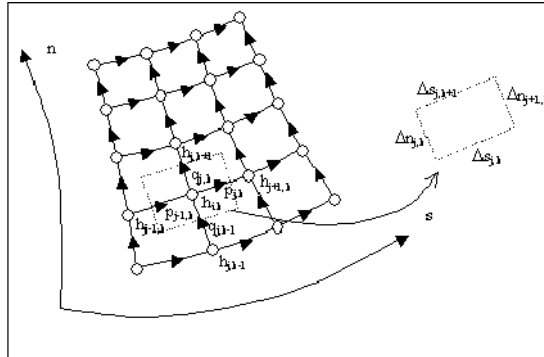
Figure 1.2   Definition sketch of curvilinear grid

Note, that the grid file is a special type of dfs2. Grid point information is saved by double precision in two static items, and by single precision in two dynamic items. Only the dynamic items can be viewed in the 'Tabular View'. If values are modified in the MIKE Zero Grid Editor (by default the Grid Editor starts when a dfs2/dt2 file is loaded into the MIKE Zero interface), the double precision information will be lost. The MIKE 21C engine will apply the double precision information is it is available (i.e. two static items written in the grid file), otherwise the single precision grid coordinate will be applied. For grids with relatively small cells and e.g. UTM coordinates (or similar large x- and y-values) application of double precision is essential for calculating the spacing functions ds and dn with sufficient accuracy. As a rule of thumb the inaccuracy in the spacing functions is around 10^{-6} compared to the grid coordinates if using single precision, while the inaccuracy is practically non-existent for double precision coordinates.

The Grid Generator always stores the coordinates in double precision, i.e. if using the Grid Generator one never has to worry about the precision of the grid coordinates.

1.1.1   Start of new application

m21gg.exe activates the MIKE 21C Grid Generator.

When the MIKE 21C Grid Generator is started without an existing grid, the user is prompted for the coordinates defining the extent of the study area:
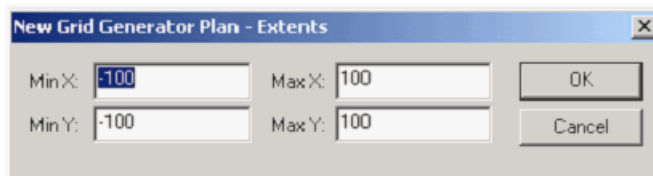
If at a later stage an existing grid file is imported with a bigger extent, the graphical view will automatically be updated. The same applies if a bitmap is imported. Using the View and Settings it is possible at a later stage to update the plan view.

The grid generator contains three main properties: Grids, Polylines and Bitmaps. A typical project encompass the following activities:

- Import a bitmap file as background image for orientation
- Generate polylines describing bank lines based on background image
- Generate grids based on polylines
- Add data items to the generated grid

The various functions for the three main properties (grids, polylines and bitmaps) are activated by right-click of the mouse, see example below.The functions with the mouse button are description under options.
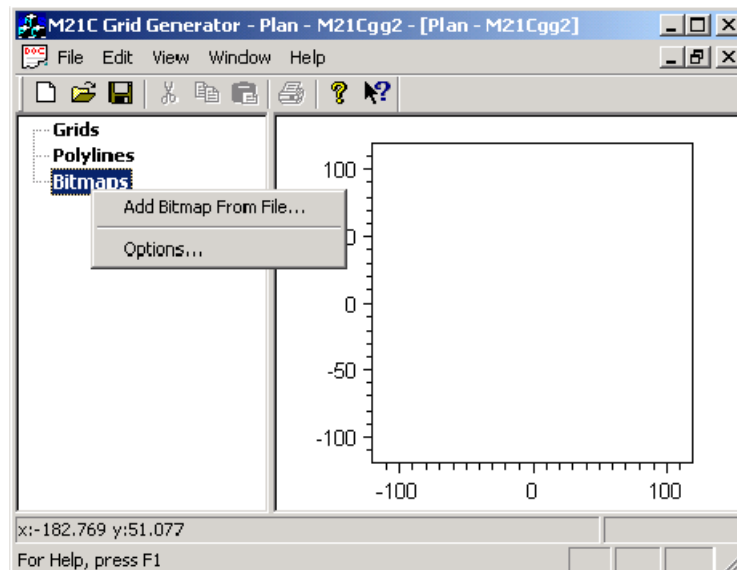
1.1.2 Creating a new grid

The creation of a curvilinear grid is divided into four parts:

- Bitmap import used for background image
- Polyline creation based on data or digitisation of bitmap
- Grid creation based on defined polylines
- Data map creation based on defined grid

The curvilinear grid is defined by 4 borderlines. There are called the J, J', K and K' line as shown below. The MIKE 21C grid has to be orthogonal meaning that also the borderlines must meet at right angles. A curvilinear grid is defined using the "New Grid" function.
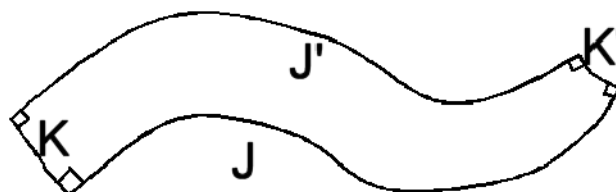

Figure 1.3   Definition of border lines

Border lines are defined as polylines. Polylines can be digitised directly on top of a background image by using the "New Polyline" function, or they can

be imported from data files (using the "Add Polyline from File" or "Import Polyline from DAT/XYZ file".

Background images are displayed graphically by using the "Add Bitmap from File" function.

The numbering of grid points follow the definition of the borderlines, as the point (j,k)=(0,0) is at the lower left corner where J and K line meet, and the point (j,k)=(jmax,kmax) is at the upper right corner where the J' and K' line meet.

The distribution of the (j,k) points in the interior of the grid is determined by the solution of a set of elliptical equations expressing the orthogonality of the grid, see Grid Orthogonality. After creation of a new grid, the grid points are "orthogonalised" using a "Grid Update"-function.

Often, it is desirable to shape the grid in a particular way around islands in the middle of a river, bifurcations and channel confluences. This is possible by dividing the grid into smaller grid parts from the beginning. Each grid part is defined and orthogonalised independently and subsequently merged together into one large grid.
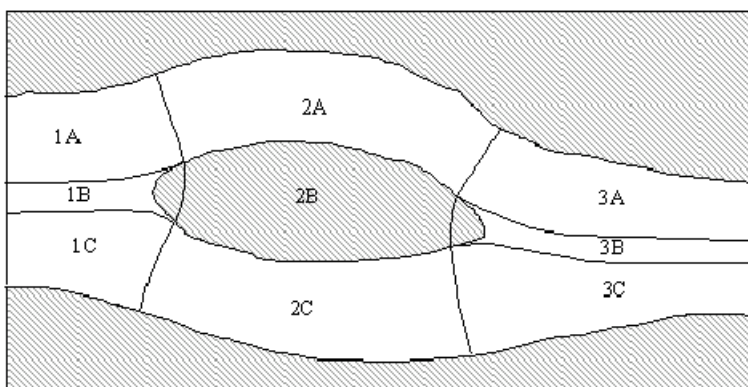
Figure 1.4   Planning of grid parts to be orthogonalised before merging

1.1.3   Modifying a grid

Corrections and modifications to an existing grid can be done. When a grid is divided into multiple parts, it is important to be able to split the work into parts and be able to take backups of each part. Various import facilities exist for this:

- Data maps can be imported from/exported to *.dfs2 files
- Grid files (entire or parts of the grid) can be imported from /exported to *.dfs2 files

- Sub-grid files can be extracted and/or merged

- Polylines defining border can be imported from /exported to data files

- Sub-polylines can be extracted and/or merged

The Grid Editor for MIKE 21 is applied for standard *.dfs2 files, but can also be applied to change either the data files or the grid files.

Data or grid files defined in other curvilinear format than MIKE 21C can be converted into ASCII text file format, imported to a *.dfs2 file using the Grid Editor in MIKE 21 and subsequently be imported to the MIKE 21C Grid generator. Similarly, the files generated by MIKE 21C grid generator can be exported as ASCII files using the Grid Editor in MIKE 21.

1.1.4 Grid orthogonality

The theoretical background for the grid generator is outlined below. Refer to "Gridgen - Scientific background" for further details. The orthogonal curvilinear grid is obtained by solving the following elliptic partial differential equations:

$$\frac{\partial}{\partial \xi}\left(g\frac{\partial x}{\partial \xi}\right) + \frac{\partial}{\partial \eta}\left(\frac{1}{g}\frac{\partial x}{\partial \eta}\right) = 0$$

$$\frac{\partial}{\partial \xi}\left(g\frac{\partial y}{\partial \xi}\right) + \frac{\partial}{\partial \eta}\left(\frac{1}{g}\frac{\partial y}{\partial \eta}\right) = 0$$

(1.1)

where

x,y Cartesian coordinates

ξ,η curvilinear coordinates (anti-clockwise system)

g "weight" function

The weight function is a measure of the ratio between the grid cell length in the x - and the y -direction, respectively. It is defined through the following relationships:

$$g = \sqrt{\frac{g_{11}}{g_{22}}}$$

(1.2)

where

$$g_{11} = \left(\frac{\partial x}{\partial \xi}\right)^2 + \left(\frac{\partial y}{\partial \xi}\right)^2$$

$$g_{22} = \left(\frac{\partial x}{\partial \eta}\right)^2 + \left(\frac{\partial y}{\partial \eta}\right)^2$$

(1.3)

The elliptic grid equations are solved using an implicit finite difference approximation and Stone's strongly implicit procedure (abbr. SSIP, see Stone, 1968). The input for the grid generator is the grid weights, g, in every grid point and the boundary conditions in terms of a set of (x,y) co-ordinates for each of the four boundary lines. The output from the grid generator is the (x,y) co-ordinates of the grid line intersection points. With the present MIKE 21C grid generator, the grid weight g is not defined explicitly as input. Instead g is calculated from the initial grid point distribution, and subsequently filtered based on user-defined parameters.

Generation of an orthogonal curvilinear grid is an iterative process in which boundaries are smoothened and weight functions are adjusted until the computational grid is judged to be sound, i.e. be orthogonal with sufficiently gradual transitions. Use of graphical facilities is an important tool in assessing the quality of the generated grids.

1.1.5 Specifications for grid generator

The specifications applied for each MIKE 21C Grid generation can be stored for later use.

To save M21 Grid Generator setup with all the parameters for the grid generation, go to File Save or Save As and select file name for the parameter file you want to save.

To open an existing setup file, go to File - Open and select the file format that you are looking for.

When you have selected the setup to edit, the editor is ready to work. Similar to other MIKE Zero editors, a parameter file is associated with the application. In this case, the extension of the parameter file (text file format) is *.mgg.

1.2 New Grid

Specification of a new grid requires that 4 borderlines are available. In the example below, the existing borderlines are Polyline1, Polyline2, Polyline3, and Polyline4. The borderlines are displayed in the graphical view.

1.2.1   Specifications

Result Grid
If <Not assigned> is specified the grid generator will generate a new file. Otherwise, browse to the name of an existing grid file that will be overwritten.

Border 1 (J)
Browse to the selected polyline. This border is between (j,k) = (0,0) and (jmax,0).

Border 2 (K')
Browse to the selected polyline. This border is between (j,k) = (jmax,0) and (jmax,kmax).

Border 3 (J')
Browse to the selected polyline. This border is between (j,k) = (0,kmax) and (jmax,kmax).

Border 4 (K)
Browse to the selected polyline. This border is between (j,k) = (0,0) and (0,kmax).

Interpolation
There is one option: Bilinear interpolation. The interpolation defines the type of the initial grid, which will be generated using the "Generate" function. This initial grid is non-orthogonal (orthogonalisation is performed later in "Grid Update").

Points JxK
Press the "…" button to define the grid size.
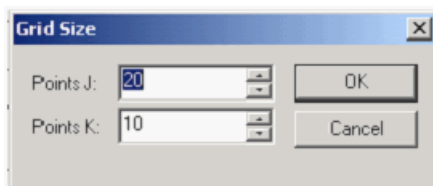
1.2.2 Action buttons

Generate

The initial grid is generated as specified. If the result grid name is <Not assigned> a control box appears to confirm that a new grid has been generated and added to the project:

Snap

Adjacent polylines should match at the corner points. However, due to accuracy, it will never be completely fulfilled. With the "snap" functionality a new common end point is defined between the two end points which were supposed to be identical.

Edit Points

After the size of the grid has been defined, the grid generator will automatically distribute points uniformly along the four borders. Interpolation will take place between these points for the initial grid. Using the Edit Point functionality, it is possible to make a non-uniform point distribution along the borders. At each border line, use the "…" button to enter "Edit Point" properties. Define control points, which are distributed depending on the existing distribution of points. Use "Edit Points" to move all points between the control points along the border graphically.

```
Border - M21Cgg6                                    [X]

Border:        4, K=10                    Edit Points
Polyline:      Polyline8
                                             Snap
Control Points:  3        [  ]
                                             Close

No.   # dots          x            y
0       2         -19.32        82.46
1       1         -23.56        77.59
2       1         -27.80        72.72
```
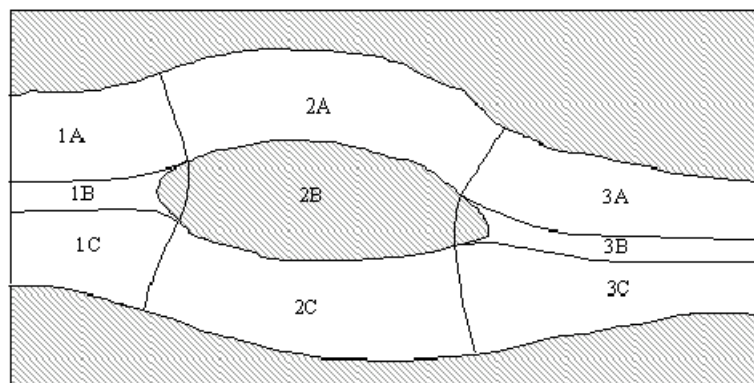
1.3   Merge Grids

In simple cases it is sufficient to generate one grid. However, if a study area is more complicated (perhaps with an island in a river channel), it is necessary to split the grid into grid parts and prepare each part separately. The figure below shows an example of a grid generation project, which has been divided into 9 different parts.

The purpose of this function is to merge two grids with identical numbers of points along the common border. Before the two grids are merged, they must be prepared separately using New Grid and (but not necessarily also) Grid Update. As discussed below, it is important that the points along the common

border between the grids to be joined are coincident. Therefore, the same polyline is usually applied for generating each grid. In addition, the common border is usually fixed when Grid Update is applied for each of the grid parts. This will ensure that the points along the border coincide in both grids.
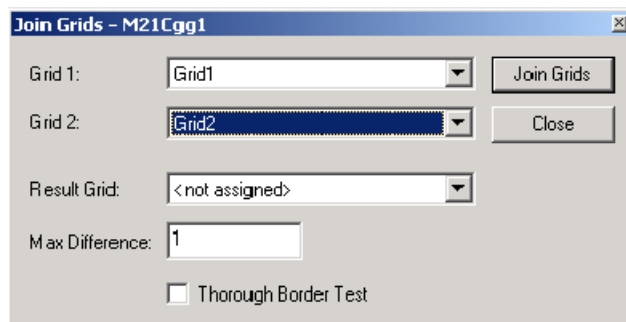

Figure 1.5   User dialog for merging the grids

Grid 1 and Grid 2 contain the names of the two files to be merged. The input for the Result Grid can be either <not assigned> or the name of an existing grid file in the project. In the latter case, that grid file will be overwritten with the new merged grid.

In principle, the points along the common border should be exactly the same. In practice, the points can be different because of each of the two grids has been orthogonalised, which will cause the grid points along the border to move. The allowed max difference between two points, which were supposed to be identical, can be specified here. If the points are still too far apart, an error message will occur:
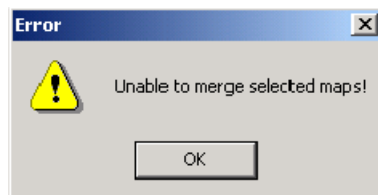
If the *thorough border* test is activated, the points must be exactly the same along the common border.

1.4   Add Grid

An existing grid file (*.dfs2 or *.dt2 format) can be imported into the grid generator. The purpose can be to

• Modify the grid

- Merge the grid with another

- Add items to the grid (e.g. bathymetry)
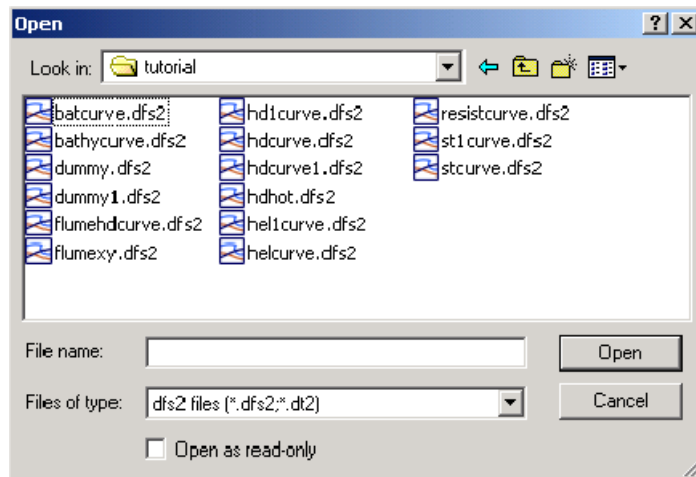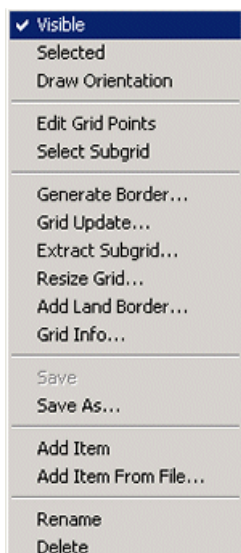

Figure 1.6   Add grid from file dialog

1.5   Grid Operations

The following operations (right-click selected grid in the project) can be performed on the grid:

1.5.1   Draw grid orientation

The curvilinear grid prepared for MIKE 21C is oriented according to the direction of the J-lines and K-lines. Usually, the following orientation is applied: J=0 at the upstream boundary and J=max at the downstream boundary.

The orientation is shown with letters and colour codes as depicted below. In this case (J,K)=(0,0) at (x,y)=(-60,-14) at the upstream boundary. In the downstream boundary, (J,K)=(19,0) at (x,y)=(10,-60) approximately.
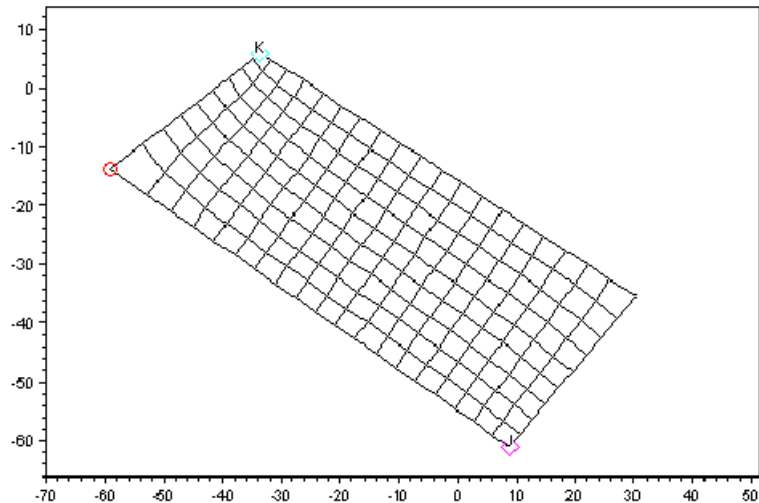
1.5.2 Edit grid points

After completion of grid generation, the user has a possibility to move few points manually by using this function. With the mouse, it is possible then to select and drag the grid points graphically in the view section.

The function is useful if grid points have to match exactly to certain points in the interior of the modelling area.

1.5.3 Select subgrid

Selection of subgrids is important for various reasons

- In connection with orthogonalisation of subareas: Grid Update will only operate on the selected subgrid.

- In connection with modification of data item: Operations on data will only be effective within selected subgrid.

- In connection with extraction of a subgrid: The selected subgrid will be extracted.
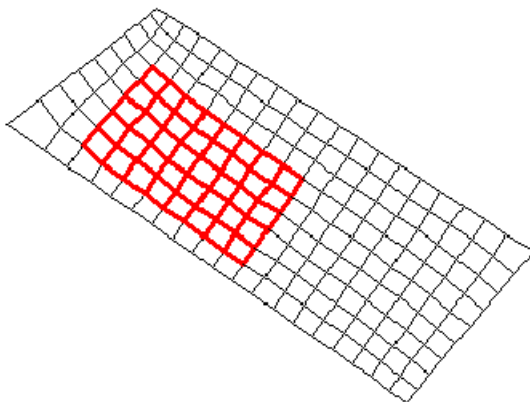
After pushing the Select Subgrid button, see below, the user can mark the relevant area graphically with the mouse. In order to see the actual selection, it may be necessary to update the options for display of subgrid.
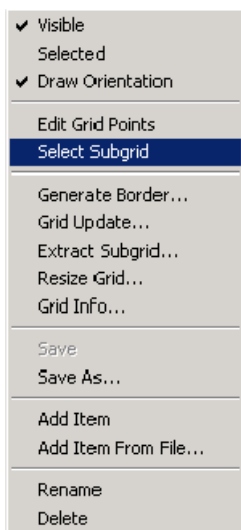
1.5.4 Generate border

With this function, a polyline can be extracted from an existing grid file.

Grid specifies the name of the grid in the project, from which a border line (polyline) should be extracted or generated.

Grid Border specifies from which side of the existing grid, the border should be extracted. It can be one of the four sides but not from the interior of the grid. Thus Grid Border can be J, J', K or K' (see definition of alignment in the introduction).

If **Extract border part** is selected, the start point and the end point must be specified, either directly in the table (From and To) or graphically by using the mouse in the view window after pressing the "…" button.

The **Save to Border** works together with the New Grid-dialog, see below.

If **Save to Border** is specified as J, then it correspond to Border 1 (J) in the dialog above and the name of the extracted border liner will be "Polyline1" because that is the name displayed in the New Grid-dialog. Thus, the function should be used with caution, as any existing polyline stored under the name will simply be replaced by the new data from the Generate Border application.

If in this case the Border 1 (J) input in New Grid-dialog is <not assigned>, the grid generator will automatically assign a new name to the extracted border line (polyline) and place the name in the Border 1 (J) input.

1.5.5   Grid update - orthogonalisation

The MIKE 21C flow model engine requires that the curvilinear grid is orthogonal. The present function will activate a grid generator engine, which will orthogonalise the grid by solving a set of elliptical equations (see Grid orthogonality *(p. 13)*). The grid update (orthogonalisation) operation is often applied in connection with Select subgrid. Only grid points within the selected subgrid will be modified.

Stop Criterion and Maximum Iterations

The solution is found by iteration, where the user must specify the stop criteria for convergence **Stop Criterion**. The default value is 0.1% (=0.001) change from one iteration to another in average for all grid points. The user also defines an upper limit of the number of iterations (default is **Maximum Iterations** = 100).

Boundary Smooth filter

In principle, the grid points along the borders must be movable in order to obtain convergence of the solution of the elliptical equations. The grid generator calculates the position of the points along the border by extrapolating interior points perpendicular to the border. If the border is curving too much compared to the density of interior grid points, there is a risk that the grid will not converge. Therefore, a filter **Boundary Smooth** is applied to the curvature of the border line. If the curvature of the border line (=1/Radius) is more than the specified value, the border points will be smoothed. Thus, the smaller value, the more smoothening of the border lines.

Grid Weight Smooth filter

The grid weights q expressing the ratio of the width and length of each grid cell will be the same throughout the iteration towards a solution. The grid weight is calculated at the very first iteration based on the <u>initial</u> grid. The grid weight can vary throughout the grid domain. A high variation in grid weights represents a quite non-uniform grid, whereas a small variation indicates a smooth grid. For numerical reason in the MIKE 21C flow model engine, a smooth grid is preferred. Therefore, the user can specify a critical value for the variation in the grid weights. If the grid weight at a point minus the average of the neighbouring points is more than the specified **Grid Weight Smooth** value, the grid weights will be smoothed. Thus, the smaller value, the more smoothening of the grid.

Recalculation of Grid Weights

As mentioned, the elliptical model require that the grid points along the borders must be movable in order to obtain convergence of the solution of the elliptical equations (see Grid orthogonality *(p. 13)*). However, in some circum-

stances, it is necessary to fix one or more of the borders. This is the case if the user want to orthogonalise a subgrid only. Thus, if points along the borders are fixed, the remaining degree of freedom is the grid weight in the interior of the model. This function allows the user to recalculate the grid weights during the iteration.

The parameter **Relaxation for Grid Weight Update** represents the relaxation parameter:

- If value = 0 the grid weights are fixed throughout the simulation.
- If value = 1 the grid weights are updated based on recalculated values.
- If value = 0.8 (for instance) the grid weights are updated based on a weighted value of the old grid weight and the recalculated value.

The parameter **Frequency of Grid Weight Update** specifies the frequency by which the q-values are updated:

- A value =1 will update the grid weights at every iteration time step, but will also slow down the iteration considerably.
- A value = 10 will update the grid weights at every 10 iteration time step, and is usually sufficient.

The filter on the grid weights (**Grid Weight Smooth**) is also active when the grid weights are recalculated. However, if the filter is too fine (smooth grid) it can be difficult to obtain an orthogonal grid as the filter together with the fixed borders puts a constraint on the degree of freedom for the grid to adjust. Thus, there is a compromise between how smooth the grid is, and how orthogonal the grid is.

Grid weight item

By default, the initial grid weights q expressing the ratio of the width and length of each grid cell are calculated from the initial grid. There is an option, however, to let the grid weight be a function of the value of a data item. This is useful if for instance the grid weight should be a function of the local depth, velocity field, concentration field or similar. The only requirement is that the particular Add item is associated with the grid. In such case, the grid generation will be an iterative process as the item can not be associated with the grid before it is completed, and the grid cannot be complete until the data item has been defined.

Fixed borders

If a sub-grid is orthogonalised, it is important to specify that the border points are fixed along the borders towards the surrounding grid. Otherwise, the grid orthogonality in the adjacent points in the surrounding grid will be destroyed. As a rule of thumb, **Relaxation for Grid Weight Update** should be larger than 0 to obtain orthogonality when the borders are fixed. In this case, the
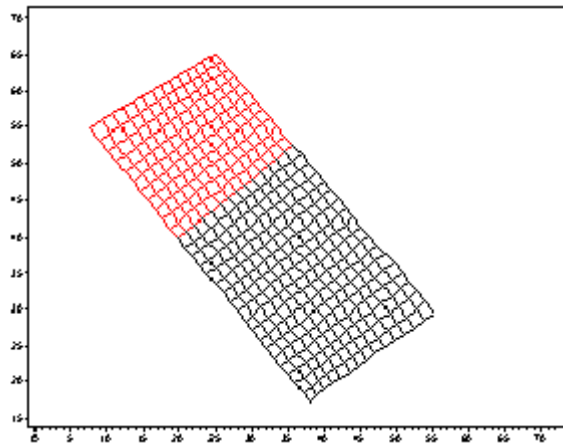
Grid Weight Smooth should be adjusted by trial and error until an acceptable trade off balance between 1) fixed borders, 2) distortion of grid cell sizes and 3) orthogonality is achieved.

1.5.6   Extract subgrid

An existing grid can be split up into subgrids in the following way:

1) Right-click on the grid and select a subgrid

2) Right-click on the grid and choose Extract Subgrid

Source Grid is the name of the grid from where the subgrid is extracted.

Size J x K is information about the source grid.

Result Grid contains the name of the extracted subgrid. If <not assigned> is applied, the MIKE 21C Grid generator will invent a name.

Extract executes the operation.

1.5.7   Resize grid

The Resize Grid function creates a new grid with user-specified number of grid points. The grid generator will interpolate in the existing grid in order to find the position of the new grid points in the interior of the grid.

The function is useful in connection with development of grids with a higher resolution without having to redo the entire grid generation. The grid orthogonality will be maintained (down to certain accuracy).
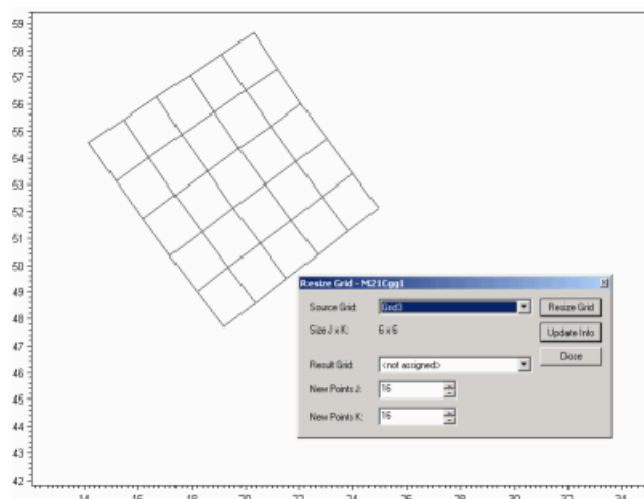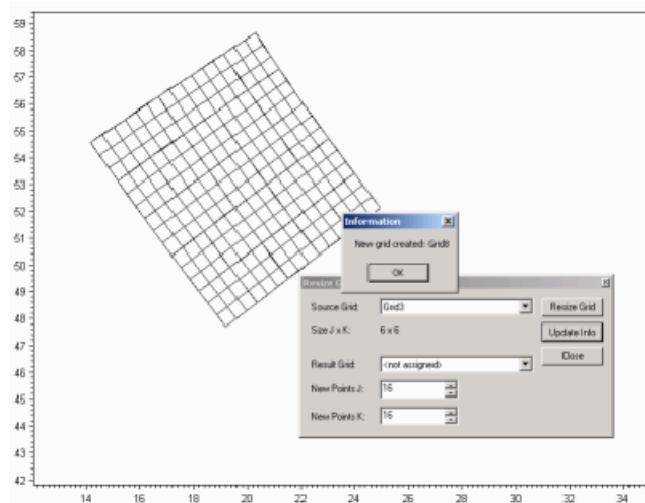
1.5.8   Add land border

The grid generation is usually based on polylines which follow the bank lines.

The computational engine, however, requires one extra row of land cells defining the banks and the border between water and land. The "Add Land Border" facility can be used to add an extra grid line to the generated grid covering the water area only. The application will simply extrapolate the grid points along the bank line to the new row of grid points on the bank.

The result of this operation is a new grid with the added grid lines along the specified borders J, J', K and/or K'.

Later during "Add item", the bathymetry values in these new additional grid points along the channel should be defined above the defined land value (see Properties *(p. 35)*).

1.5.9   Grid info

The function displays the information about the current grid:

- Size (number of points in the J and the K direction)
- (x,y) coordinate at the origin (j,k)=(0,0), lower upstream
- (x,y) coordinate at the lower downstream (j,k)=(jmax,0)
- (x,y) coordinate at the upper upstream (j,k)=(0,kmax)
- (x,y) coordinate at the upper downstream (j,k)=(jmax,kmax)
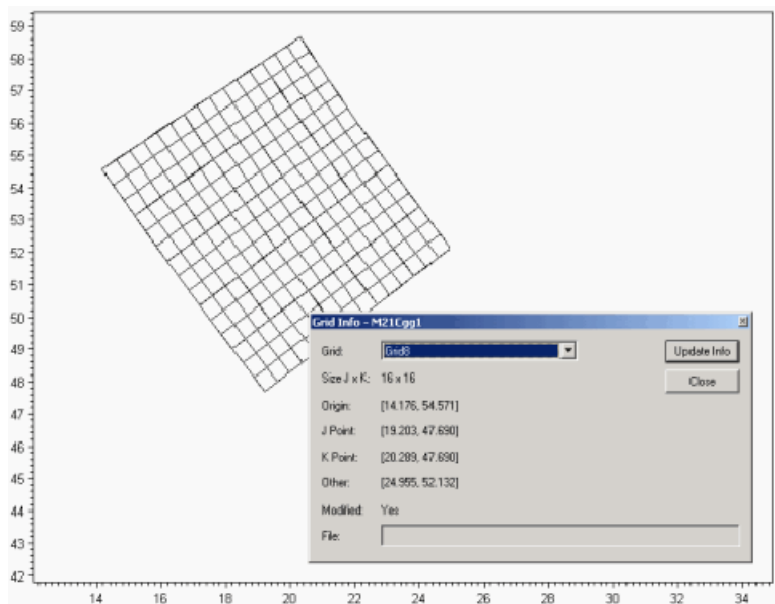
1.5.10 Add item

The grid files contain information about the horizontal coordinates (x,y). Use this function to associate an item with the grid, such as bed elevation (z) or bed resistance (M, n, C).
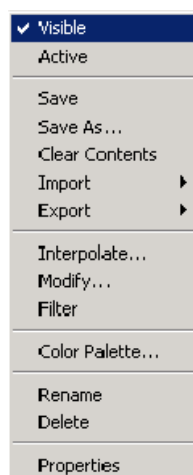
The data item is stored in a separate file. Thus, complete information about (for instance) bed bathymetry is contained in two *.dfs2 files (or *.dt2 files). Relevant operations on the data items are described in Items *(p. 31)*.

In most applications a GIS is used at the principal data storage and mainte-nance tool. For generation of a bathymetry item, the following options exist

- Export the grid cell-centre locations to a GIS containing a DEM, interpo-late depths onto the points, then re-import the updated points into the MIKE 21C Grid Generator;

- Import a file of XYZ data from a GIS (or other source such as MIKE Zero Bathymetry Editor) into the MIKE 21C Grid Generator and interpolate the depths onto the grid points; or

- Manually insert the bathymetry using the DT2 editor tools in MIKE Zero using Cartesian coordinates (not curvilinear).

1.5.11 Add item from file

A new item can be imported from an existing curvilinear data file (dfs2) of the same size, i.e. corresponding to the grid, to which the item is added.

1.5.12 Items

Active item

Colour contours of the data item and a colour legend can be displayed in the View Window. However, as only one item can be displayed at the time, the user can define whether the item is active or not. This is important when more than one item has been defined.

Save - save as

The generated data item can be stored in a separate *.dfs2 file or *.dt2 file by using this function. The user specifies the name of the new file.

The size of a data item file (z) is always one less than the size of the grid file (x,y). The reason is that the z-value is cell-centred whereas the xy-values are node centred. This is illustrated below, where each computational cell in MIKE 21C is surrounded by four xy coordinates describing the corner points.
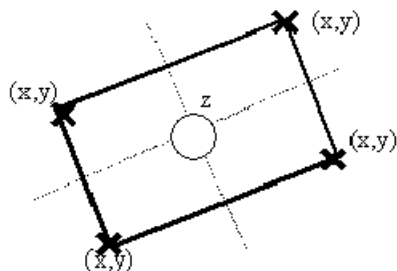
Clear

The data item within the grid will be reset (to delete value). The operation is often applied in connection with Select subgrid. Only values within the selected subgrid will be deleted.

Import

The data item can be imported in different formats

- ASCII file, the data will be imported from three columns with (x,y,z) and placed in the curvilinear grid. Notice that there are no units associated with the xyz data from an ASCII-file, so you have to specify the units for xy and z data, respectively, before loading the ASCII file. If more than one discrete value appears within one grid cell, the average of these values will be computed before import to the grid cell.

- Rectilinear Dfs2 file, the data will be stored in a standard rectilinear file (not yet implemented)

- Curvilinear Dfs2 file, use the Add item from file command

Export

The data item can be exported in different formats

- ASCII file, the data will be stored in three columns with (x,y,z). If a sub-grid is selected, only the values within this grid is stored in the ASCII file

- Rectilinear Dfs2 file, the data will be stored in a standard rectilinear file (not yet implemented)

- Curvilinear Dfs2 file, use the Save - save as command

Interpolate

Missing data can be interpolated using three different kinds of interpolation routines.

- J interpolation - searching for points along the J-lines only (longitudinal direction)

- K interpolation - searching for points along the K-lines only (transverse direction)

- Elliptical interpolation - Searching within an ellipsoid

Often, bed levels in e.g. a river are available in cross-sections with a certain distance. In such a case, K interpolation can be used to close gaps in each cross-section. This operation is followed by J interpolation, which will close the gap between the cross-sections.

More interpolation operations are possible if the data item file is loaded into the Grid Editor in MIKE Zero.

Modify

Different operations are available for modifying the data. The operations are usually applied in connection with Select subgrid. Only values within the selected subgrid will be modified.
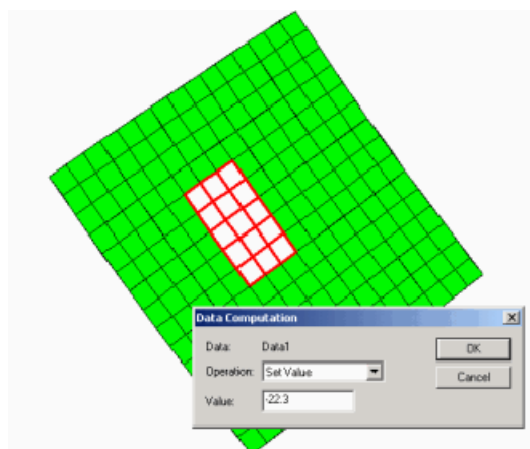
Available operations:

- Orthogonality check
- Spacing ds
- Spacing dn
- Area A
- Set Value
- Add Value
- Multiply Value

More operations are possible if the data item file is loaded into the Grid Editor in MIKE Zero.

Filter

Data can be smoothed. The operation is often applied in connection with Selection of Subgrids. Only values within the selected subgrid will be smoothed using the relationship: $Z_{j,k} = (Z_{j+1,k} + Z_{j-1,k} + Z_{j,k} + Z_{j,k+1} + Z_{j,k-1})/5$

More smoothing operations are possible if the data item file is loaded into the Grid Editor in MIKE Zero.

Colour palette

The colour legend can be changed using the standard MIKE Zero colour palette Wizard.

A separate colour palette file cannot be saved and loaded in the present version of the grid generator. However, the specified colour palette will be saved together with the *.mgg project file. Thus, when the project is reloaded, the same settings will appear.

Rename

The data item will get a default name by the MIKE 21C grid generator (Data1, Data2, Data3, etc.). Subsequently, the user can rename the data item to e.g. **Bed level**, **Surface elevations** , etc.

Delete

The data item can be removed from the project by using the delete function.

Properties

Most MIKE 21 and MIKE 3 data files have a custom block called "M21_misc". The bathymetry file in MIKE 21C must contain this custom block. The custom block can be created and item 4 defined, which is the zland value (see below) inside the present MIKE 21C Grid generator. Other items in the custom block can be modified using the Grid Editor in MIKE Zero. The custom block has 7 floating point values:

- item 1: orientation at origin relative to true north.

- item 2: drying depth.

- item 3: code for identifying whether or not the data contains geographical information; it is -900 if it contains geographical information.

- item 4: the zland value, the value above which bathymetric data (the data itself in case of bathymetry data file; the prefix record containing the bathymetry in other cases) is considered as land.

- item 5-6: are more free and may have different meaning in different situations.

Right-clicking the **Properties** of the selected data item generates the following dialog, where the user can define the value of land points.

1.6 Polyline

There are nine functions for polyline generation:

- New polyline

- Merge polyline
- Edit polyline
- Add polyline from file
- Import polyline from DAT/XYZ file
- Import polyline from MIKE 11 setup
- Show all
- Hide all
- Options – polylines

The functions are activated by selecting **Polylines** with the mouse and Right-click.

Additional functions are associated with each polyline in the project, activated by selecting the relevant polyline with the mouse and Right-clicking, see Polyline operations *(p. 39)*:

1.6.1 New polyline

When this menu is selected (right-click on Polylines), a line can be digitised by left-click on the screen with the mouse. End each line by double-click or by pressing SHIFT + left-click.
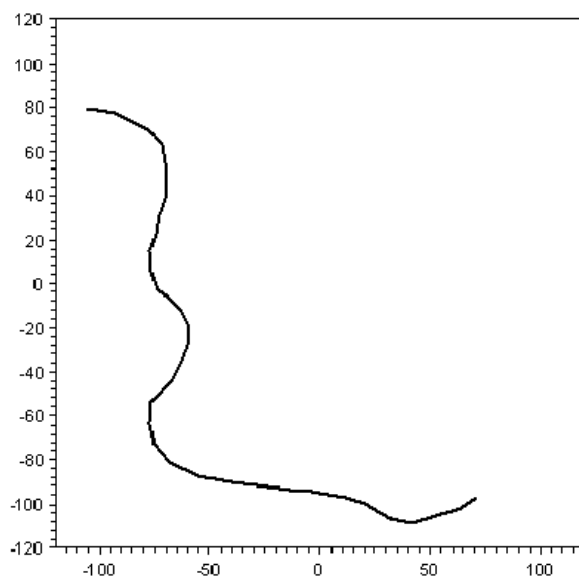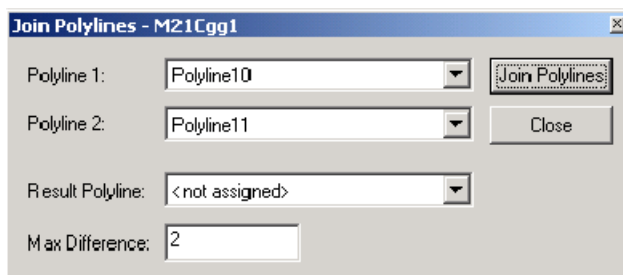

During digitisation, it is still possible to use the right-click for zooming in and zooming out

1.6.2 Merge polyline

When this menu is selected (right-click on Polylines), two polylines can be merged.

Polyline 1 and **Polyline 2** contain the names of the two polylines to be merged. The **Result Polyline** can have the value <not assigned>, in which case the grid generator automatically assigns a name. Alternatively, the name of an existing polyline in the project is provided. **Max Difference** is the tolerance for the distance between the two polylines to be merged.

The merging polylines function is particularly useful when long banks are digitised piece by piece.

1.6.3 Edit polyline

This is an option to manually edit the polyline by moving the vertices with the mouse.

1.6.4 Add polyline from file

Each time a new polyline is created (digitised), the MIKE 21C grid generator automatically creates a text file with the digitised points. The name of the text file is <name of polyline> + .ggp.
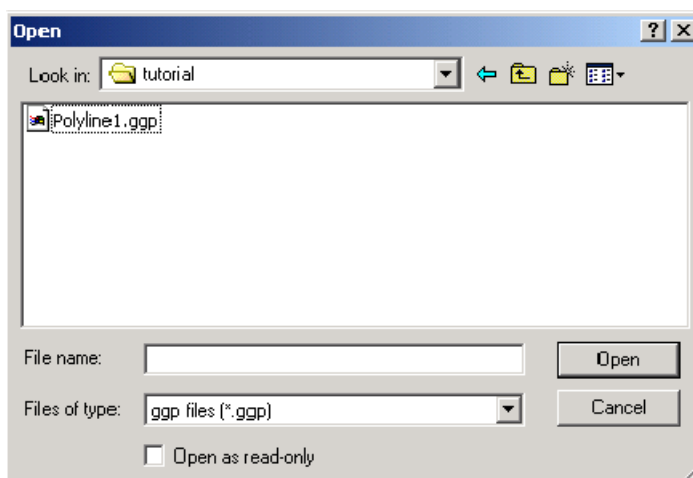
An example of such a text file is depicted below.

```
// Created  : 16-09-2015 13:52:41
// Computer : APC195
// User     : snt
// Creator  : Grid Generator (15.0.0.9257, C:\Program Files (x86)\DHI\2016\bin\x64\m21gg.exe)

[Polyline]
    Name = 'bnd3'
    Point = 501713.635064405, 1303424.97074581
    Point = 501453.5222, 1303660.7922
    Point = 501148.03276473, 1303831.26337513
    Point = 500818.4692, 1304011.6882
EndSect  // Polyline
```

The grid generator can import *.ggp files created during an earlier grid gener-
ation process.

1.6.5 Import polyline from DAT/XYZ file

Polylines can be imported from raw text files containing only two columns
with the two horizontal co-ordinates (x,y). An example of such a text file is
depicted below. The extension of the text file <u>must</u> be *.xyz or *.dat

```
501713.63    1303424.97
501453.52    1303660.79
501148.03    1303831.26
500818.46    1304011.68
```

More than one polyline can be imported from the same text file. Each polyline
is separated by a blank line. The user dialog when importing polylines from
*.dat files is shown below. Notice that there is no unit information associated
with a raw .dat/.xyz - file, so you have to specify what metric unit the data
should be interpreted as.
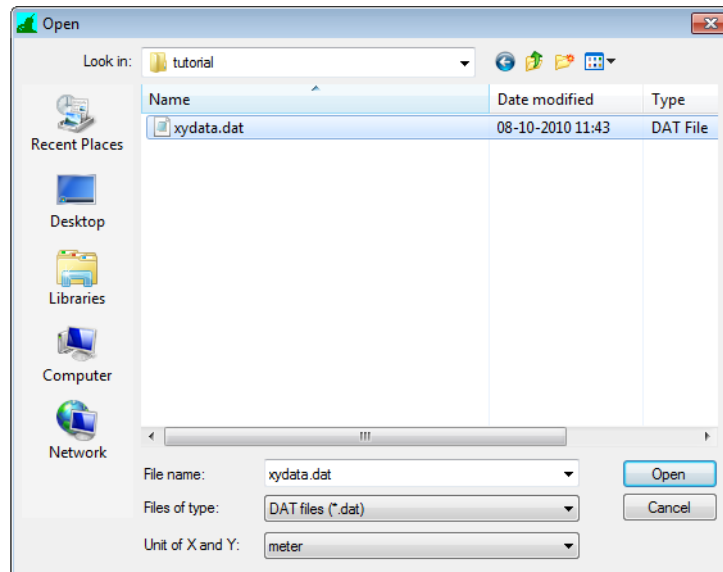
1.6.6 Import polyline from MIKE 11 setup

This function allows import of bank lines from a MIKE 11 model, which is done by pointing to the .sim11 file. It should be noted that MIKE 11 models are usually not as detailed as MIKE 21C models (cross-sections are usually further apart in MIKE 11 models than the longitudinal grid spacing in an equivalent MIKE 21C model), so the tool should be used with caution, i.e. use for determining an initial grid for a MIKE 21C model covering the same area as a MIKE 11 model.

1.6.7 Polyline operations

The following operations (right-click selected polyline in the project) can be performed on the polyline:
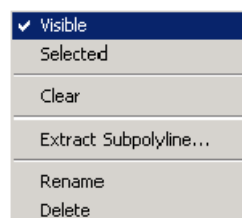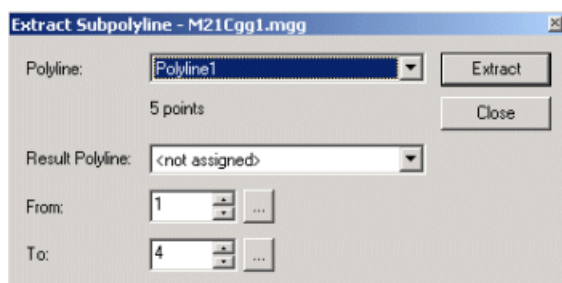

More information is available for the Extract subpolyline functionality.

Extract subpolyline

This function will convert a section of a polyline into a new polyline. This is useful in situations where (for example) a polyline is available that describes an entire model domain, and is required for several grids.

In the example above, **polyline** "Polyline1" consists of 18 digitised points. The extracted polyline will extend from point 5 to point 8. The "…"-button is applied to select the points graphically with the mouse. The **Result Polyline** can be either <not assigned> (i.e. the MIKE 21C grid generator assigns a name), or it can be the name of an existing polyline in the project.

The original polyline remains intact.

1.7 Bitmap

Bitmap files are applied to provide background images for grid generation. This is not a requirement, as polylines may already exist (prepared earlier using an external application). Bitmap facilities are:

- Adding bitmap files to the project
- Bitmap operations
- Options for displaying bitmap file name

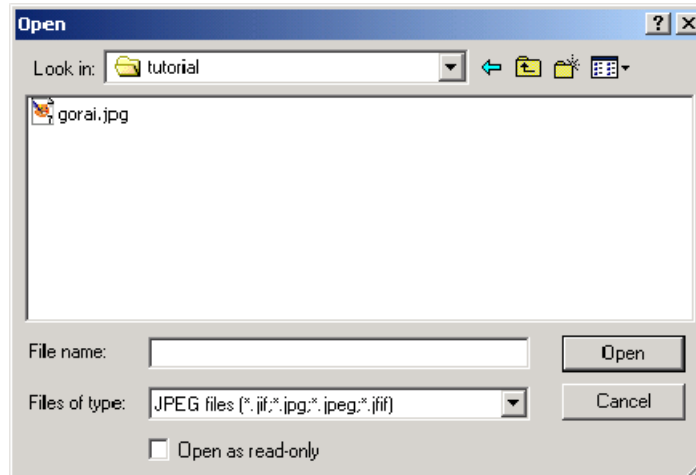### 1.7.1 Adding bitmap files to the project

Right-click on Bitmaps:
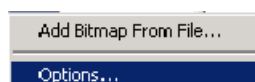
To Add Bitmap From File, specify the name of the file. Available file formats include

- *.jpg file
- *.tif file
- *.bmp file

The placement of the image in the project space needs to be defined. Specify coordinates of the lower left corner, the lower right corner and the upper left corner. If a "DHI World File" exists (JPGW or BMPW extension) press Cancel. After clicking Cancel a Loading coordinate file pop-up box will appear. Here you have to specify which metrical unit the coordinate from the .jpgw file should be interpreted in.
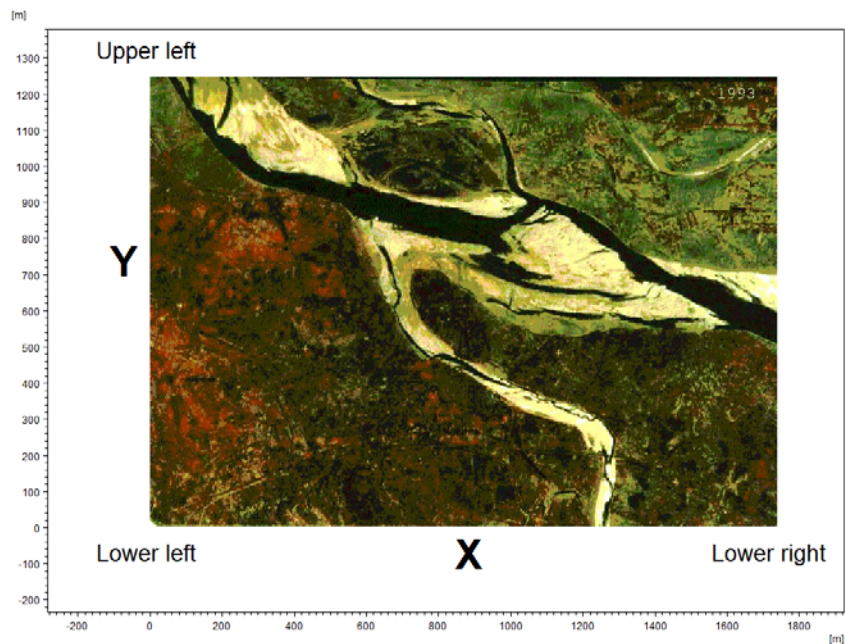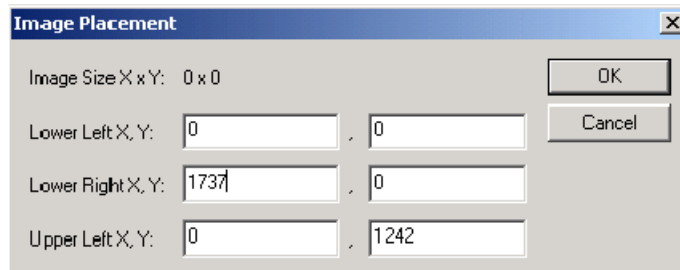
1.7.2   Bitmap operations

The following operations (right-click selected bitmap in the project) can be performed on the bitmap:
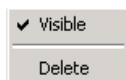
1.8   Options

From the MIKE 21C Grid Generator header bar, enter **View** and **Settings**. The display of the

- Working Area (Plan),
- Grids
- Data (grid items)
- Polylines
- Bitmaps

can be modified with this function. See also Mouse operations *(p. 48)*.

1.8.1   Plan

From the MIKE 21C Grid Generator header bar, enter **View** and **Settings**. The minimum and the maximum X and Y co-ordinates in the working area can be modified with this function.

Furthermore, the function Globals will search for coordinates of all data in the project, and return the minimum and maximum X and Y coordinates accordingly.
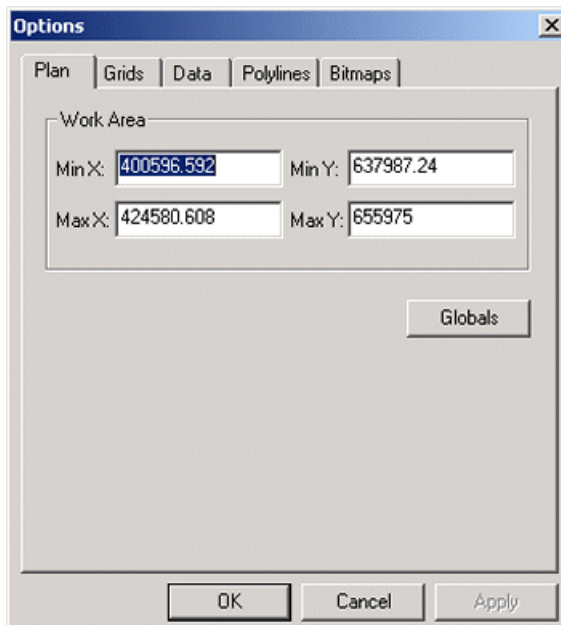
1.8.2   Grids

The display of grids can be modified with this function. All grids are by default displayed (normal). The colour and the style of grid lines can be redefined.

For the display of selected subgrids, it is important to be able to distinguish the subgrid from the main grid. It is possible to define another colour of the grid lines as well as another line width.

Finally, changing the colour as well as the line width can highlight selected grids.
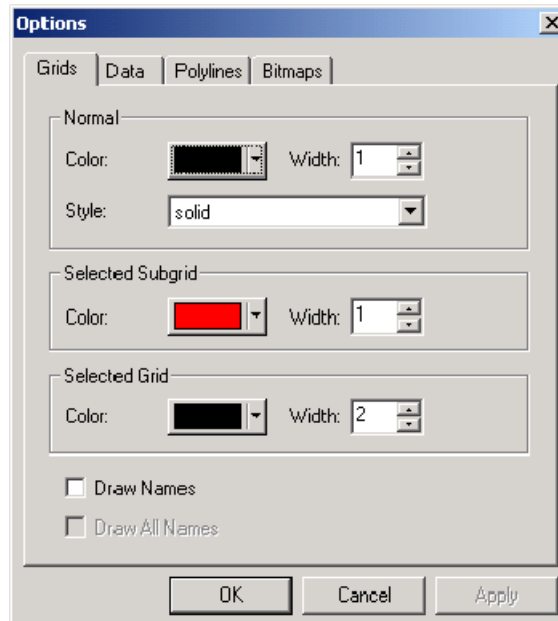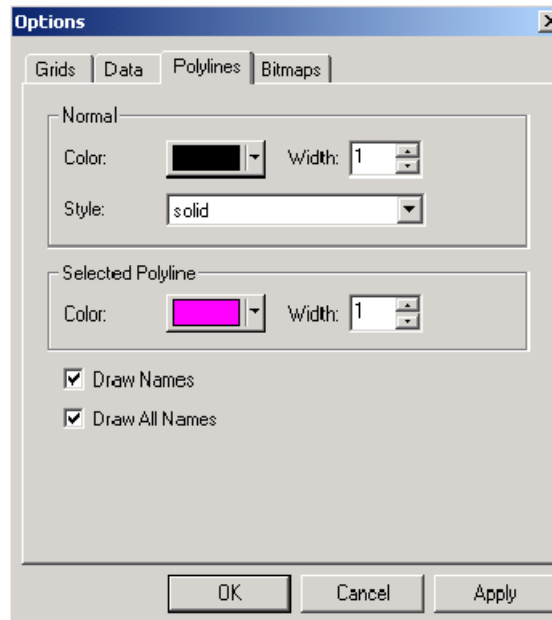
1.8.3   Data

The display of the data (grid items) such as bathymetry, bed resistance etc. can be modified with this function.
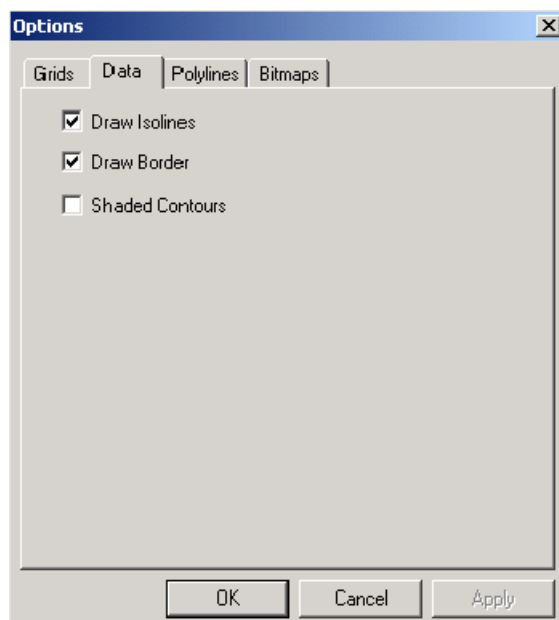
1.8.4 Polylines

The display of the polylines can be changed with this menu.

The selection of the option Draw Names is particularly useful during grid generation, where the appropriate polylines have to be selected.
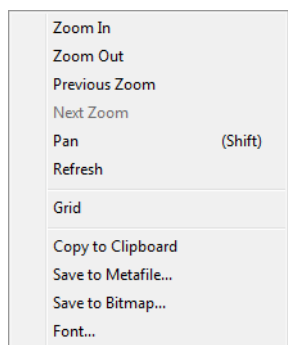
1.8.5 Bitmaps

The display of the bitmaps can be changed using this menu.

1.8.6 Mouse operations

When the mouse cursor is in the view window, a right-click activates the following functions.

Zoom in, out and use of previous zoom is applied for displaying different levels of details of the grid in the project. **Refresh** is applied after settings have been changed. **Grid** is applied if vertical and horizontal grid lines should be displayed. The functions **Copy to clipboard**, **Save to metafile**, **Save to bitmap** are used for storing the display of the grid in another format than on the screen. The **Font** changes the font of the numbering of the horizontal and vertical axes.

When the mouse is in the management window to the left, a **right-click** will activate the menus for Grids, Polylines and Bitmaps, respectively.

2   Example

2.1   Introduction

This tutorial describes the development of a curvilinear model grid using the MIKE 21C Grid Generator interface. The grid generated at the end of the tutorial will be in a format suitable for performing a simulation of MIKE 21C. The application described is based upon a real problem. The river bathymetry is shown below:
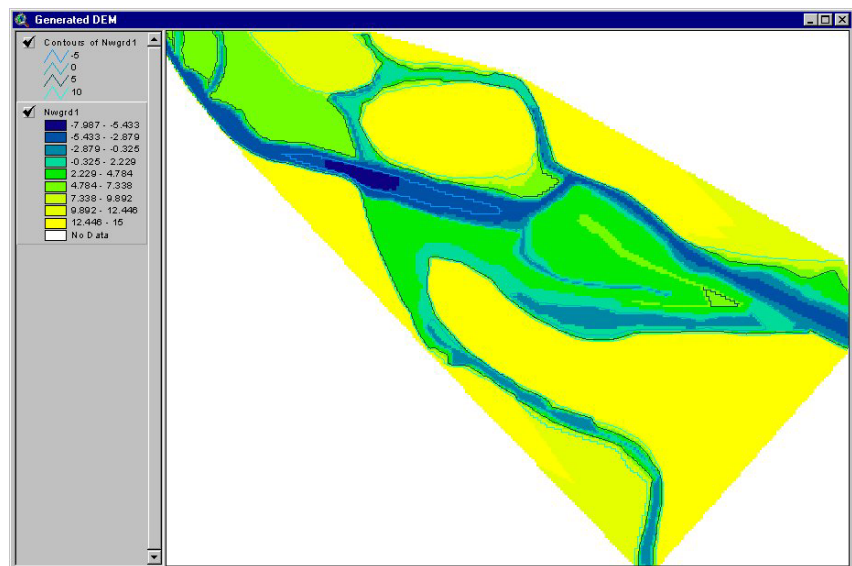

Figure 2.1   River bathymetry

The model in question consists of a bifurcation in a river. The emphasis of the study is to assess bank stability issues at the bifurcation. This tutorial will describe the steps required to develop a curvilinear grid of this river reach and the bifurcation. More information on the river and bifurcation is provided in Section 2.4.1.

2.2   Ideas and Theories behind MIKE 21C Grid Generator

2.2.1   General guidelines

Specifics will be described below. However, bear in mind the following points when creating a curvilinear grid:

- The quality of the grid generation affects the quality of the model.

- The curvilinear grid created at the end of this process is a *single* grid, which has a set number of cells in the flow direction (j-coordinate) and a set number in the transverse direction (k-coordinate). Even if your model has branches, bifurcations, confluences, or islands it is a single grid that if straightened out would form a rectangle. However, within that grid regions of land can be specified.

- Model accuracy is reduced when grid cells are not orthogonal and when the difference in adjacent cell sizes is too great.

- Model accuracy is also reduced when grid cells are too coarse or are not aligned to bed contours sufficiently to accurately describe the bed.

- When generating your first grid, save often and expect to make some repetitions and mistakes.

- Grid generation is usually a stepwise process, creating and joining small sub-grids to make the whole. Try to formulate a strategy before starting, perhaps on a separate piece of paper.

- Remember that the bed levels are not fixed to the grid until grid generation is complete. At the same time, be aware that a good mesh should be able to highlight important features of the bathymetry (such as higher resolution in areas of interest and grid lines following bathymetric contours).

2.2.2 Polylines

A grid or subgrid is defined by 4 **polylines** that describe the 4 boundaries (Figure 2.1). The polylines are ordered according to the axes J, J', K and K'. A **polyline** can be created in several ways by right clicking on the Polyline heading.
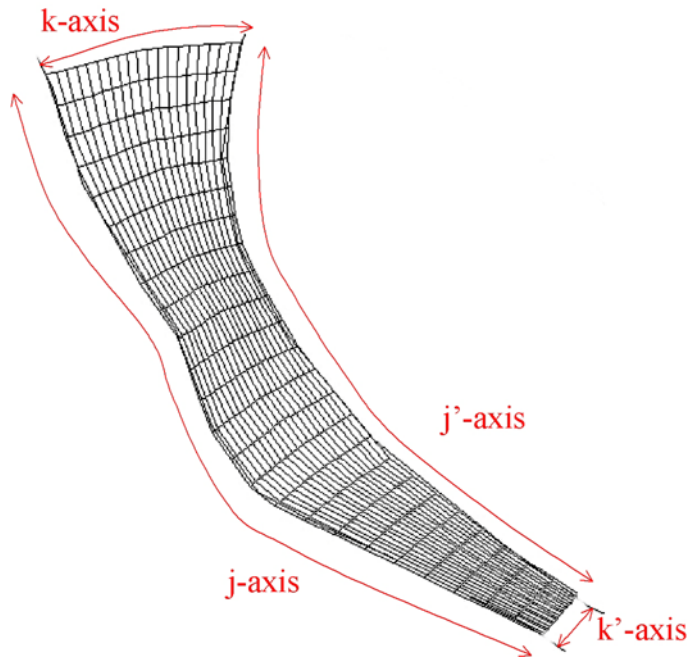
Figure 2.2   Grid defined by 4 polylines

New Polyline
A new polyline can be traced using the mouse.

Merge Polylines
Two polylines can be merged into a single polyline.

Add Polyline from file
A polyline can be added from another, existing grid generation file. The extension is "ggp".

Import Polyline from DAT/XYZ file
A polyline can be imported using the DAT file format. The DAT file is ASCII (can be read by a text editor) and consists of 2 columns defining the x and y coordinate. More polylines can be specified for each DAT file by separating each from another with a blank line in the ASCII file.

More information on polyline operations is available in the Reference Manual, see 1.6 Polyline *(p. 35)*.
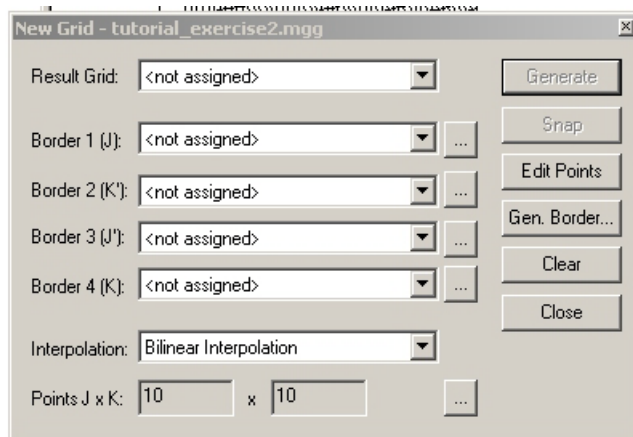
2.2.3   Grids

A grid can be generated in several ways:
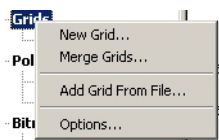
New Grid

A new grid is created from the four polylines describing the boundaries. Each polyline is entered in its appropriate border location. Options are available to Generate a Border, where a polyline defining a border is generated from an existing grid.

On the bottom of the dialog is the specification of number of points in each direction. Note that this is the number of points including corners (and not the number of cells or number of spaces).

Merge Grids

A new grid is created by merging two existing grids together. The tolerance between grid points at the merging boundary can be specified.
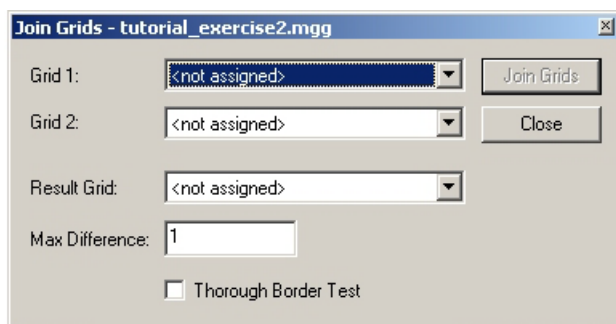
Add Grid from File

A grid can be added from another, existing grid generation file containing two data items: The x and the y coordinate of every grid point. The extension is dfs2.

2.2.4 Grid update

The **Grid Update option** orthogonalises and smoothes a grid or a subset of a grid. This means that the grid is modified so that the angles between successive grid cells are close to orthogonal (90°) and grid weights are modified to be uniform across the grid domain. Grid locations are moved to achieve this. The option to fix cell locations along each boundary is available.
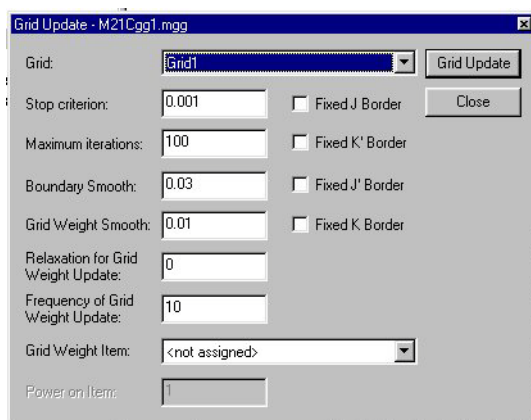
The **Grid Update dialog** contains additional options (right). The options are available to adjust the balance between orthogonalising and smoothing, which is critical to the successful development of a grid. More information on each option is provided below

The solution is found by iteration, with a **Stop criterion** or convergence specified. Once the average change in grid point positions reaches this value the

iterations stop. Otherwise, iterations will continue until the **Maximum iterations** have been reached.

If the boundary is too curved relative to the interior grid point density, the grid may not converge. A filter is therefore applied to the curvature of the border line (**Boundary Smooth**). If the curvature (1/Radius) is more than the specified value, the border points will be smoothed. So, a smaller value means a smoother border. Note this is only applied where a boundary is *not* fixed.

The grid weight is the ratio between the length and width of a grid cell. For numerical reasons a smooth grid (or uniform grid weight) is preferred in a MIKE 21C simulation. Grid smoothing occurs if the grid weight minus the average of the neighbouring grid weights is more than the specified **Grid Weight Smooth** value. So a smaller means a smoother grid.

Grid weight is calculated at the first iteration. Recalculation of grid weights is done according to the **Relaxation for Grid Weight Update** and the **Frequency of Grid Weight Update**. The relaxation factor is similar to an explicit / implicit weighting factor:

- grid weights are fixed if equal to 0;
- grid weights are updated using the recalculated values if equal to 1; and
- if equal to 0.8 (for example) grid weights are updated using a weighted value of the previous and recalculated values.

The frequency factor specifies the frequency that the grid weights are updated. So a value of 1 means grid weights are updated every iteration, and a value of 10 means updates every 10 iterations.
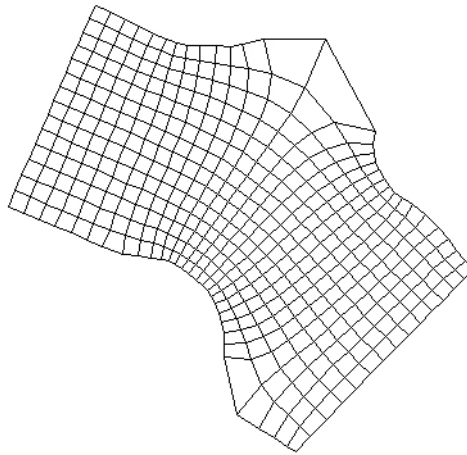
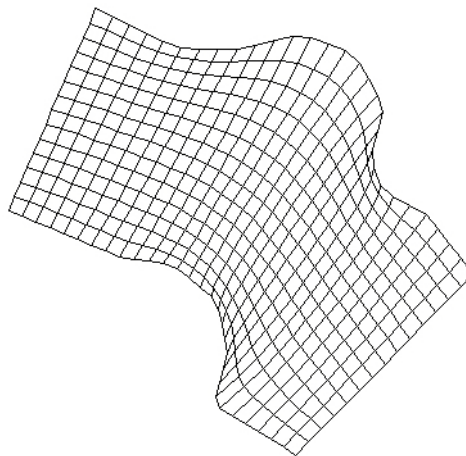To illustrate the grid update, consider the grid:
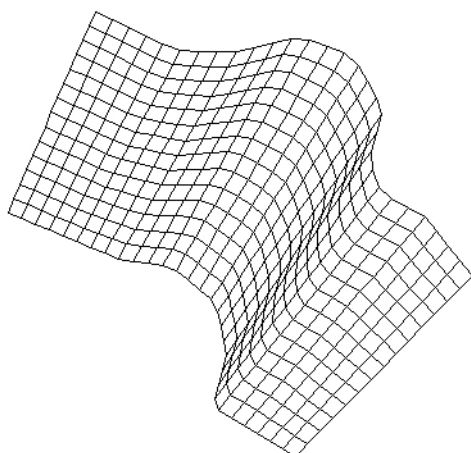
A grid update operation with no borders fixed will give:

A grid update operation with borders fixed will give:

As a rule of thumb, the relaxation for grid weight should be larger than 0 to obtain orthogonality when the borders are fixed. In such case, the grid weight smooth should be adjusted accordingly.

Alternatively, set the **Stop criterion** value to be 0.1, leaving all borders unfixed. As shown, the grid does not change as much.
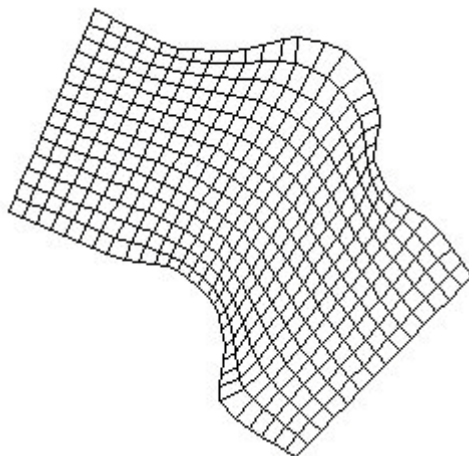
Try to set the **Boundary Smooth** value to a small number (say 0.001). The grid is now unrecognisable:
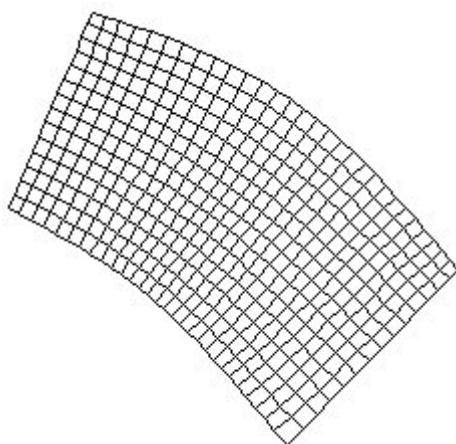
As can be seen, the final generated grid can be quite different. The option to **Select Subgrid** and perform a grid update on the subgrid can be used to perform a series of updates at different zones in the grid. In each zone each of the four boundaries can be selectively fixed or freed. With some iterations the following grid can be generated:
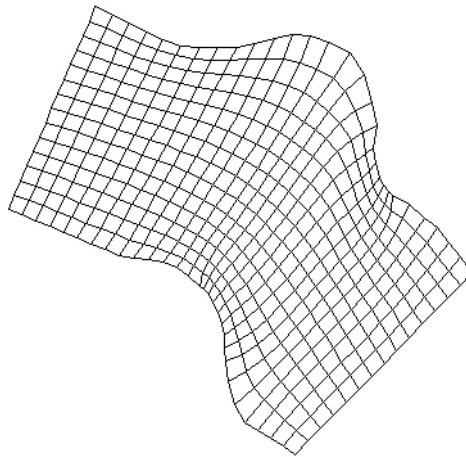
If the grid generation does not produce a suitable mesh using the methods described above, there are two additional features available:

Edit Grid Points
Points on boundaries and in the interior of the grid can be moved using the mouse.

Resize grid
The grid can be resized to increase the cell resolution. Note that linear interpolation between the existing grid cells is performed.

2.2.5 Derived grid information

When having created a final grid for a specific modelling problem the quality of the grid should be checked before proceeding to the bathymetry interpolation and the hydrodynamic and morphological modelling. The checks that should be made are:

- Check of orthogonality
- Check of spatial spacing gradients in both horizontal directions $\partial(ds)/\partial j$ and $\partial(dn)/\partial k$
- Check of grid aspect ratio *ds/dn*
- Location of true land cells

Lack of grid orthogonality and too large spatial spacing gradients causes less accurate results due to violation of the assumptions made for the equations solved in the flow and sediment transport model. Large spatial spacing gradients can also be responsible for numerical instabilities in areas with transition between flooding and drying. The aspect ratio is important in the sense that it can be used to choose the optimal number of points needed to resolve the

flow in the stream wise direction (given the number of points across the model area). For convection dominated flow problems like river flow aligned with the curvilinear grid the optimal aspect ratio is in the range from 3 to 8. For floodplain flow with a less significant flow direction the aspect ratio criteria should be reduced to the range 1 to 3.

Identification of the true land cells in the bathymetry is important for the checking of the grid, because in these areas all requirements for grid orthogonality and changes in grid size can be ignored, i.e. larger islands in a river can be resolved with very few grid cells and without being orthogonal, if defined as a true land area.

In the following the applications for checking of the quality of the grid is described.

Check of grid orthogonality
The orthogonality check of the grid is made by the following steps:

- Add a new item related to the final grid

- Right-click on the new added item in the tree on the left and click on modify

- Chose the operation S**et value** in order to set a dummy value for the grid

- Select modify again, but choose now the operation **Orthogonality check**

- Right click on the added item and click on active. A colour palette will now be shown to the right and when moving the cursor around on the grid the x, y coordinates, the value of the item (orthogonality measure), and the j, k coordinates are shown on the bottom bar.

- Save the orthogonality information into a dfs2-file by clicking at S**ave as** and specify a file name.

For an ideal curvilinear grid the orthogonality measure would be equal to zero everywhere. However, for practical applications one should try to create a curvilinear grid with values inside the range from -0.05 to 0.05, depending of the complexity of the grid. In the example shown below, it is seen that for very simple grids the criterion given above can be reduced to, say -0.01 to 0.01.

Note, that it is the user that creates the boundary conditions for the grid generator, i.e. if the polylines have been created so that they not fulfil the orthogonality criterion at the corners, it will be impossible to create a satisfactory orthogonal grid.
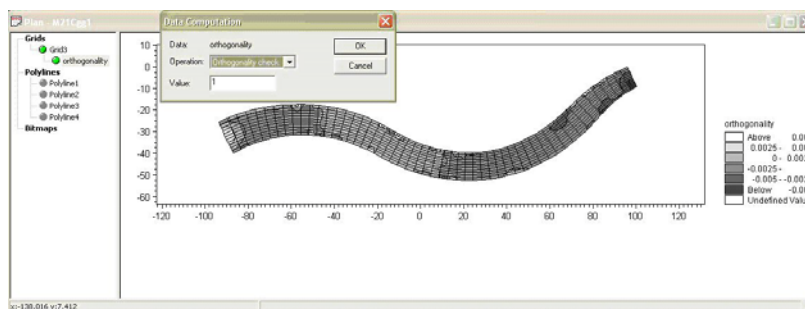
Figure 2.3   Creating an orthogonal grid

Spacing *ds*

The cell spacing in the j-direction can be obtained in the same way as the grid orthogonality and saved into a dfs2-file. The *ds* values contain the length in the j-direction of the grid cells (cell centred) not the length of the faces. It should be checked that the values varies smoothly along the grid without any abrupt shifts except at areas defined by a true land value. The *ds* information can also be used to obtain a chainage value along the model and the total length of the model.

Spacing *dn*

Likewise, the cell spacing *dn* in the k-direction can be obtained and saved into a dfs2-file. The values contain the cell-centred width of the curvilinear grid cells. Again, it should be checked that the values varies smoothly in the grid, except at the true land values. The width of the model can be obtained as the sum of the values along a k-line.

Area A

Finally, the grid cell areas can be obtained for the grid and saved into a dfs2-file. This information can be useful for calculation of bed volume changes (using the calculator options in the MIKE Zero Grid Editor).

Having saved the information about *ds* and *dn* information into two separate dfs2-files the grid aspect ratio can be obtained by use of the above mentioned MIKE Zero tools that allows the two dfs2-files to be divided with each other. For an optimal curvilinear grid the aspect ratios should be inside the range from 2 to 8, except at the flood plains and areas defined by true land.

2.3   Before Starting this Tutorial...

MIKE 21C uses the MIKE Zero model environment. Although MIKE 21C Grid Generator is not part of the MIKE Zero interface, the files created are compatible. It is assumed that you are familiar with this interface and are aware of the various file types used in MIKE Zero.

2.3.1 Files to start with

This is a tutorial and some of the files are pre-prepared. In particular, the outlines of river banks and river bathymetry have already been generated. The following files are needed:

- **River_outline.dat**
  The file contains a single line that essentially describes the model extent, including the river banks.

- **Gorai.jpg and Gorai.jpgw**
  These two files contain a background image of the river. The JPG extension is a standard picture format, while the JPGW extension is a "world" file, describing the location of the image in a coordinate system.

- **dtm_points.xyz**
  This file contains the model bathymetry. This bathymetry has been generated externally from several data sources, including the image above. The file is a space delimited text file with 3 columns containing the x, y and z values of a digital terrain model. There is no header file. This file can be read into a GIS to recreate the DTM (or DEM, depending upon your terminology).

2.3.2 Additional file

- **Gorai-grid-final.dfs2**
  This file contains the final grid obtained going through the steps described in the following section. It can be used for bathymetry generation and setting up a hydrodynamic and morphological model, if one wants to proceed fast through the grid generation procedure/process.
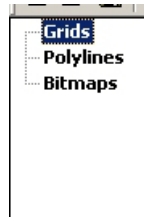
2.4 Create Tutorial Curvilinear Grid

2.4.1 Import background image and river outline

Start the MIKE 21C Grid Generator. Start a new grid (Menu File -> New). The grid generator extents can be specified at this time, (although window extents can be changed later). Enter the following coordinates:

The left window contains a tree structure:

There are three types of file in the MIKE 21C Grid Generator. Grids are the subgrids that form the final grid. Polylines are used to define the edges of grids. Bitmaps are available to help define the outline of the problem and as a guide to drawing polylines.

See the Users Guide for more information.

Import the background image. To do this, right click on the **Bitmaps** heading in the tree and **Add Bitmap from File**. Using the **file-open** dialog that will appear, select the file **gorai.jpg**. When the **Image Placement** window appears, press **Cancel**. Select the unit of the coordinates from the .jpgw file to be interpreted as meter, and click OK. The world file will be used to define the coordinates of the image instead. In the right window (the **map** window), right click to zoom into the problem area:
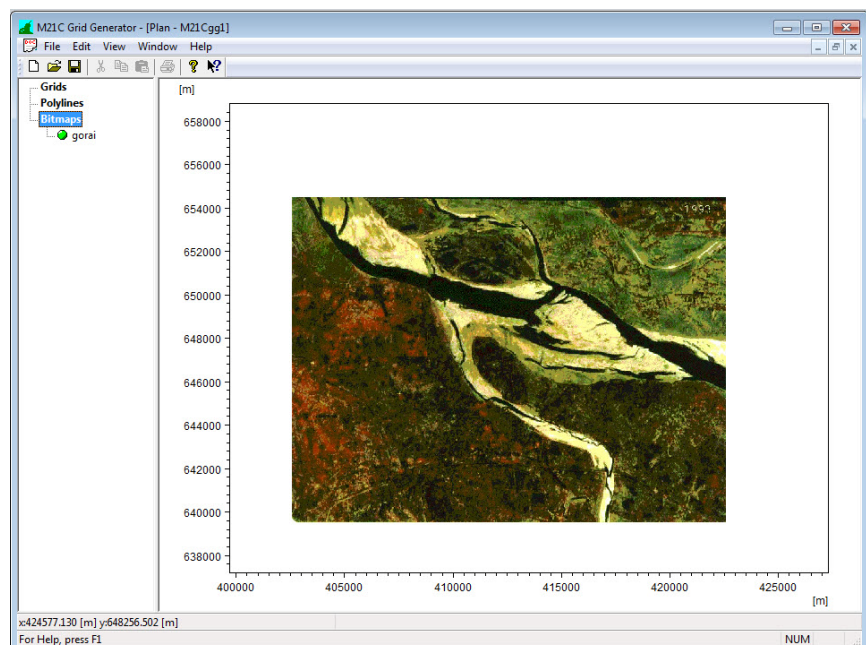

Figure 2.4   Creating bitmaps

As shown, the main channel flows from west to east. A smaller river flows to the south and takes off at the bifurcation in the centre of the image. The main

focus for this problem is the bifurcation, so particular emphasis should be given to this area. Beyond this area, grid resolution does not need to be as fine.

Import the river outline. To do this, right click on the **Polylines** heading and **Import Polyline from DAT file**. The existing file is called **river_outline.dat**. If the background image is not visible (this is done by right clicking on the image file name), the river outline can be seen more easily:
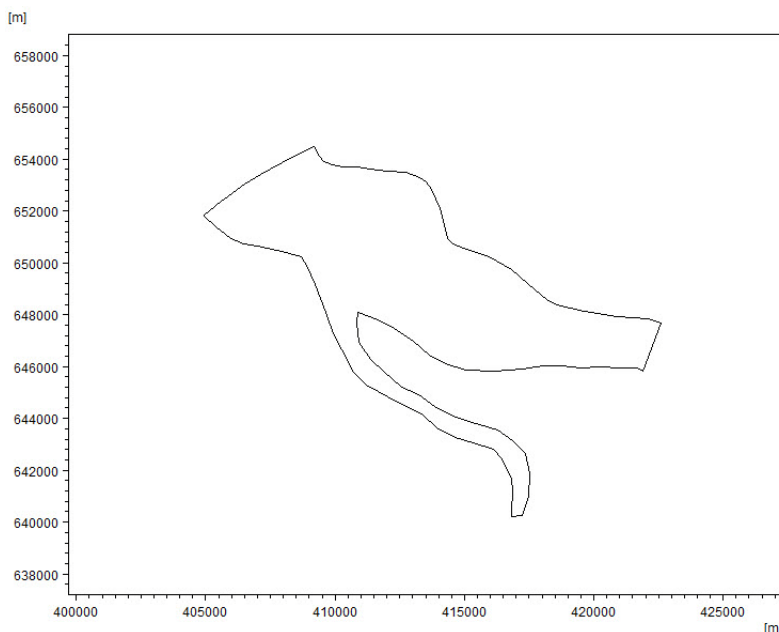

Figure 2.5   Importing river outline

2.4.2   Grid generation strategy

The river outline will be used to generate the grid. Before jumping straight in, take some time to plan your strategy:

- There is a bifurcation. This means that at least two sub-grids will need to be generated and then merged.

- The area around the bifurcation is the particular area of interest. Grid resolution outside of this area does not need to be as detailed.

- Ultimately, the sub-grids created will be joined together / merged to form a **single** grid. This may need some "lateral" thinking to achieve in the optimal way.

2.4.3   Bifurcation

Consider this problem in terms of the grid aligned to the main river channel, with the j axis along the river and the k axis across the river. What is the orientation of the secondary river - is it aligned with the j axis also, or with the k axis instead? Consider the two simplified grids below which illustrate this. The dark shading represents the river bank, or land / water interface:
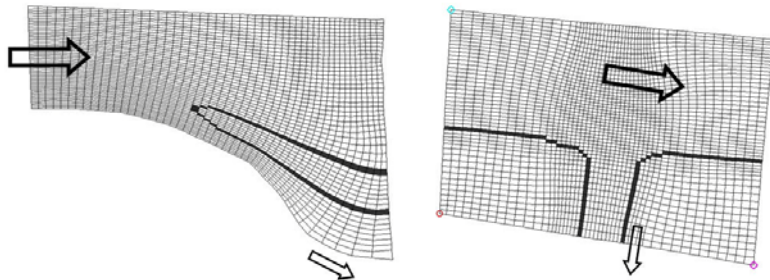

Figure 2.6   Grid alignments

The first grid presents a case where the second river is aligned with the j axis. In this way the grid lines follow the alignment of the outer (southern) banks at the bifurcation. However, the inner bank (northern bank of secondary river) at the bifurcation will not follow the grid lines, and the land/water interface is diagonal to the grid cells in some places.

The second grid presents the case where the second river is aligned with the k axis. The grid lines follow the direction of flow from the main river into the secondary river. However, both the outer (west) and inner (east) banks do not always follow the grid lines and a diagonal land/water interface exists at the bifurcation.

These examples illustrate the extreme cases for the choice of alignment, and selection is reasonably clear. However, for this tutorial case the choice of alignment is less clear. Also, this particular problem is to investigate bank erosion at the bifurcation, and in particular along the outer or southern bank of the bifurcation. For this reason the first alignment is more appropriate.

2.4.4   Grid resolution

The resolution of a numerical model always seems to be at the limit of computational ability. Therefore, it is often desirable to manage computational effort so that the near field region around the problem is emphasised, while far field regions are given less emphasis. The MIKE 21C model can do this by allowing variations in grid size.

For this problem, the area around the bifurcation is the point of focus. Therefore, a higher grid resolution (transverse) should be used in this area compared to the rest of the model domain.

2.4.5 Grid generation methodology
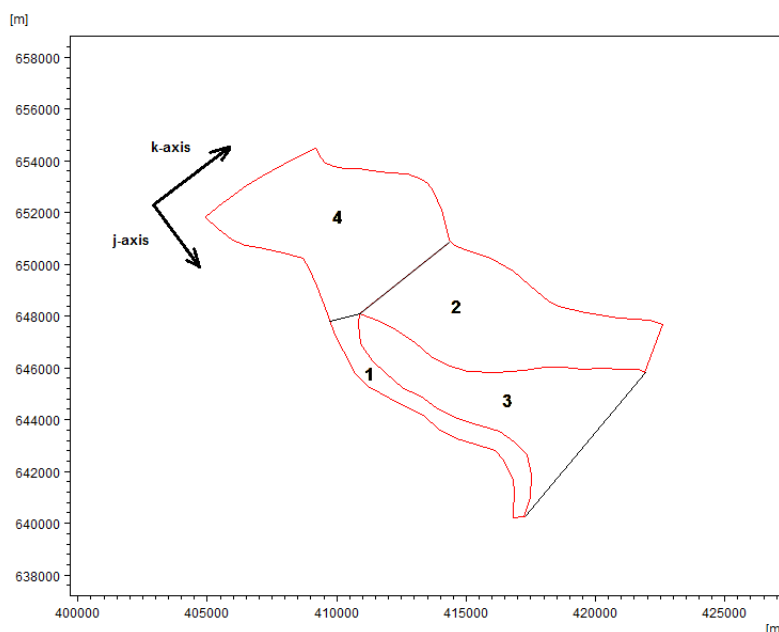
Consider the following diagram:

Figure 2.7   Grid resolution diagram

In terms of grid resolution, sub-grids 1, 2 and 4 will be made with a high resolution, while sub-grid 3 will use a very coarse resolution. In terms of grid alignment, the smaller river will be aligned with the j axis of the main river. This means that grid lines will be aligned with the outer (south) bank of the secondary river, which is of importance in this case. The opposite bank of the bifurcation will not be completely aligned with the grid and some sections of the bank will be diagonal to the grid alignment.
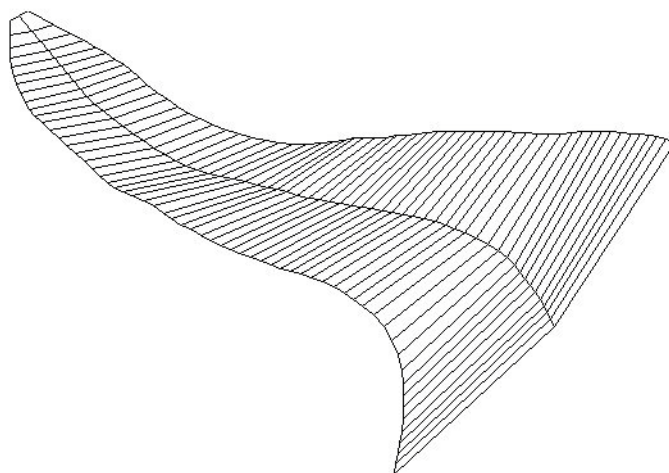
The order in which the grids are to be joined is also important. The steps, and the reasons for each step, are discussed below:
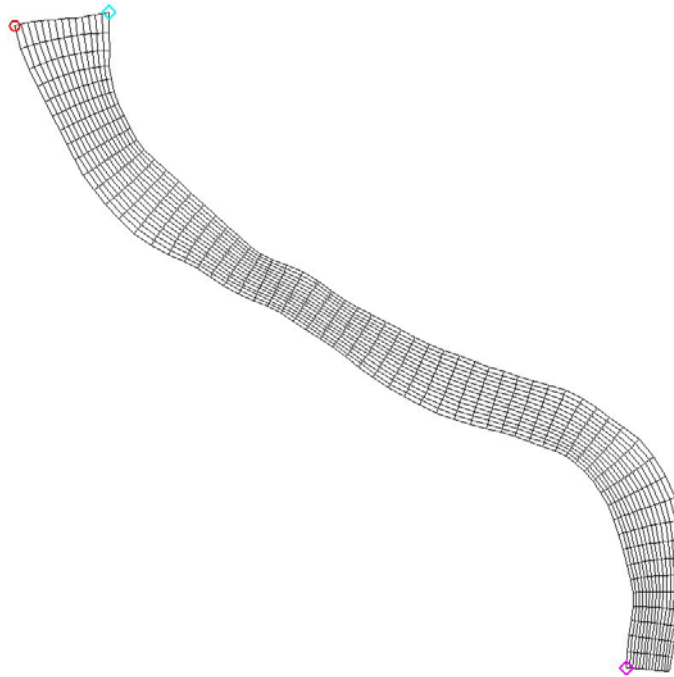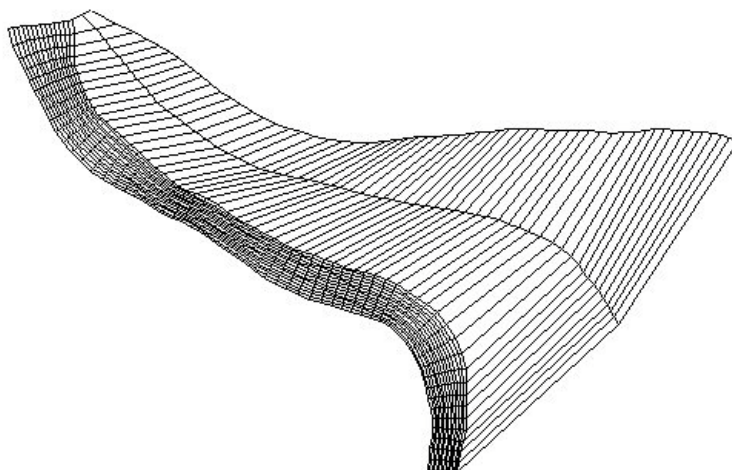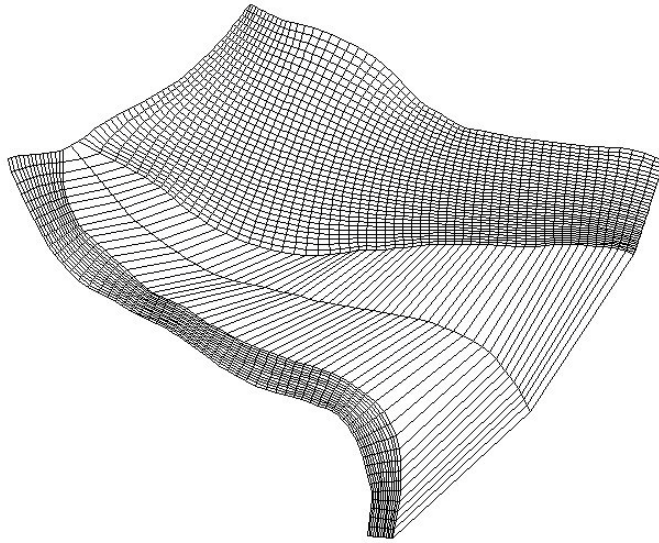
Grid 1 (60x15) is generated and orthogonalised
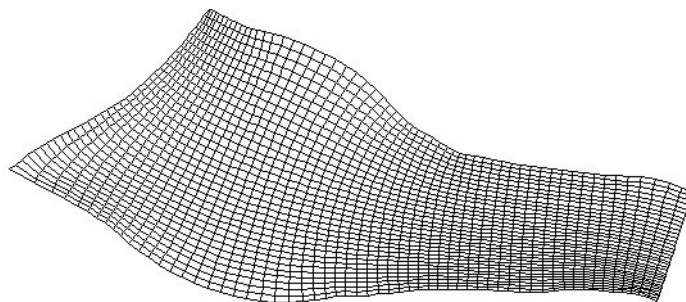
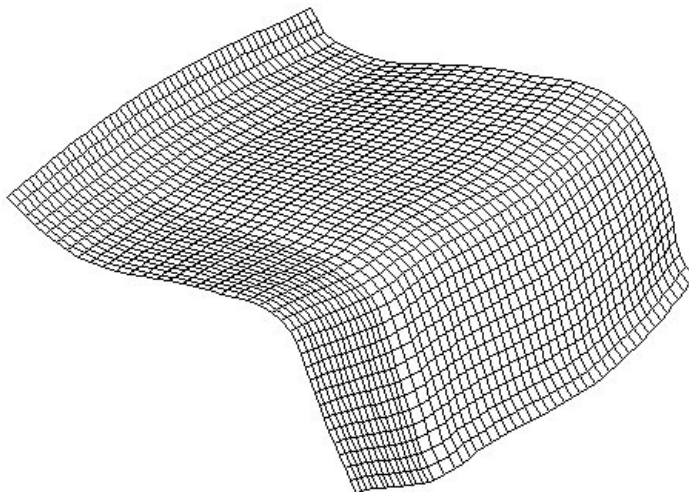**Grid 2** (60 x 35) is generated and orthogonalised. It has the same number of cells as grid 1 in the j-direction

Grid 3 (60 x 3) is generated, but not orthogonalised, because it is an area of no interest. The j-axis of **Grid 1** is used as the j-axis, and the j-axis of **Grid 2** is used as the j- axis by application of the **Generate Border** facility
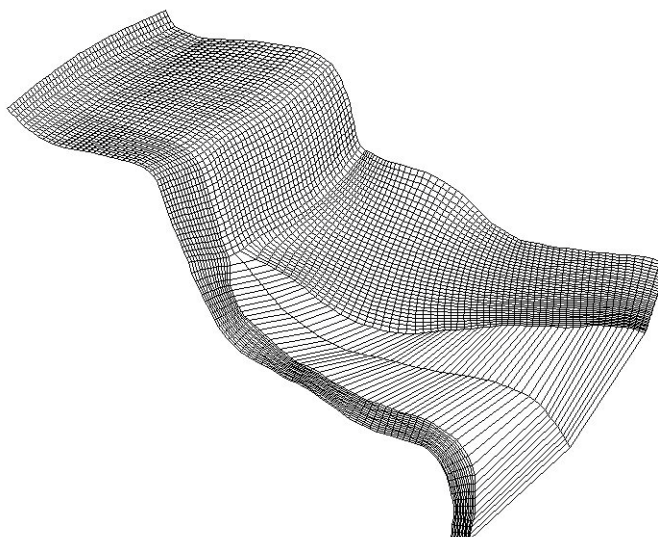

Grid 1 and **Grid 3** are merged together into **Grid 5** (60 x 17). The order of the grids to be merged must follow the direction of the j-axis or k-axis
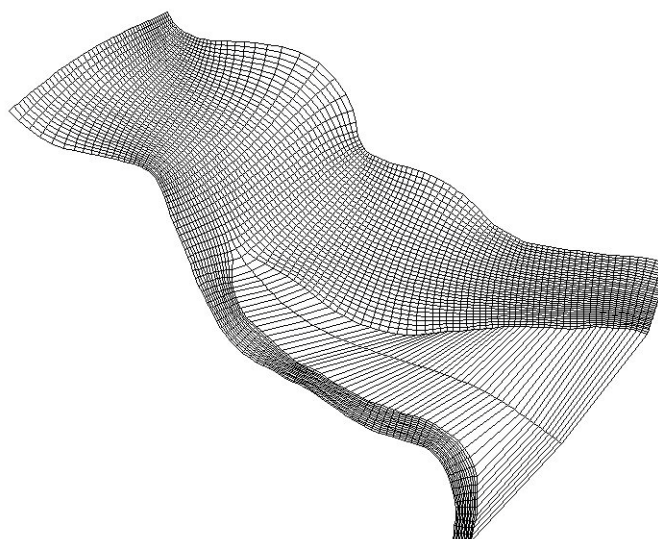
Grid 5 and **Grid 2** are merged together into **Grid 6** (60 x 51)

The west boundary of **Grid 6** (k-axis) is used as the k-axis for **Grid 4**. **Grid 4** (45 x 51) is generated and orthogonalised. Remember to keep the k'-boundary fixed, when orthogonalising the grid

Grid 4 and **Grid 6** are merged together into **Grid 7** (97 x 51)

Subgrids are selected and orthogonalised until a grid that satisfies the orthogonality criteria is obtained

The next step is now to investigate the quality of the grid by adding an item and make the orthogonality check. For the grid developed in this exercise, the following results are obtained.
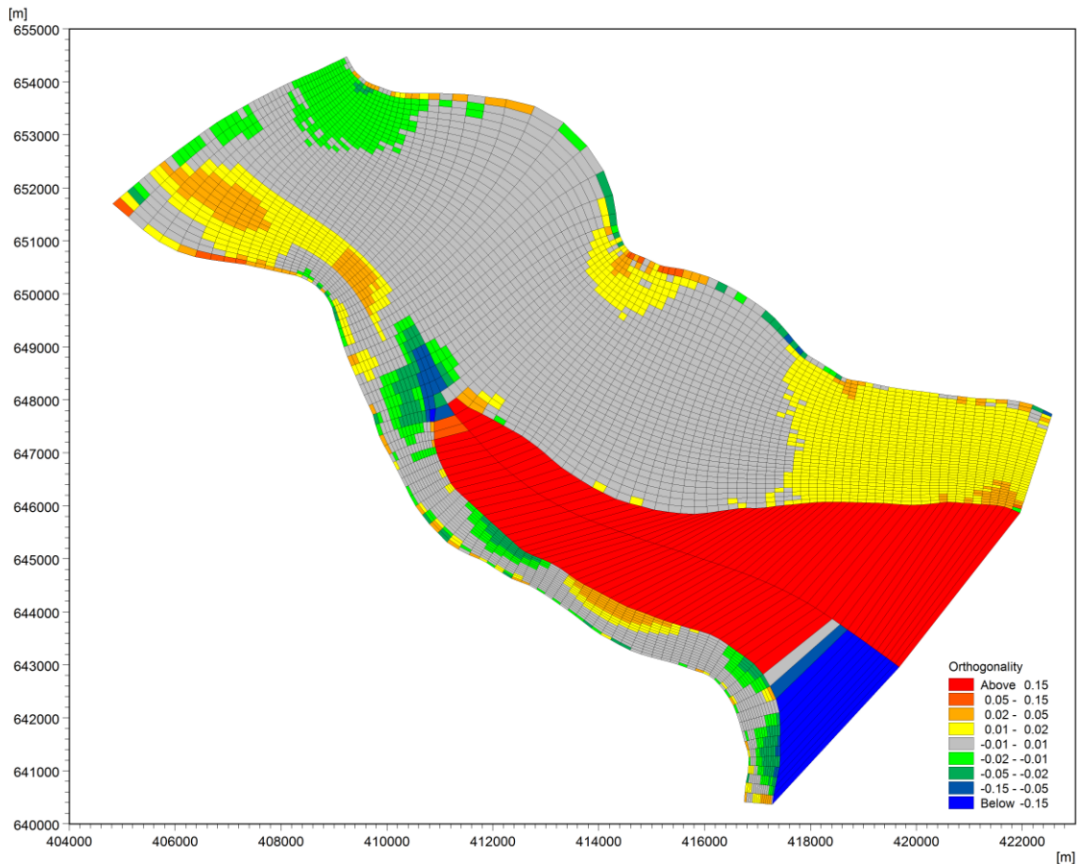
Figure 2.8   Orthogonality check

It is seen that the grid fulfils the orthogonality criterion given in the previous section (values between -0.05 and 0.05) everywhere, except at the area between the two branches that can be modelled as true land.

The next step is now to investigate the aspect ratios in the grid. Due to the fact that the curvilinear grid is not aligned with the low flow channels in a large part of the domain only modest values for the aspect ratio can be allowed. The grid aspect ratio for the present grid is shown below. It is seen that in the part of the domain, where the grid is aligned with the dominating channels aspect ratios varies from 2 to 5, while in the part of the grid where cross flow occurs aspect ratios are reduced into the range between 1 and 2.

Note that the versions from before 2007 saves the grid file as a standard dfs2-file with single precision. For the present case this means that the grid is saved with an accuracy of +/- 0.1 metres. For the applied grid size this is not a problem. However, when grid generation is based on UTM-coordinates the accuracy can often be +/-1 meter. For these cases large errors can be introduced if the flow problem is resolved by relatively small grid cells. In order to

prevent this inaccuracy offset values should be subtracted from all x and y coordinates (to get smaller numbers) used for grid generation and interpolation of bathymetry. The hereby obtained grid file should be used for the model runs, while a grid without the offset correction can be used for the presentation of the results.

In the 2007 and later versions grid coordinates are saved with double precision in two static items. This implies that the spacing functions *ds* and *dn* can be calculated with satisfying accuracy even though coordinates are specified as true UTM-coordinates or something similar. However, this implies that the Grid Editor cannot be applied to make changes to the dfs2 grid file without destroying the double precision information in the grid file.
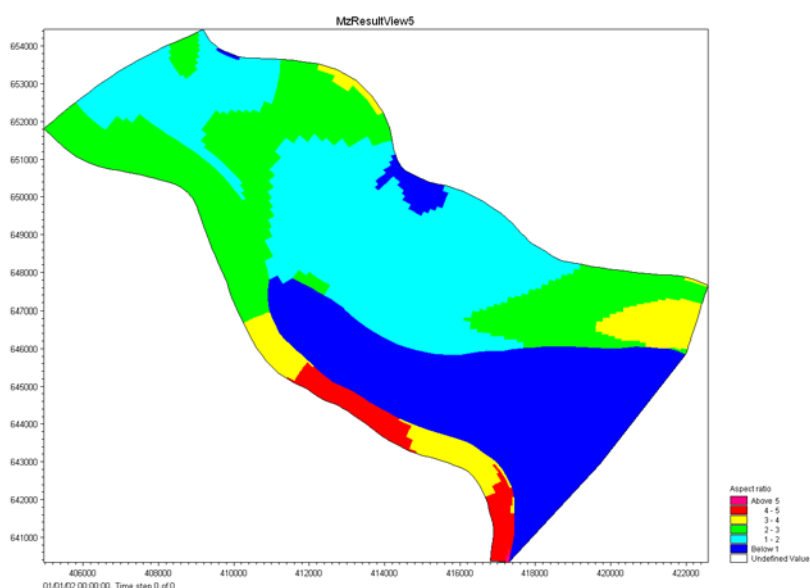

Figure 2.9   Aspect ratio

After having checked that the curvilinear grid satisfies our quality requirements, we only need to add a row of land border cells along the j-axis and the j'-axis. Hereby, we obtain the final grid **Gorai-grid.dfs2** shown below.
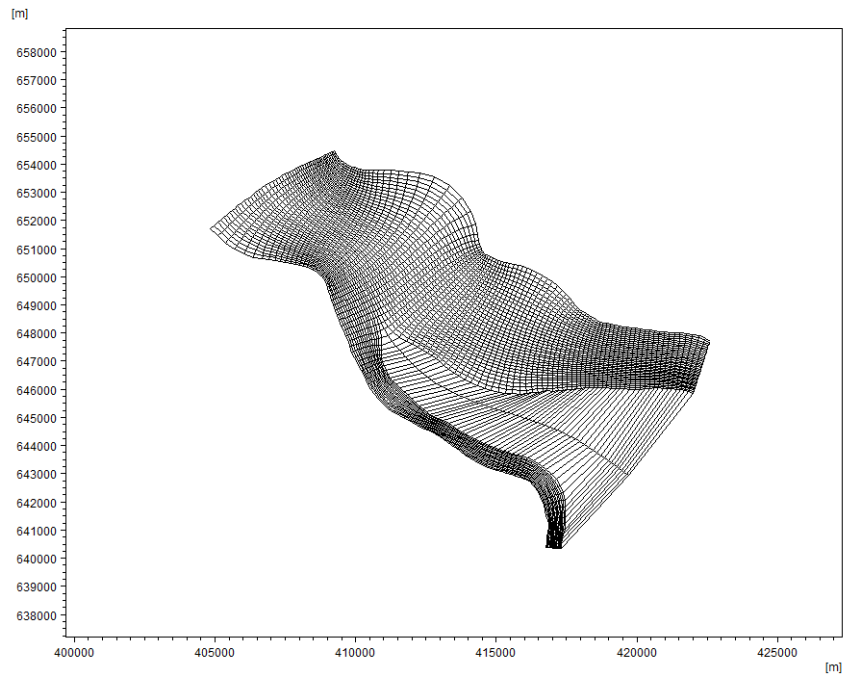
Figure 2.10   The final grid - Gorai-grid.dfs2

2.5   Generate Bathymetry

Once the curvilinear grid has been generated and checked for orthogonality, the grid points need to be updated with bed levels. There are a number of ways to do this:

- Export the grid locations to a GIS containing a DEM, interpolate depths onto the points, then re-import the updated points into the MIKE 21C Grid Generator;

- Import a file of XYZ data from a GIS (or other source) into the MIKE 21C Grid Generator and interpolate the depths onto the grid points; or

- Manually insert the bathymetry using the dfs2 editor tools in MIKE Zero using Cartesian coordinates (not curvilinear).

In most applications a GIS is used at the principal data storage and maintenance tool. Therefore, the first method (export to GIS and interpolate from a DEM) is likely to be the preferred method. The following steps can be followed if using ArcView 3.2a/3.3 with Spatial Analyst and 3D Analyst.
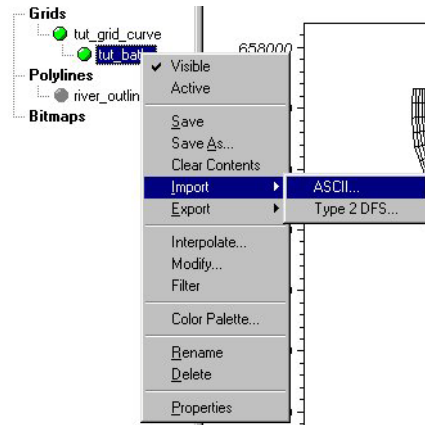
Add an item to the curvilinear grid (right), then rename the item as "**tut_bathy**" (below).
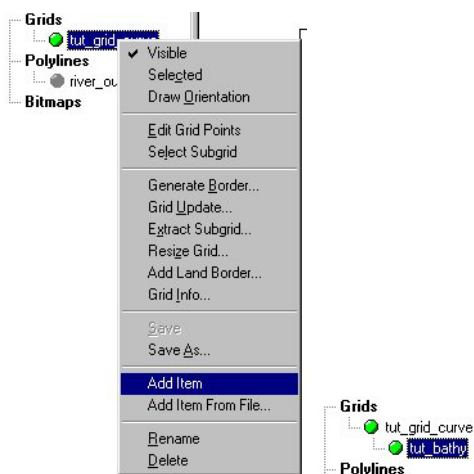
Click on **Modify** to specify a dummy bathymetry value, say -99.999 metres for all cells in the grid.
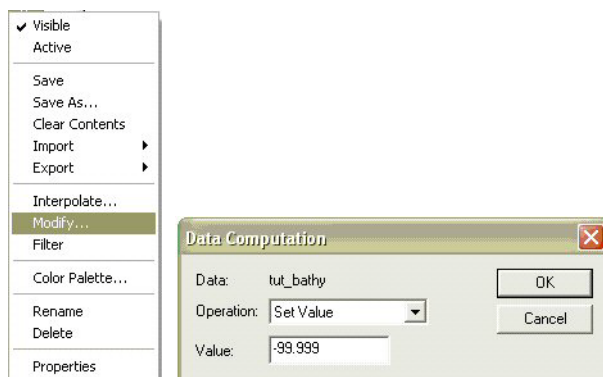
Export the item to an ASCII file called "**tut_bathy.txt**".

This ASCII file is in a space separated column format (x, y, z). However, in order to be able import the file into ArcView, it must be converted to a comma separated format and given the header information "X", "Y", "Z" in the first line. This file is in the following referred as file number 1. The bathymetric/topographic surveys must be made available in an ASCII file number 2 with a format similar to file number 1. The following steps should hereafter be carried out in ArcView:

- Open ArcView 3.2a/3.3 and go to Extension and make active **Spatial Analyst** and **3D Analyst** extensions.

- Import files number 1 and 2 from: **Projects** > **Add Table** > List of Type Delimited TXT

- From **View 1** go to **Menu** > **View** > **Add Event Theme** > Select Table TXT file and also the fields that identified the X and Y coordinates. Similar for both files.

- Now in **View 1** in the theme menu list on the left there will be two themes TXT file. File number 2 must be converted to a **SHAPE** file. For this click on the file name in order to select it and go to **Menu** > **Theme** > **Convert to shape** > Specify a file name for the shape file and add it to the Theme menu (by answering yes).

- Select shape file number 2 by clicking at it in the Theme menu. Go to **Menu** > **Surface** > **Create a TIN from Features** > in **Active Feature Themes** must be listed the selected theme. On the right must be selected:

  Class: Point

  Height Source: Z

  Input as: Mass Points

Value Field: <none>

- Specify a name for the TIN. Now the TIN is added to the Theme menu on the left of **View 1**.

- Select file number 1 (the dummy bathymetry) in the Theme menu. Go to **Menu** > **Theme** > **Convert to 3D ShapeFile** > Chose **Surface** when asked **Get Z values from** > Select the created TIN > Specify a file name for the 3D shape file and add it as a theme to the view.

- Select the 3D shape file in the Tables Theme list and click **Open**. When the attribute table has been opened you will not observe any changes from the original dummy bathymetry file.

- Start editing the attribute table by choosing: **Menu** > **Table** > **Start Editing**. Select the field Z by clicking in the headers of the file. Choose **Go to Field** > **Calculate** > Double-click on **SHAPE** and write **.getz** in the **Field Calculator** window. The statement must look: [SHAPE].getz. Press **Ok**, the Z column will now be replaced by interpolated values from the TIN surface.

- **Save** and **Stop Editing**.

- Export the interpolated 3D shape file to an ASCII file: Click on the attribute table and go to **Menu** > **File** > **Export** > **Delimited text** > Specify a file name for the interpolated xyz-file.

- Before importing the xyz file into the grid generator the header line must be removed and the commas replaced by spaces.

It should be noted that the advantage of using ArcView or another GIS tool for the bathymetry interpolation is that all values are obtained directly from the surveyed data. When using the interpolation routines in the grid generator one very often will end up using a mix of interpolated and surveyed bathymetry values to obtain new bathymetry values in the grid cells with no information. However, if the bathymetry generation is based on public domain DEM's that only contain information from topographic surveys one should expect poor results for the main channel bathymetry. Because this part of the model area, typically will be represented by values for the surface elevation of the water and not the elevation of the bed.

In this tutorial example the file "dtm_points.xyz" mentioned in Section 2.3.1 has been prepared by GIS-interpolation, so that it can be used to generate a surface of bed levels directly, without interpolation:

Import the updated bathymetry back into the curvilinear grid (right).
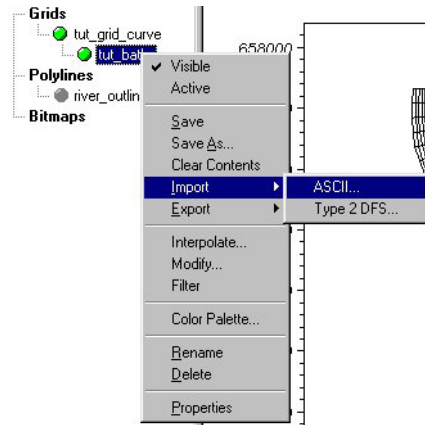
Also, remember to update the **Land value** for the grid. All bed levels higher than or equal to the Land value will be regarded as land and are not included in the computational domain in MIKE 21C.
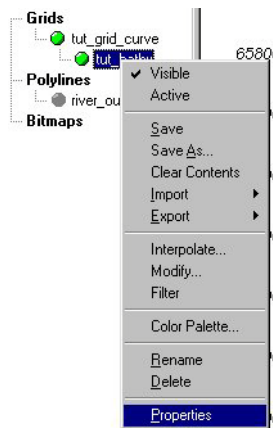
The grid generation is now complete. The curvilinear grid will be contained in the file "**tut_grid_curve.dfs2**", and the corresponding bathymetry is in the file "**tut_bathy_i.dfs2**". If either of these names are unsuitable, use the "**Save As...**" command in the grid options.
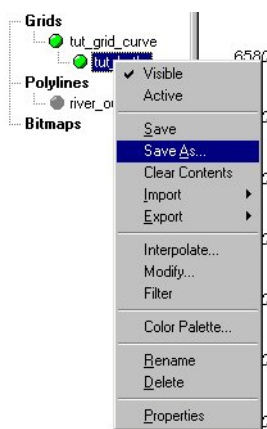
If satisfied with the grid generation procedure, continue on to the MIKE 21C tutorials.

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