Nestor

Validation Manual

Version v8p5

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Contents

1. Nestor 1: dredging and dumping

1.1 General information about usage of Nestor

1.1.1 Nestor in the steering files

Nestor settings in the GAIA/TELEMAC2D STEERING FILE:

```
NESTOR                         = YES
NESTOR ACTION FILE             = name of the Action file
NESTOR POLYGON FILE            = name of the polygon file
NESTOR SURFACE REFERENCE FILE = name of the reference level file
NESTOR RESTART FILE            = optional
ORIGINAL DATE OF TIME          = 2000;01;01
ORIGINAL HOUR OF TIME          = 0;0;0
```

Because the reference level file contains the flow length coordinates which are attached to the sections (fig. 3.3), the reference level file must exist, even if it is not adressed by an Action. The file must contain at least two sections which define an area that covers all polygons (fig. 4.5, 4.6). The flow length coordinates are required to print the NodeInfo line (chpt. 1.1.5.1 / page 8)

1.1.2 General structure of the NESTOR ACTION FILE

General structure of the NESTOR ACTION FILE (= steering file for Nestor):

```
RESTART = FALSE/TRUE
/ comment line
ACTION
  ActionType = ...
      ...
ENDACTION
...
ACTION
  ActionType = ...    / comment at the end of a line
      ...
ENDACTION
ENDFILE
```

Inside the block `ACTION - ENDACTION` all other keywords, excluding `GrainClass` (chpt. 1.1.4 / page 6), may appear in any order.

1.1.3 About Nestor polygons

General structure of the NESTOR POLYGON FILE:

```
/this is a comment line
#this is a comment line as well
NAME:polygon_name
   x-koord     y-koord
   x-koord     y-koord
   :           :
NAME:polygon_name
   x-koord     y-koord
   x-koord     y-koord
   :           :
ENDFILE
```

The keyword `NAME:` induces a new polygon.
The polygon name must start right after the colon.

Convention regarding to polygons:

- The polygon name must start with an unique integer number between 100 and 999. Any text after that is treated as a comment to help the user.
  Example: `123anyString`
  Internally only the number is used to identify the polygon.
- Multiple assignements are not allowed. That means a polygon may be assigned only to one Action. (The assignements are defined in the Action file.)

1.1.4 About supply material

Convention for definition of the supply material:

- The sum of the fractions of the grain classes must be 1.
- The number of the grain classes must be the same as set in the GAIA STEERING FILE.
- The order of the grain classes must appear in the Action block in the same order as they are set in the GAIA STEERING FILE.

1.1.5 Information about Nestor in the Telemac listing file

In order to find specific Nestor information in the Telemac listing file about:

- which Action was when active and what was going on, search for **"?>"** (see below or chpt. 1.7 / page 16)
- what was the users mistake, search for **"?> error"** (see below)
- the dredged volume, search for **"XdigX"** (see chpt. 1.1.5.1)
- the dumped volume, search for **"XdumX"**

In case of parallel computation you have to search in the listing file of each partition !

Excerpt from the telemac listing with information about the Action status:

```
?> :
?> info:=========================================================+
?> info:            NESTOR                                       |
?>
?>          action number    :   1
?>
?>          start action     : Dig_by_time
?>  nominal start time  [s]  :    50.000000000000000
?>          start time  [s]  :    50.000000000000000
?>
?>          FieldDig         : 201_Abschnitt_1_2_1000m**2
?>     dz per time step [m]  :   1.0000000000000002E-003
?>
?>          FieldDump        : 202_Abschnitt_6_7_1000m**2
?>     dz per time step [m]  :   5.0000000000000010E-004
?>
?> info:=========================================================+
?> :
```

Excerpt from the Telemac listing file with information due to a user mistake:

```
?> :
?> error:=========================================================+
?> error:           error in dredge module Nestor                |
?> error:                                                        |
?> error:  occured in Subroutine       ReadDigActions
?> error:  occured in parallel thread  0
?> error:
?> error:  while read the Action file
?> error:  reason:  unknown keyword:     xReferenceLevel
?> error:           check spelling !
?> error:  occured in line:     10
?> error:                                                        |
?> error:=========================================================+
?> :
```

1.1.5.1 Node Information

While a Nestor Action is active, the elevation of the nodes inside the assigned polygon (working area) will be changed every time step a little bit. At the time step, when an Action changes a node the last time, a "NodeInfo" line will be printed in the Telemac listing file. Each info line is marked with the lable **"XdigX"** or **"XdumX"** at the beginning and followed by the values shown below

- `TimeStart` *of the Action-X* *[s]*$^{(*)}$
- `Time` *when the last change to the node happened* *[s]*$^{(*)}$
- `Delta-Z` *total evolution caused by Action-X* *[m]*
- `Delta-Volume` *= Delta-Z * node area* *[m^3]*
- `Index` *global number of node*
- `Km` *flow length coordinate* *[km]*
- `X-coordinate` *[m]*
- `Y-coordinate` *[m]*
- `Name` *of the assigned polygon*
- `Action` *number of the Action*

$^{(*)}$ seconds since simulation start

Excerpt of listing file with NodeInfo lines :

```
 :
XdigX 800.00 820.00  10.73  10.12   853   1.871  1058.3149  -708.833   100_Fairway  1
XdigX 800.00 824.00  14.89  15.44  1502   1.175  1167.8081  -153.119   100_Fairway  1
XdumX 900.00 960.00  14.95  13.96  1042   2.797  949.61357   1302.40   100_Fairway  2
 :
```

1.1.6 Tables of Nestor keywords

Table 1.1: Keywords for Nestor Action `Dig_by_time`

KEYWORD		VALUE	UNIT	COMMENT
`ActionType`		`Dig_by_time`		
`TimeStart`		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
`TimeEnd`		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
`FieldDig`		polygon name		
`DigVolume`		real	[m^3]	
`FieldDump`	opt.	polygon name		dumping happens only if set
`DumpRate`	opt.	real	[m/s]	if not set, dumping ends at TimeEnd
`DumpPlanar`	opt.	`FALSE` (default) `TRUE`		

`ReferenceLevel`	opt.	`GRID`
		`SECTIONS`
		`WATERLVL1`
		`WATERLVL2`
		`WATERLVL3`
				must be set if
				DumpPlanar = TRUE

opt.: optional				

Table 1.2: Keywords for Nestor Action `Dump_by_time`

KEYWORD		**VALUE**	**UNIT**	**COMMENT**
`ActionType`		`Dump_by_time`		
`TimeStart`		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
`TimeEnd`		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
`FieldDump`		polygon name		
`DumpVolume`		real	[m^3]	
`GrainClass` : `GrainClass`		real real real		the sum of all grain classes must be 1.0 see chpt. 1.1.4
`DumpPlanar`	opt.	`FALSE` (default) `TRUE`		

`ReferenceLevel`	opt.	`GRID`
		`SECTIONS`
		`WATERLVL1`
		`WATERLVL2`
		`WATERLVL3`
				must be set if
				DumpPlanar = TRUE

opt.: optional				

Table 1.3: Keywords for Nestor Action Dig_by_criterion

KEYWORD		**VALUE**	**UNIT**	**COMMENT**
ActionType		Dig_by_criterion		
TimeStart		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
TimeRepeat		real	[s]	
TimeEnd		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
FieldDig		polygon name		
DigRate		real	[m/s]	
CritDepth		real	[m]	
DigDepth		real	[m]	
MinVolume		real	[m^3]	
MinVolumeRadius		real	[m]	
ReferenceLevel		GRID SECTIONS WATERLVL1 WATERLVL2 WATERLVL3		
FieldDump	opt.	polygon name		dumping happens only if set
DumpRate	opt.	real	[m/s]	must be set if dumping
DumpPlanar	opt.	FALSE (default) TRUE		
opt.: optional				

Table 1.4: Keywords for Nestor Action Save_water_level

KEYWORD		**VALUE**	**UNIT**	**COMMENT**
ActionType		Save_water_level		
TimeStart		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
ReferenceLevel		WATERLVL1 WATERLVL2 WATERLVL3		

Table 1.5: Keywords for Nestor Action `Backfill_to_level`

KEYWORD		**VALUE**	**UNIT**	**COMMENT**
`ActionType`		`Backfill_to_level`		
`TimeStart`		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
`TimeEnd`		date-time	[$yyyy.mm.dd - hh : mm : ss$]	
`FieldDump`		polygon name		
`CritDepth`		real	[m]	

`ReferenceLevel`		`GRID`
		`SECTIONS`
		`WATERLVL1`
		`WATERLVL2`
		`WATERLVL3`		

`GrainClass`
`:`
`GrainClass`
		real
		real
		real
				the sum of all grain classes must be 1.0 see chpt. 1.1.4

`DumpRate`	opt.	real	[m/s]	if not set, backfilling ends at TimeEnd
opt.: optional				

1.2 Purpose (Dig_by_time)

Example for Nestor:
dredging and dumping of the dredged material

Details about:

- `ActionType = Dig_by_time`

1.3 Description of the problem

This example covers a test case for the dredging and dumping of recently dredged material. Hydro- and morphodynamic processes are not looked at closely.

Excerpt from the Action file `_DigActions.dat` where the Action is defined:

```
/=================================================================
ACTION
  ActionType    =  Dig_by_time
  TimeStart     = 2000.01.01-00:00:50     / [yyyy.mm.dd-hh:mm:ss]
  TimeEnd       = 2000.01.01-00:02:30     / [yyyy.mm.dd-hh:mm:ss]
  FieldDig      =  201_Abschnitt_1_2_1000m**2
  DigVolume     =  100.00                 / [ m**3 ]

  FieldDump     = 202_Abschnitt_6_7_1000m**2
  DumpRate      =  0.0005                 / [ m/s ]
  DumpPlanar    =  FALSE
ENDACTION
/=================================================================
```

100 m^3 material will be dredged in the polygon named `201_Abschnitt_1_2_1000m**2` over a time period of 100 s. The polygons are defined (chpt. 1.1.3) in the file `_DigPolys.dat`.
This dredging field is located between meter 100.5 and meter 300.5 of a flume. The area of the field is 200 x 5 = 1000 m^2. In this part of the flume only coarse material (d = 2 mm) is present (fig. 1.2). The date when the simulation starts is set in the GAIA steering file `gai_nestor1.cas` through the keywords:
`ORIGINAL DATE OF TIME = 2000;01;01`
`ORIGINAL HOUR OF TIME = 0;0;0`
The total simulation period of 250 s is computed in 1 s time steps. The simulation starts at 2000.01.01-00:00:00 and 50 s later, at 2000.01.01-00:00:50, the dredging starts. Dredging then ends 100 s later at 2000.01.01-00:02:30. This is defined in the NESTOR ACTION FILE.
Due to the dredging the bottom is lowered about 0,1 m in the dredging area. The dredging rate (calculated by Nestor) is the dredging volume devided by the dredging time and the dredging area $\frac{100m^3/s}{100s*1000m^2} =$ 0.001 m/s
At the time when dredging starts the dredged material will be dumped in the polygon named `202_Abschnitt_6_7_1000m**2`, which is located between meter 700.5 and 900.5 of the flume. The area of the dump field is 200 x 5 = 1000 m^2. At the start of the simulation, only fine material (d = 0.1 mm) is located here. Due to the dumping rate (preset to 0.0005 m/s), which is half the dredging rate, it takes 200 s to dump the material. In the end a 0.1 m thick layer of dredged material will be deposited in the dumping field.
The sediment distribution will not be changed in the dredging area but in the dumping area. There the mean grain size will be increased during the dumping of coarse material. In the dumping area the final mean grain size is about 1.3 mm (fig. 1.4) due to mixing processes of the Hirano layer model.

1.4 Physical parameters

The simulation is set up with three grain classes (d = 0.1 / 0.2 / 2.0 mm), but only the fine and the coarse material are used. The bottom is discretised with three layers. A constant active layer (10 cm), an underlying stratum (10 cm) and a last layer down to the rigid bed (9.8 m).

The Meyer-Peter Mueller transport formula is used but the `MPM COEFFICIENT` is set to zero to supress sediment transport. Consequently all bottom changes are caused by the dredging and dumping processes.

1.5 Geometry and Mesh

A 1000 m long flume with three wide sections has been chosen as the test geometry (fig. 1.1). The flume width is 10 m and increases up to 30 m in the wider sections. Two of the wide sections are 100 m long and the third is 200 m long. The initial bottom has a continuous slope of 0.09 %. The mesh consists of 18411 nodes and 34800 elements.The node area for every node is 1 m^2 in order to easily calculate and check dredging and dumping volumes.

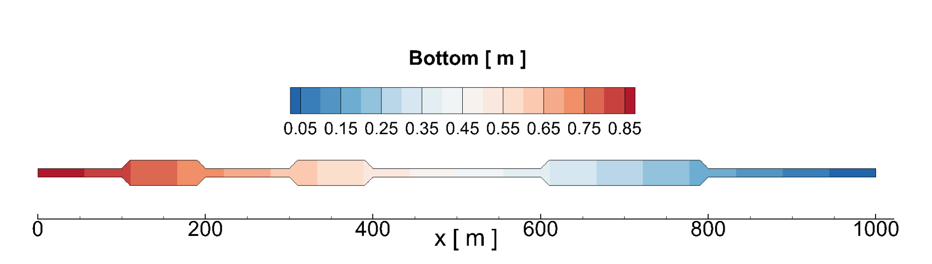


Figure 1.1: Geometry of the test flume with three wide sections

1.6 Initial and Boundary Conditions

Steady state boundary conditions:
- Discharge at the inlet = 20 m^3/s
- Water depth at outlet = 1 m
- Sedimentological equilibrium at the inlet (bottom level is constant, bedload transport will be calculated)

Initial conditions hydraulic:
- Fully developed flow from a previous simulation is used as hydraulic initial conditions.

Initial conditions sedimentological:
- The grain composition (fig. 1.2) in the left part of the fulme consists completely of the grain class 1 (d = 0.1 mm). The right part consists completely of the grain class 3 (d = 2.0 mm). Grain class 2 is not present. These are preprocessing settings which are set in the PREVIOUS SEDIMENTOLOGICAL COMPUTATION FILE.

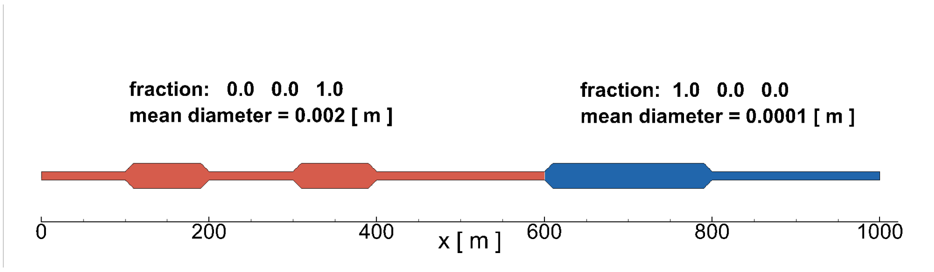


Figure 1.2: Initial mean diameter in the active layer due to the distribution of the grain classes

1.7 Results

Information about when the Action was active and what was going on, was printed (lines with "?>" at the beginning) into the telemac listing file.

Excerpt from the telemac listing with information about the Action status:

```
?> :
?> info:=========================================================+
?> info:                                                         |
?> info:            NESTOR                                       |
?>
?>         action number    :   1
?>
?>         start action     : Dig_by_time
?>  nominal start time  [s]  :    50.000000000000000
?>         start time   [s]  :    50.000000000000000
?>
?>         FieldDig         : 201_Abschnitt_1_2_1000m**2
?>     dz per time step [m]  :   1.0000000000000002E-003
?>
?>         FieldDump        : 202_Abschnitt_6_7_1000m**2
?>     dz per time step [m]  :   5.0000000000000010E-004
?>
?> info:                                                         |
?> info:=========================================================+
?> :
```

Figure 1.3 shows the bed evolution after 50 s (start of dredging and dumping), after 100 s (end of dredging) and after 250 s (final simulation state and end of dumping process).

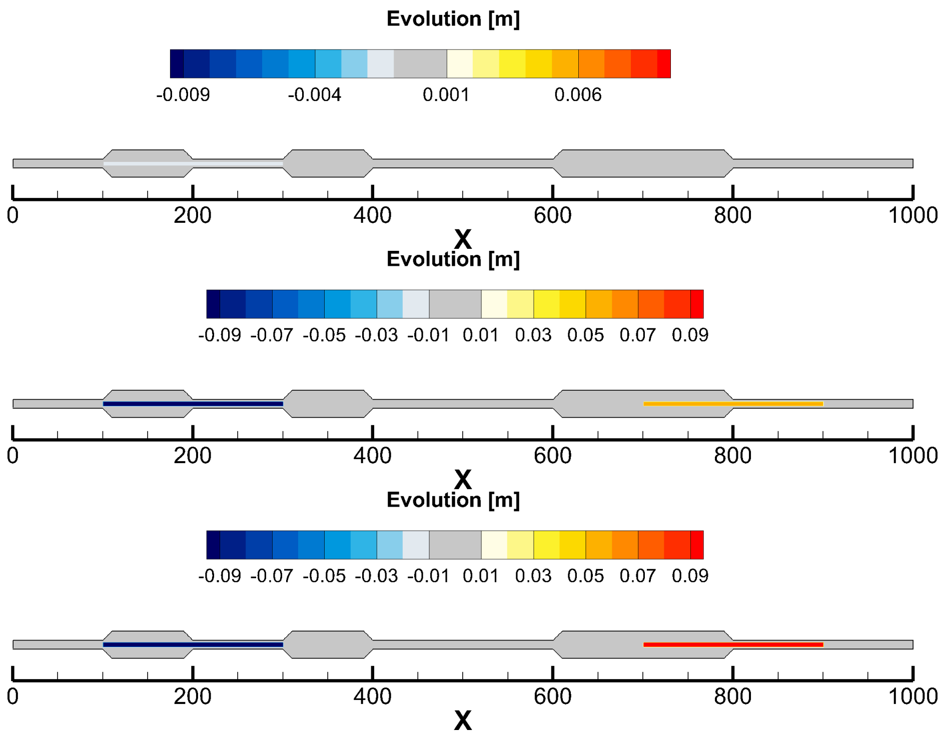


Figure 1.3: Simulated evolution after 50, 100 and 250 s.

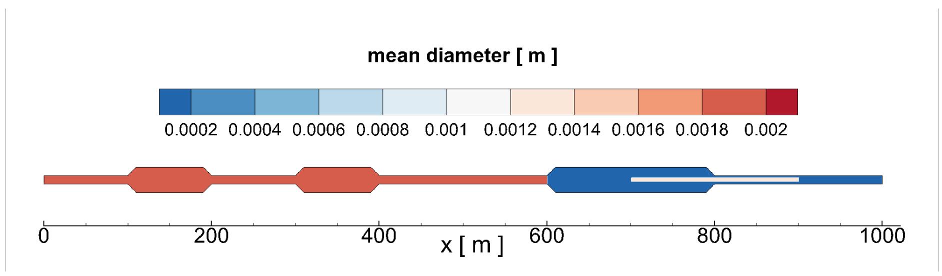


Figure 1.4: Final mean diameter in the active layer due to the distribution of the grain classes

2. Nestor2: dumping of supply material

2.1 Purpose (Dump_by_time)

Example for Nestor:
dumping of supply material

Details about:

- `ActionType = Dump_by_time`
- Convention for the supply material `GrainClass` see chpt. 1.1.4 (page 6)
- `DumpPlanar = TRUE/FALSE` for more details see chpt. 4.2.2 (page 34)
- `ReferenceLevel = SECTIONS` for more details see chpt. 4.2.3 (page 37)

2.2 Description of the problem

This example performs two actions of dumping supply material. One is running with the dumping mode `DumpPlanar = FALSE`. The other is running with `DumpPlanar = TRUE`. Two dumping areas are defined by polygons which are defined in file `_DigPolys.dat`. Both are located in the larger wide section between meter 615,5 and 766,5 (fig. 2.1). The area of each polygon is 1173 m^2 and covers a hollow in the bottom. The deepest points in the hollows are 3 m below the plane bottom (fig. 2.3).

2.2.1 Action-1: Dump with DumpPlanar = FALSE

Excerpt from the action file where Action-1 is defined:

```
    :
 /=================================================================
 ACTION
    ActionType   =   Dump_by_time

    TimeStart    =  2000.01.01-00:00:02    / [yyyy.mm.dd-hh:mm:ss]
    TimeEnd      =  2000.01.01-00:02:02    / [yyyy.mm.dd-hh:mm:ss]

    FieldDump    =   401_hollow1_1173m**2
    DumpPlanar   =   FALSE

    DumpVolume   =  586.50                 / [ m**3 ]
    GrainClass   =    0.2
    GrainClass   =    0.1
    GrainClass   =    0.0
    GrainClass   =    0.7
 ENDACTION
 /=================================================================
    :
```

Over a time period of 120 s 586.5 m^3 supply material will be dumped in the polygon named `401_hollow1_1173m**2` . Due to the setting `DumpPlanar = FALSE` all the nodes in the area will elevate about the same value (fig. 4.4); In this case about 0.5 m. The composition of the supply material is defined through the multiple use of the keyword `GrainClass` (convention for supply material: chpt. 1.1.4 / page 6).
Here the supply material is composed of the two finest and the most coarse fraction of the bed sediment. Because the 3rd grain class is not part of the supply material it is set to 0.

2.2.2 Action-2: Dump with DumpPlanar = TRUE

Excerpt from the action file where Action-2 is defined:

```
   :
/===================================================================
ACTION
   ActionType       =   Dump_by_time

   TimeStart        = 2000.01.01-00:00:02  / [yyyy.mm.dd-hh:mm:ss]
   TimeEnd          = 2000.01.01-00:02:02  / [yyyy.mm.dd-hh:mm:ss]

   FieldDump        =  402_hollow1_1173m**2
   DumpPlanar       =  TRUE
   ReferenceLevel   =  SECTIONS

   DumpVolume       = 586.50                 / [ m**3 ]
   GrainClass       =   0.2
   GrainClass       =   0.1
   GrainClass       =   0.0
   GrainClass       =   0.7
ENDACTION
/===================================================================
   :
```

Action-2: Most of the settings are the same as in Action-1 except the settings:

```
DumpPlanar     = TRUE
ReferenceLevel = SECTIONS
FieldDump      = 402_hollow1_1173m**2
```

As in Action-1 586.5 m^3 supply material will be dumped over a time period of 120 s but here in the polygon named `402_hollow2_1173m**2`. While `DumpPlanar = TRUE` the hollow will be filled up, starting from the deepest points in the area until the entire supply material is used (fig. 4.3). Thus not all nodes of the dumping field will be changed. At the end of the dumping the plain spanned through the changed nodes is parallel to the plain which is defined in the reference level file `_DigRefLevel.dat`. For more details about reference levels see chapter 10.
Due to the mixing processes of the Hirano layer model, in both actions all nodes which changed the bottom elevation, will have a modified sediment distribution.

2.2.3 Physical parameters

The total simulation period is 150 s with a time step of 1 s.
The simulation is set up with four grain classes. The bottom is discretised in three layers. A constant active layer (0.1 m), an underlying stratum (0.1 m) and a third layer which goes down to the rigid bed (9.8 m).
The Meyer-Peter Mueller (MPM) transport formula is used but the `MPM COEFFICIENT` is set to zero to stop sediment transport. Thus all bottom changes are a result of the two dumping processes.

2.2.4 Geometry and Mesh

A 1000 m long flume with three wider sections has been chosen as test geometry (fig. 2.1). The width of the flume is 10 m and increases up to 30 m in the wide sections. The first two wide sections parts are 100 m long and the third is 200 m long. The initial bottom has a continuous slope of 0.09 % with two hollows in the third wide section. The node area for every node is 1 m^2 in order to calculate and check dredging and dumping volumes easily.
The mesh consists of 18411 nodes and 34800 elements.

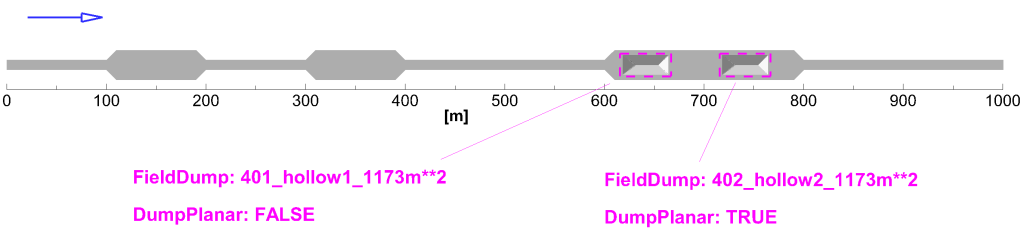


Figure 2.1: Geometry of the test flume with three wide sections, the two hollows and the two polygons

2.2.5 Initial and Boundary Conditions

Steady state boundary conditions:
- Discharge at the inlet = 20 m^3/s
- Water depth at outlet = 1 m
- Sedimentological equilibrium at the inlet (bottom level is constant, bedload transport will be calculated)

Initial hydraulic conditions:
- Fully developed flow from a previous simulation is used as initial hydraulic condition.

Initial morphological conditions:
- The computation starts with a ground composition which is set in the (GAIA STEERING FILE and in the Fotran file `user_bed_init.f`.)

2.3 Results

Figure 2.2 shows the evolution after 0s, 70s and 150s. The dumping process finished at 122s.

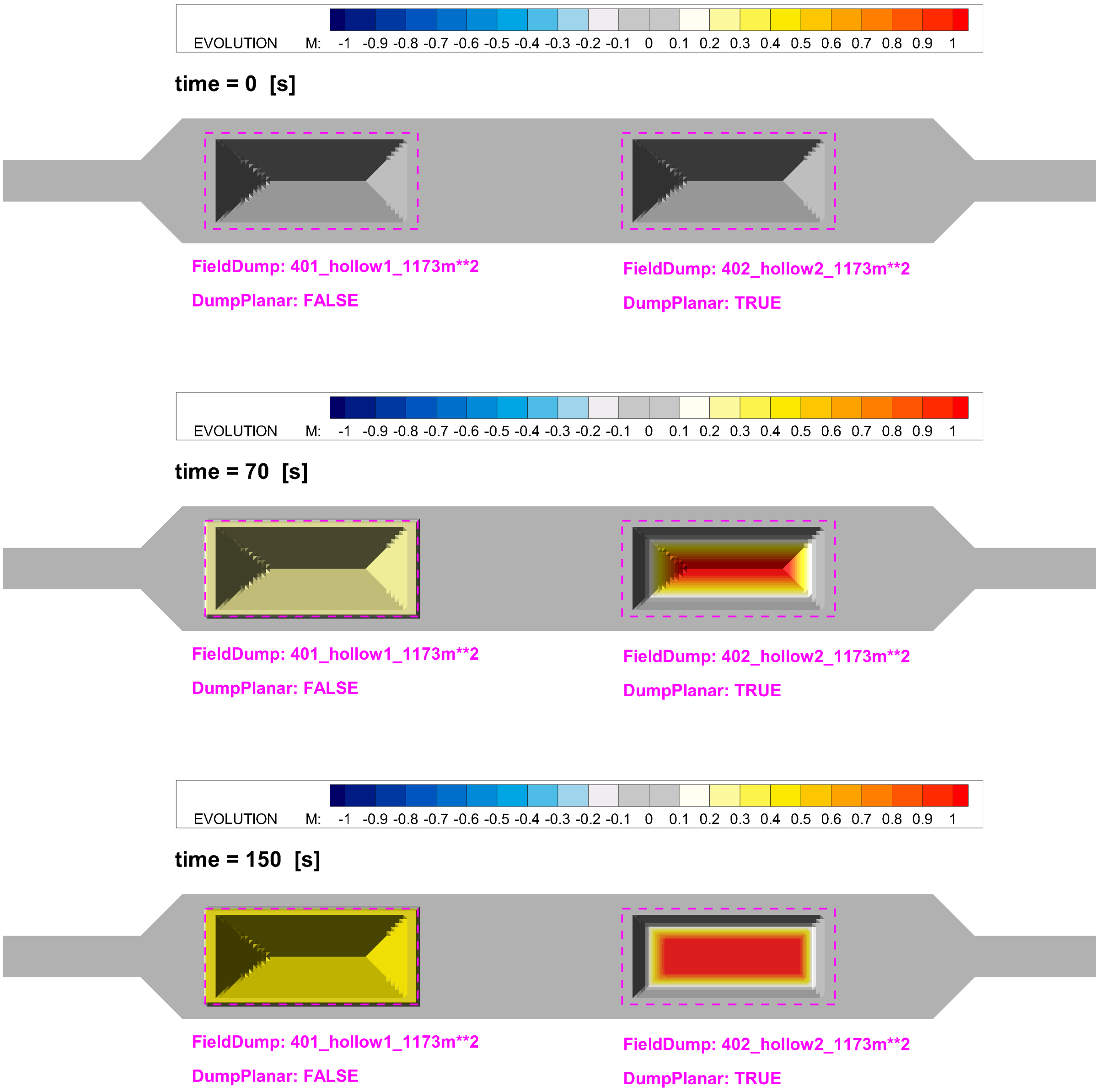


Figure 2.2: Simulated evolution after 0 s, 70 s and 150 s.

Figure 2.3 shows the evolution after 0 s and 150 s as 3D view.

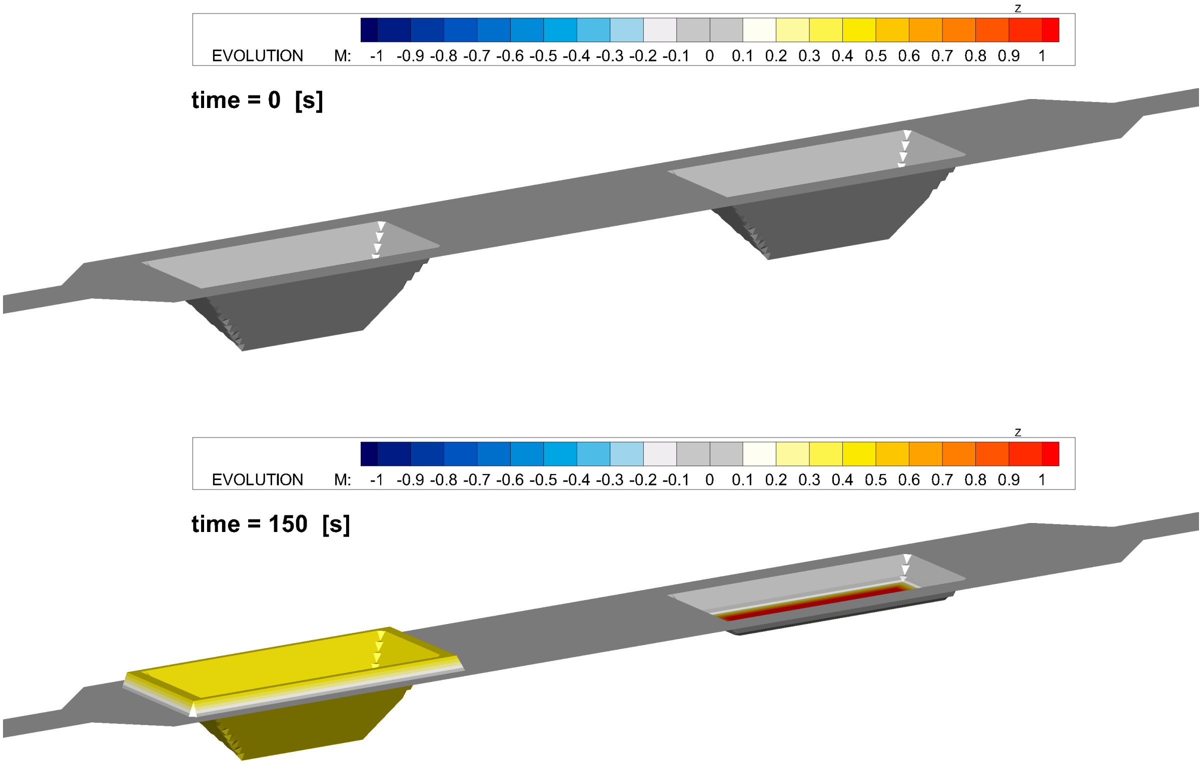


Figure 2.3: Simulated evolution after 0 s and 150 s.

3. Nestor3: maintain a fairway

3.1 Purpose (Dig_by_criterion)

Example for Nestor:
dredging in case a depth criterion is violated and dumping of the dredged material.

Details about:

- `ActionType = Dig_by_criterion`

3.2 Description of the problem

This example performs the automated maintenance of a fairway to predict the expected dredging demand.
At regular time intervals (`TimeRepeat`) (fig. 3.1) Nestor tests within the fairway polygon for each node if the depth criterion (`CritDepth`) is violated. In case of violation the node will be dredged step-by-step with a specified rate (`DigRate`) to a specified depth (`DigDepth`) and the dredged volume will be recorded in the listing file.

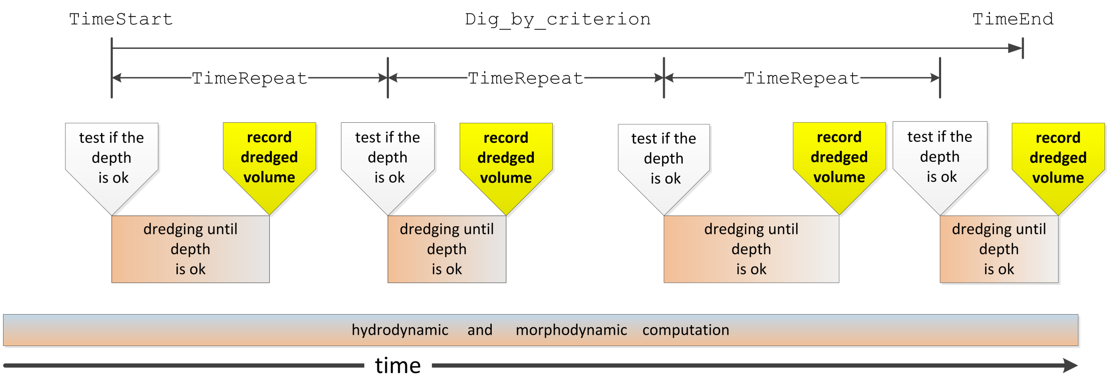


Figure 3.1: General operating schedule for dredging by criterion

The node depth is defined as elevation of the reference level minus elevation of the node (fig. 3.2).

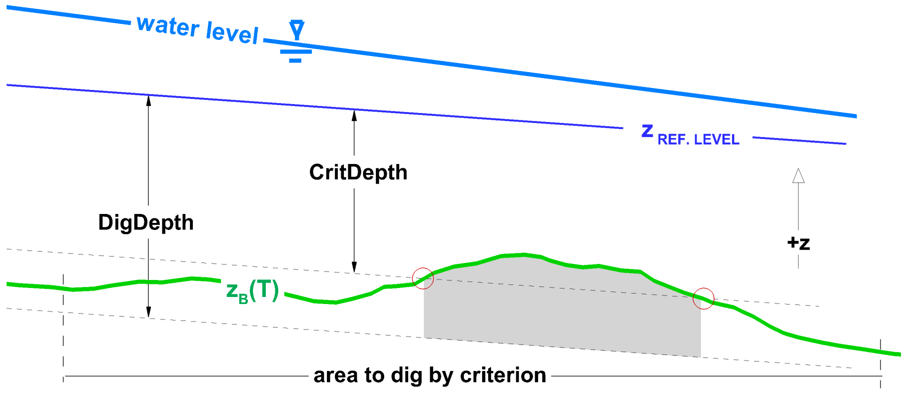


Figure 3.2: Schematic diagram of dredging by criterion

Excerpt from the action file where the Action is defined:

```
/================================================================
ACTION
  ActionType       =  Dig_by_criterion
  FieldDig         =  100_Fairway
  ReferenceLevel   =  SECTIONS
  TimeStart        =  2000.01.01-23:00:00  / [yyyy.mm.dd-hh:mm:ss]
  TimeRepeat       =  860000.0             / [ s ] 10 days
  TimeEnd          =  2000.01.12-23:59:59  / [yyyy.mm.dd-hh:mm:ss]
  DigRate          =   0.001               / [ m/s ]
  DigDepth         =  10.00                / [ m ]
  CritDepth        =  10.00                / [ m ]
  MinVolume        =   0.0                 / [ m^3 ]
  MinVolumeRadius  =   3.5                 / [ m ]

  FieldDump        =  200_DumpArea
  DumpRate         =   0.001               / [ m/s ]
  DumpPlanar       =  FALSE
ENDACTION
/================================================================
```

The reference level is defined by 17 sections (see black lines in fig. 3.3) which are defined in file `_DigRefLev.dat`. Because `FieldDump` is used, the dredged material is transferred (dumped) to the dumping area. The fairway and the dumping area (fig. 3.3) are defined by polygons which are defined in file `_DigPolys.dat`.

About `MinVolume` and `MinVolumeRadius` : In reality, it may still be acceptable for the fairway to have small shallows. Normally dredging will not be induced until the shallow becomes as serious problem or has grown to such a volume where it is worthwhile to call the dredge. To mirror this approach there are two keywords used to determine if Judge Dredd needs to pay a visit. In case a node (e.g. node-A) violates the depht criterion, Nestor adds up the derdge volume of the nodes in the neighborhood. If the sum exceeds the value of `MinVolume` node-A will be dredged. The size of the neighborhood is sepcified by the keyword `MinVolumeRadius` .

3.2.1 Physical parameters

The simulation is set up with 1 grain class. The rigid bed is 3.0 m below the initial (flat) bottom. The Meyer-Peter Mueller (MPM) transport formula is used with default settings. Thus all bottom changes are a result of sediment transport processes and fairway maintenance (dredging and dumping).

3.2.2 Geometry and Mesh

A 3.3 km long flume with two 180° bends has been chosen as test geometry. The width of the flume is 200 m (fig. 3.3).
The mesh consists of 1614 nodes and 2948 elements.

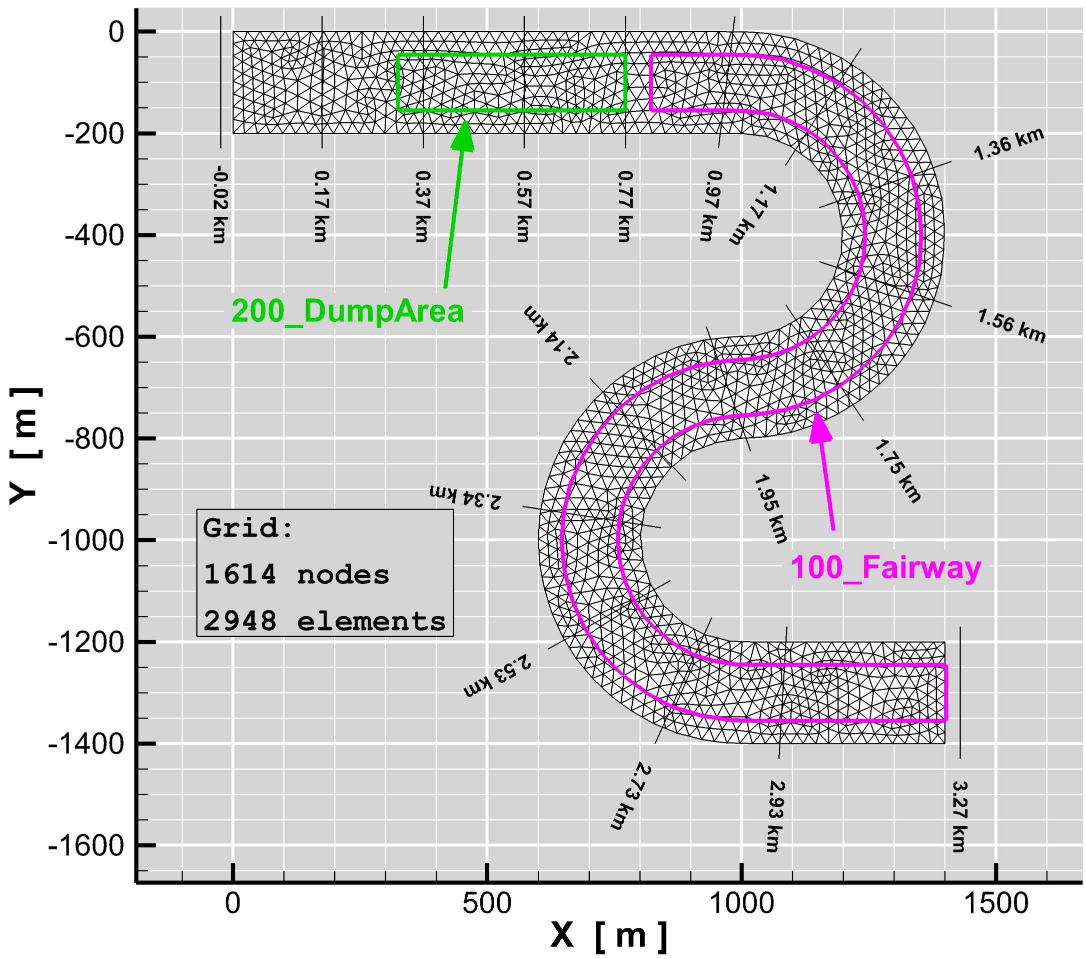


Figure 3.3: Geometry of the test flume with two bends and two polygons (fairway, dump area) and sections to define the reference level

3.2.3 Initial and Boundary Conditions

Steady state boundary conditions:
- Discharge at the inlet = 1000 m^3/s
- Water level at the outlet = 2.2 m
- Sedimentological equilibrium at the inlet (zF is constant, QS is calculated)

Initial hydraulic conditions:
- Fully developed flow from a previous simulation is used as initial hydraulic condition.

Initial morphological conditions:
- The bottom shape and
- the ground composition is resumed from a previous simulation.

The simulation period is 1200000.0 s (13.88 days) with a time step of 4 s.

3.3 Results

To find some information about when the action was active and what was going on, search in the telemac listing file for lines with "?>" at the beginning.

Excerpt from the telemac listing with information about the action status:

```
:
?> info:========================================================+
?> info:                                                        |
?> info:            NESTOR                                      |
?>
?>                   :
?>                   :
?> info:========================================================+
:
```

When a node reaches the target depth a line with information about:
- the volume of dredged material
- location of the node
- time when the dredging did start and ended

will be written to the listing file. These lines are marked with the label `XdigX` .
(see chpt. 1.1.5.1 / page 8)

Figure 3.4 shows the bottom evolution after 0 h and 1 h. The evolution after 0 d is from a previous computation file. The evolution after 1 d is driven by the first maintenance of the fairway and sediment transport. The digging and dumping were executed between 0 d and 1 d. The fairway was dredged to the `DigDepth` and the dredged material was dumped to the dumping area defined by the polygon `200_DumpArea`.
Figure 3.5 and 3.6 shows the bottom evolution due to sediment transport processes after 3 d, 7 d and 10 d. No digging and dumping actions were defined in this time period. Between 10 d and 11 d the second maintenance was executed. Again the fairway was dredged to the `DigDepth` and the dredged material was dumped to the dumping area, which leaded again to a higher bottom evolution.
Figure 3.7 shows the bottom evolution 12 d and 13.5 d due to sediment transport processes after the second maintenance of the fairway.

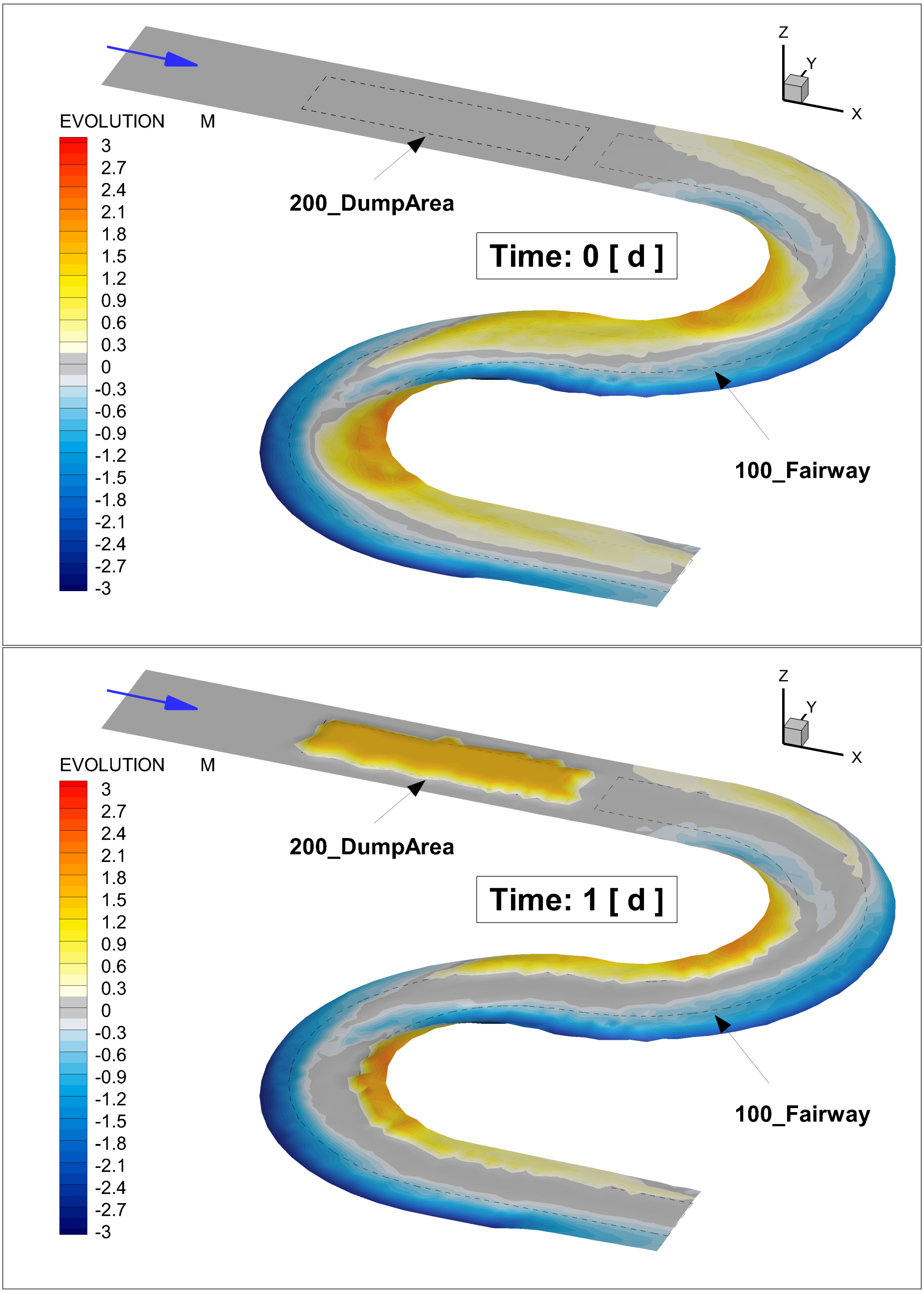


Figure 3.4: Simulated evolution over the time.

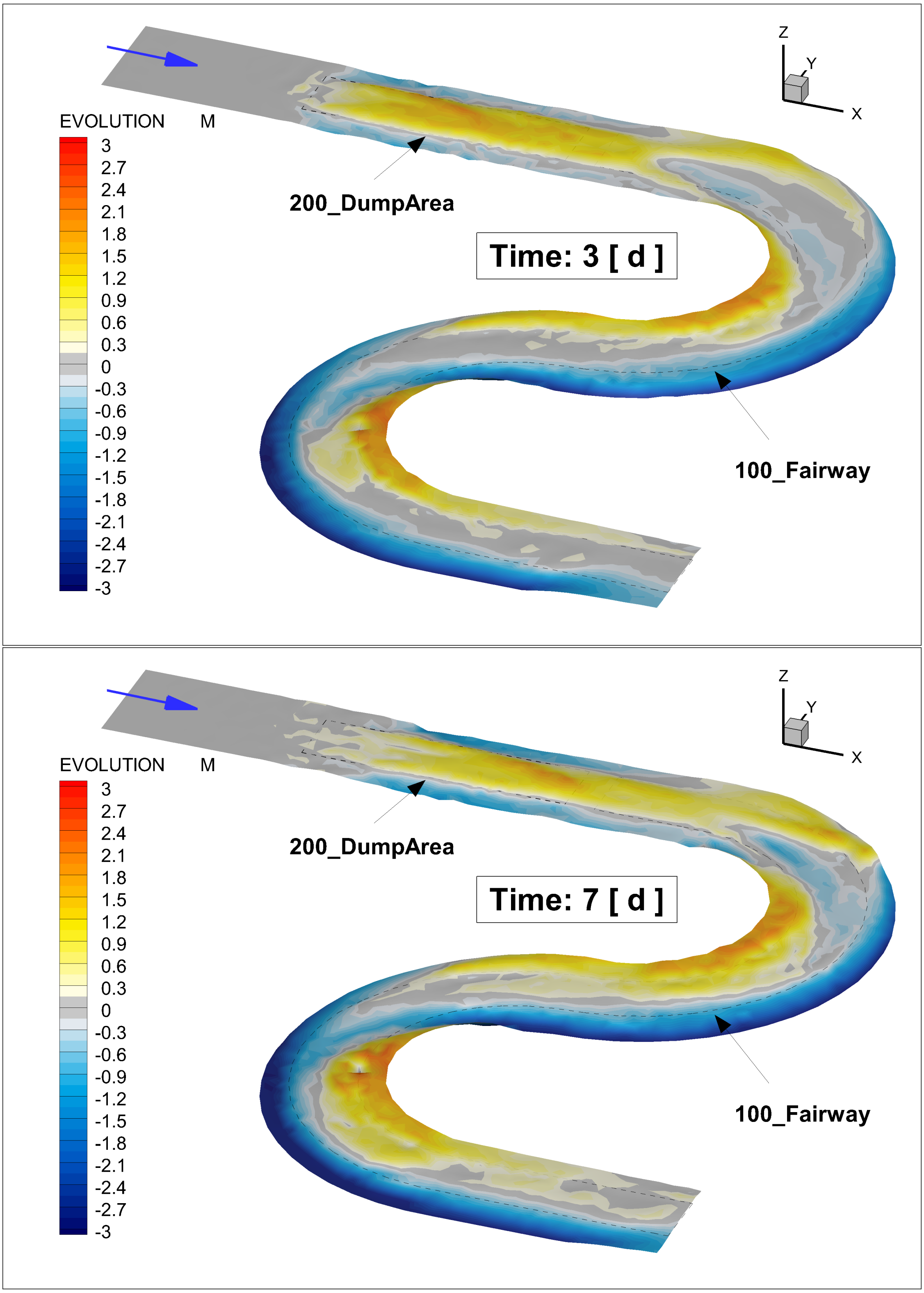


Figure 3.5: Simulated evolution over the time.

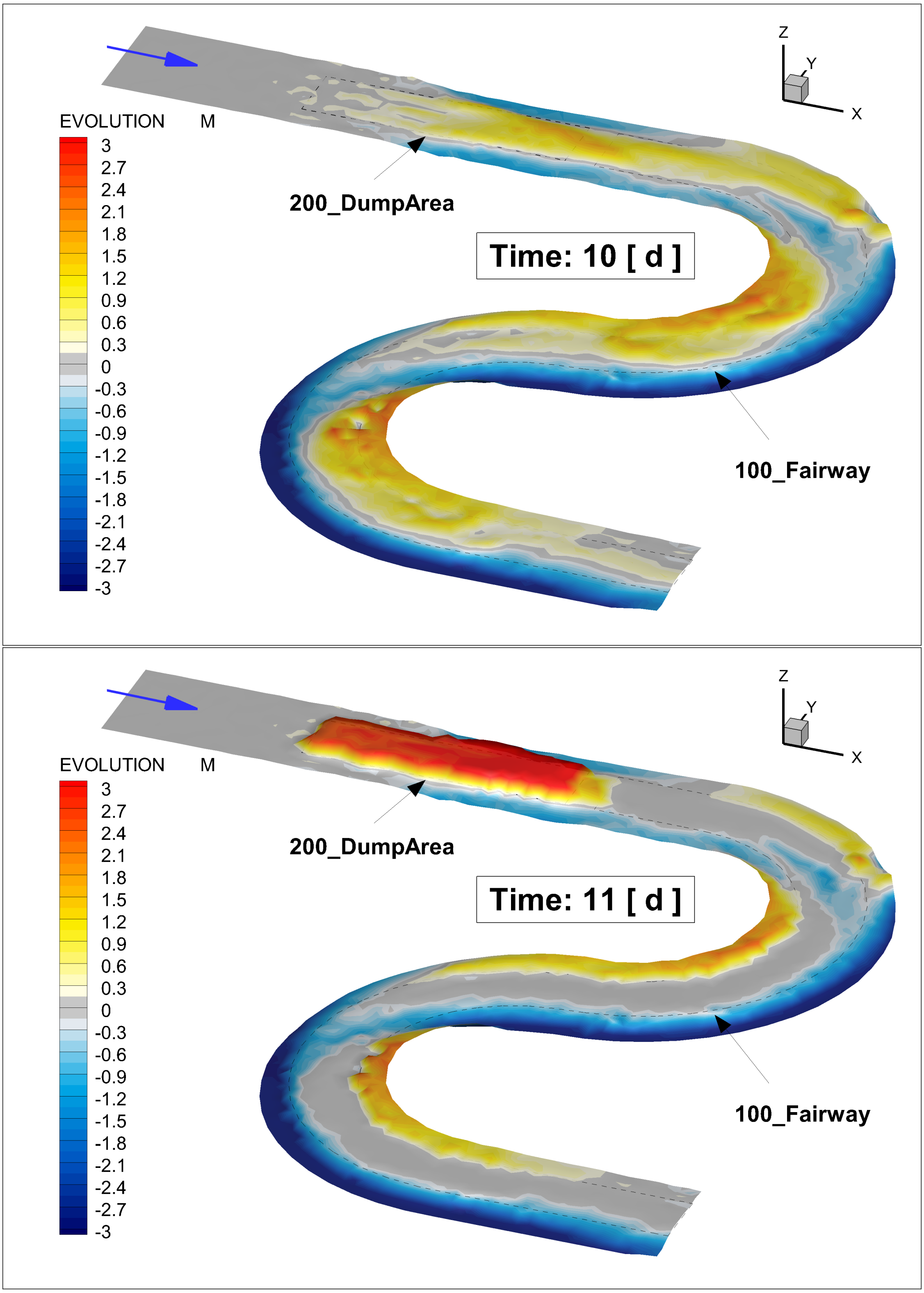


Figure 3.6: Simulated evolution over the time.

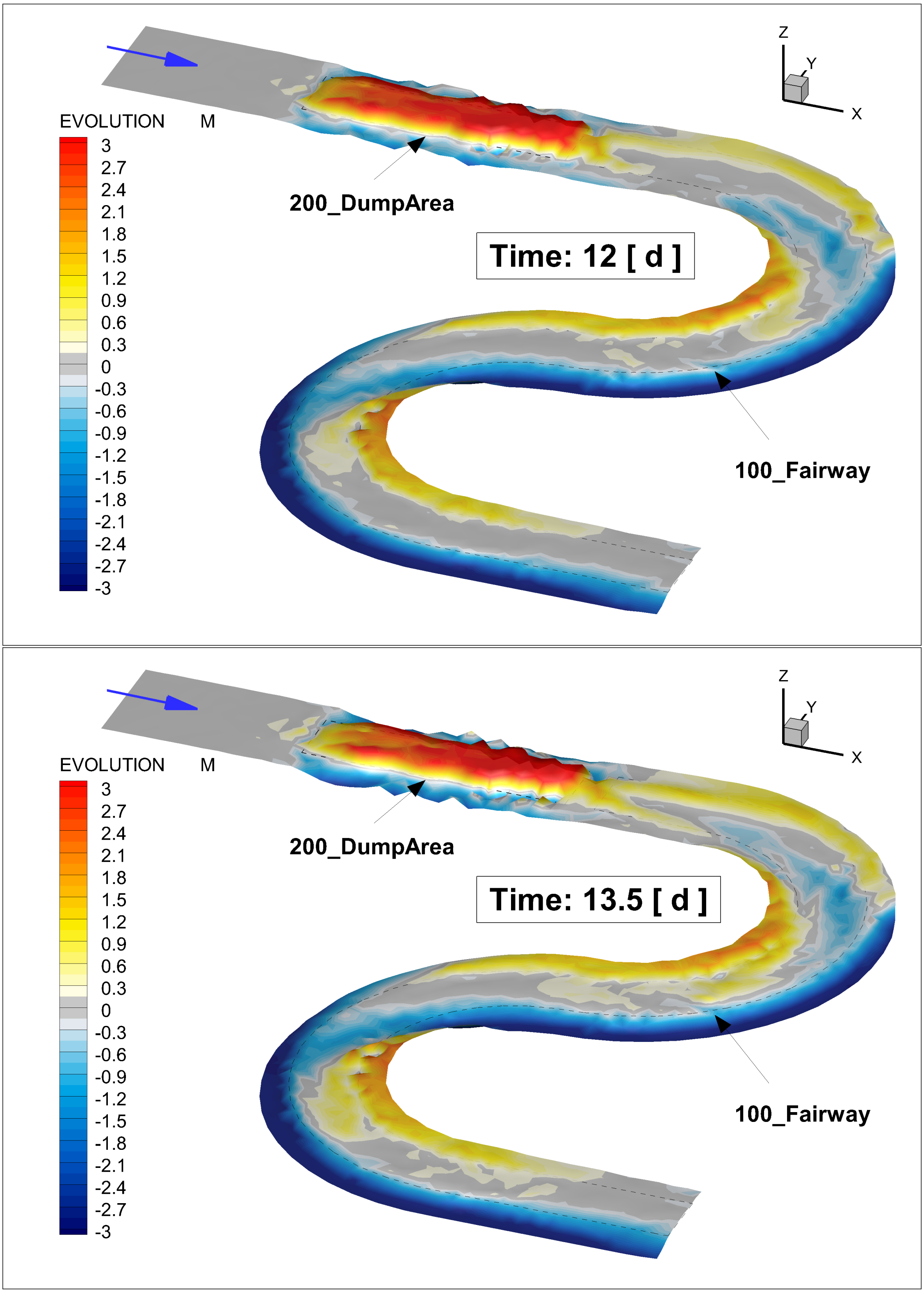


Figure 3.7: Simulated evolution over the time.

4. Nestor4: telemac2d, various types of reference levels

4.1 Purpose (Dig_by_time, Backfill_to_level. Save_water_level)

Example for Nestor:
different types of reference levels and Nestor coupled with telemac2d

Details about:

- coupling Nestor with telemac2d
- Order of execution in case of multiple actions
- dredging and dumping of the previously dredged material (`Dig_by_time`)
  - whereby the dumping is controlled by
    - a period of time (T_{start} - T_{end})
    - a user defined dump rate (dz/dt)
  - dumping below different types of reference levels
- saving a water level at a certain time to use it later as reference level (`Save_water_level`)
- locally raising the bottom to a defined (arbitrary) shape (`Backfill_to_level`)

4.2 Description of the problem

This example is a synthetic test case to demonstrate the above-mentioned tasks. It's a flat rectangle area (z=0 m) with four quadratic rising grounds (z=1 m) and four cone-shaped depressions (deepest point = -5 m) (fig. 4.1). Nestor is coupled directly with telemac2d

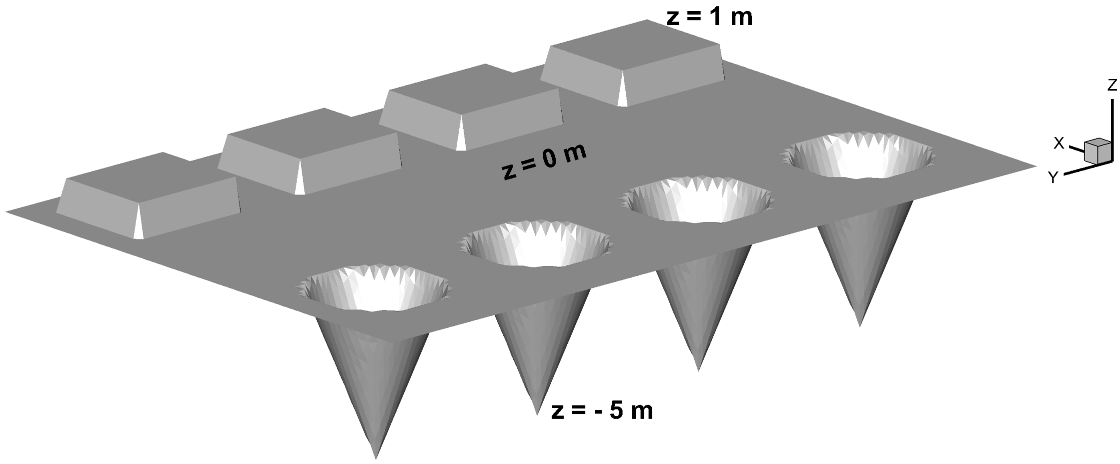


Figure 4.1: Initial bottom geometry (vertical exaggeration 5x)

To run Nestor with telemac2d in the steering file (`t2d_nestor4.cas`) settings for the Nestor related keywords are be done as shown below:

```
NESTOR                         = YES
NESTOR ACTION FILE             = _DigActions.dat
NESTOR POLYGON FILE            = _DigPolys.dat
NESTOR SURFACE REFERENCE FILE = _DigRefLevel.dat
ORIGINAL DATE OF TIME          = 2000;01;01    / year, month,  day
ORIGINAL HOUR OF TIME          = 0;0;0         / hours,minutes,seconds
```

The example shows four dredge actions (`Dig_by_time`) in which the mounds will be dredged away (more or less) and the dredged material will be dumped in different ways into the depressions. Additionally it shows how Nestor can be used to change the bottom to an arbitray shape (`Backfill_to_level`). The actions are defined in the action file (Nestor steering file) `_DigActions.dat`. The areas where the dredging and dumping will be done are defined by polygons (fig. 4.6) which are stored in the file `_DigPolys.dat`.
In case of `DumpPlanar = TRUE` a reference level is used for the dumping.

4.2.0.1 Settings due to performance issues when run the example

Because the examples are used to run in an automated test suite, same parameter settings are done to obtain slim output files. To obtain a result file which matches (by time) the images fig. 4.7, 4.8 to 4.11, change the settings in the telemac steering file as follows and run the example again.
`GRAPHIC PRINTOUT PERIOD = 3, LISTING PRINTOUT PERIOD = 1`

4.2.1 Multiple actions and order of execution

If multiple actions are defined the internal numbering of the actions follows the order of appearance in the action file.

Order of execution in case there are multiple actions defined:

- On the first level, the order of execution depends on the timeline.
- On the second level, if several actions are active at the same time or start at the same time, the numbering of the actions is significant to the order of execution during one time step.

During the first telemac (or gaia) time step, after Nestor finished the initialisation step, the file `NestorGraphic_data.dat` will be written in the work directory.
Executing `NestorGraphic_show.py` will show a timetable of the actions (fig. 4.2) to evaluate the content of the action file

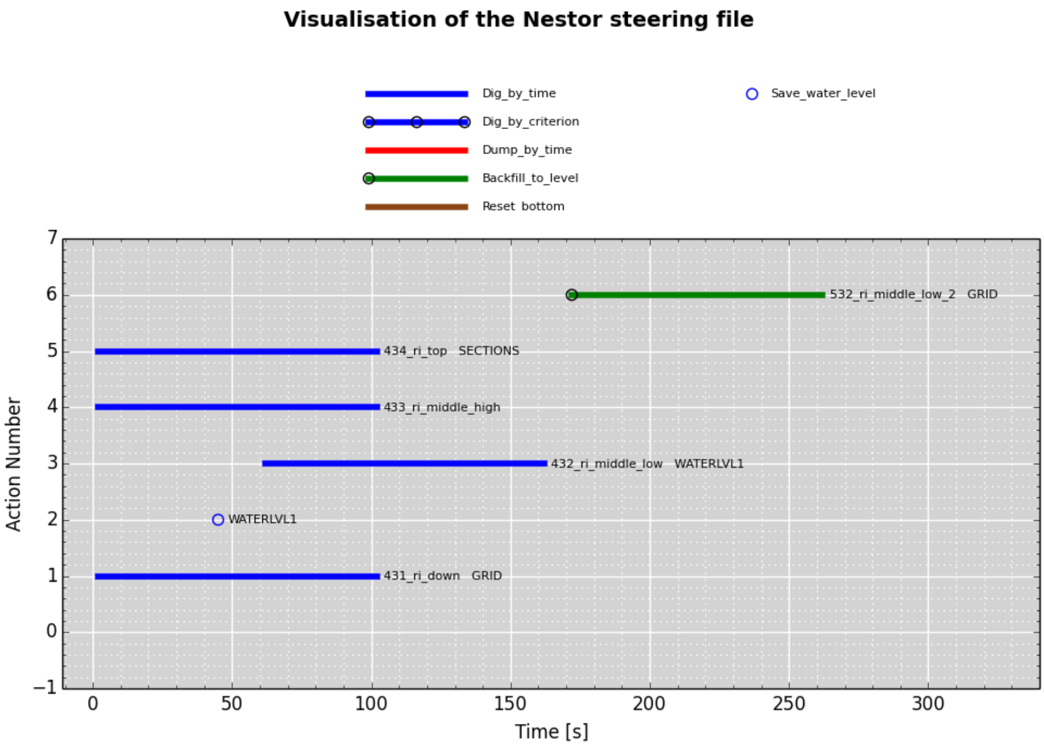


Figure 4.2: Timetable of the actions.

4.2.2 DumpPlanar details

Meaning of `DumpPlanar = TRUE`: The volume will be dumped only into the lowest areas of the dump field. As a result all the nodes which were involved will eventually have the same vertical distance to the reference surface. In other words, after dumping the bottom locally has the shape as the reference level (fig. 4.3). The value of the distance will be calculated by Nestor due to the volume which is to dump. If `DumpPlanar` = `TRUE` a reference level must be defined. It's also possible to define a curved surface as reference level.

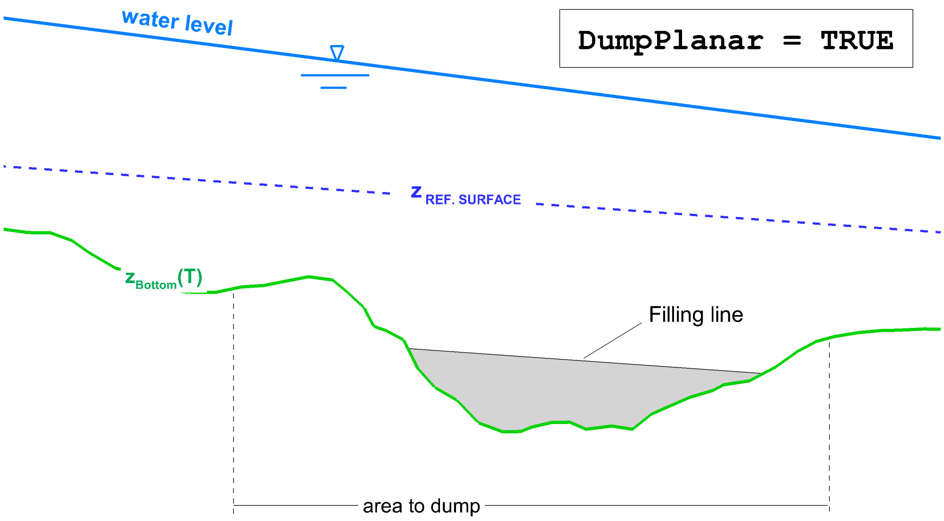


Figure 4.3: Sheme how the bottom changes when the dump attribut `DumpPlanar` = `TRUE` is set.

Meaning of `DumpPlanar = FALSE` : A reference level is not used. Every node of the dump field will be raised about the same amount ($dz_{\text{per node}}$ = const). In other words, through the consistant dumping all over the entire field a layer of constant thickness was added to the Bottom.(fig. 4.4)

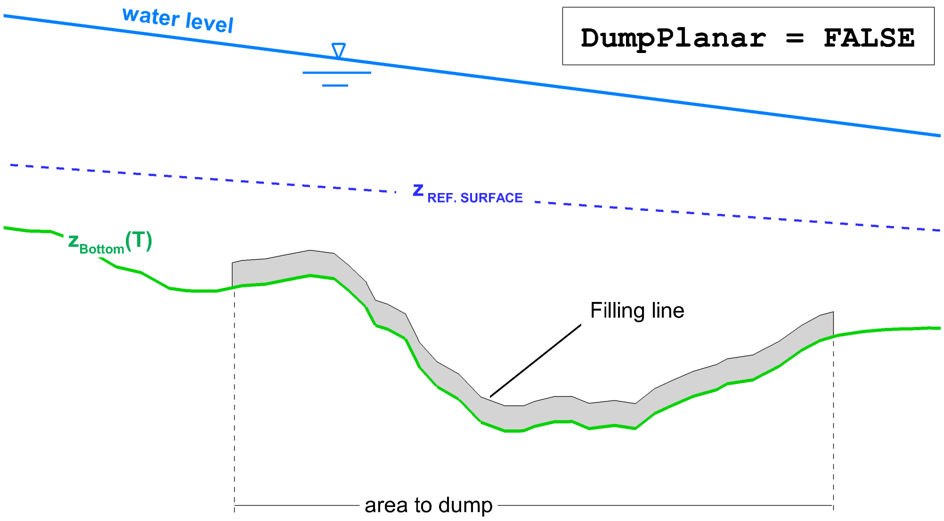


Figure 4.4: Sheme how the bottom changes when the dump attribut `DumpPlanar = FALSE` is set.

4.2.3 Various kinds of Reference levels

There are three ways to define a reference level. The specification is done in the action file.

Conventions about the usage of a reference level:

- A value for ReferenceLevel must be set only if DumpPlanar = TRUE or Dig_by_criterion or Backfill_to_level is used.
- The pre-defined values for keyword ReferenceLevel are: GRID ; SECTIONS ; WATERLVL1 ; WATERLVL2 ; WATERLVL3

- ReferenceLevel = SECTIONS: define a surface by using sections (fig. 4.5 and 4.6) which are stored in the file _DigRefLev.dat (see page 38)

- ReferenceLevel = GRID: use the variable REFERENCE LEVEL in the GEOMETRY FILE or PREVIOUS COMPUTATION FILE to specify a surface which is used as reference level (see grey surface in fig. 4.5). (If coupled with gaia use PREVIOUS SEDIMENTOLOGICAL COMPUTATION FILE.)

- ReferenceLevel = WATERLVL1: use a water level as reference level.
  The water level must be saved sometime before, before it can be used as reference level. Executing the action Save_water_level will save thels water level which was computed in the last time step. It's possible to use three different water levels at the same time. To address them use WATERLVL1,WATERLVL2,WATERLVL3

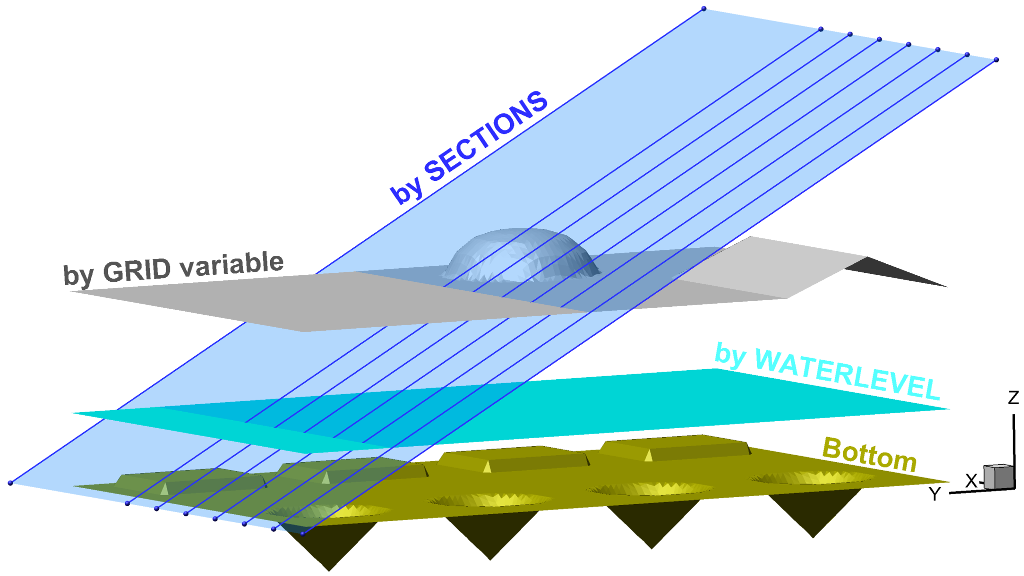


Figure 4.5: Initial bottom geometry, various reference levels defined through sections, through a waterlevel and through a grid variable (vertical exaggeration 2x)

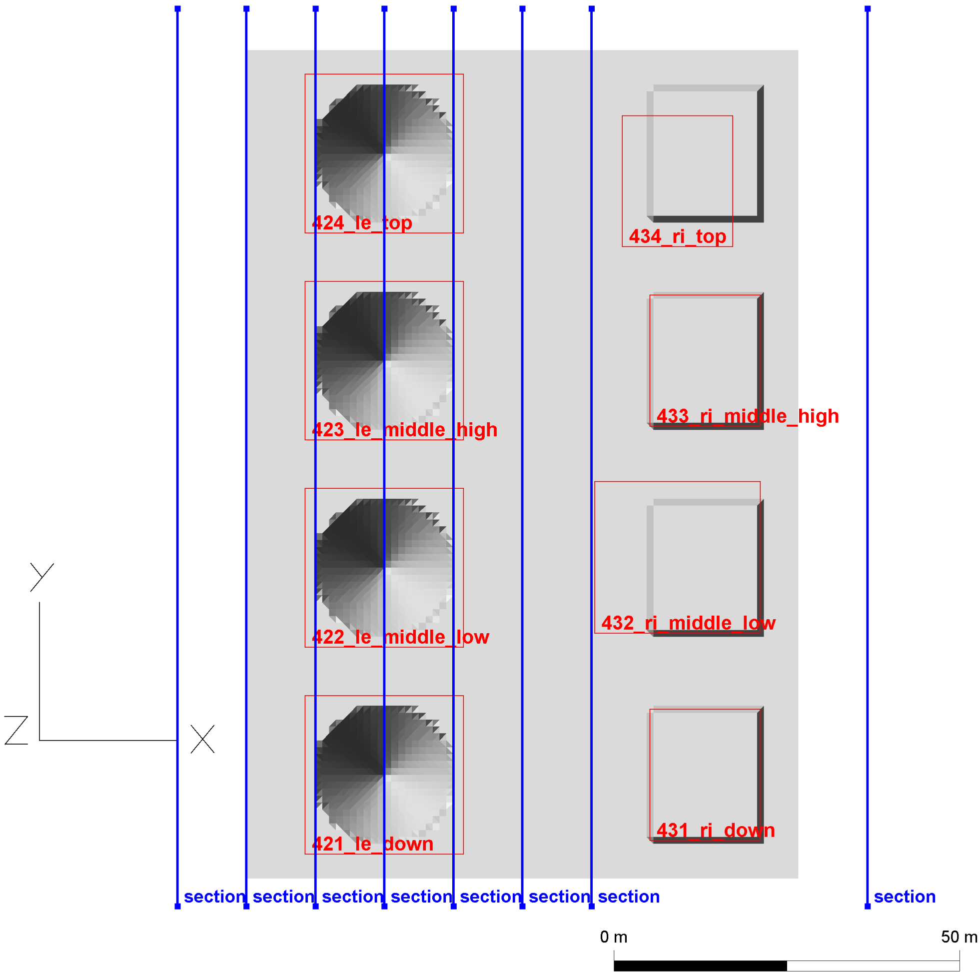


Figure 4.6: Initial bottom geometry, polygons to define the dredging and dumping fields and sections to define a reference level

Excerpt of the reference level file `_DigRefLev.dat`:

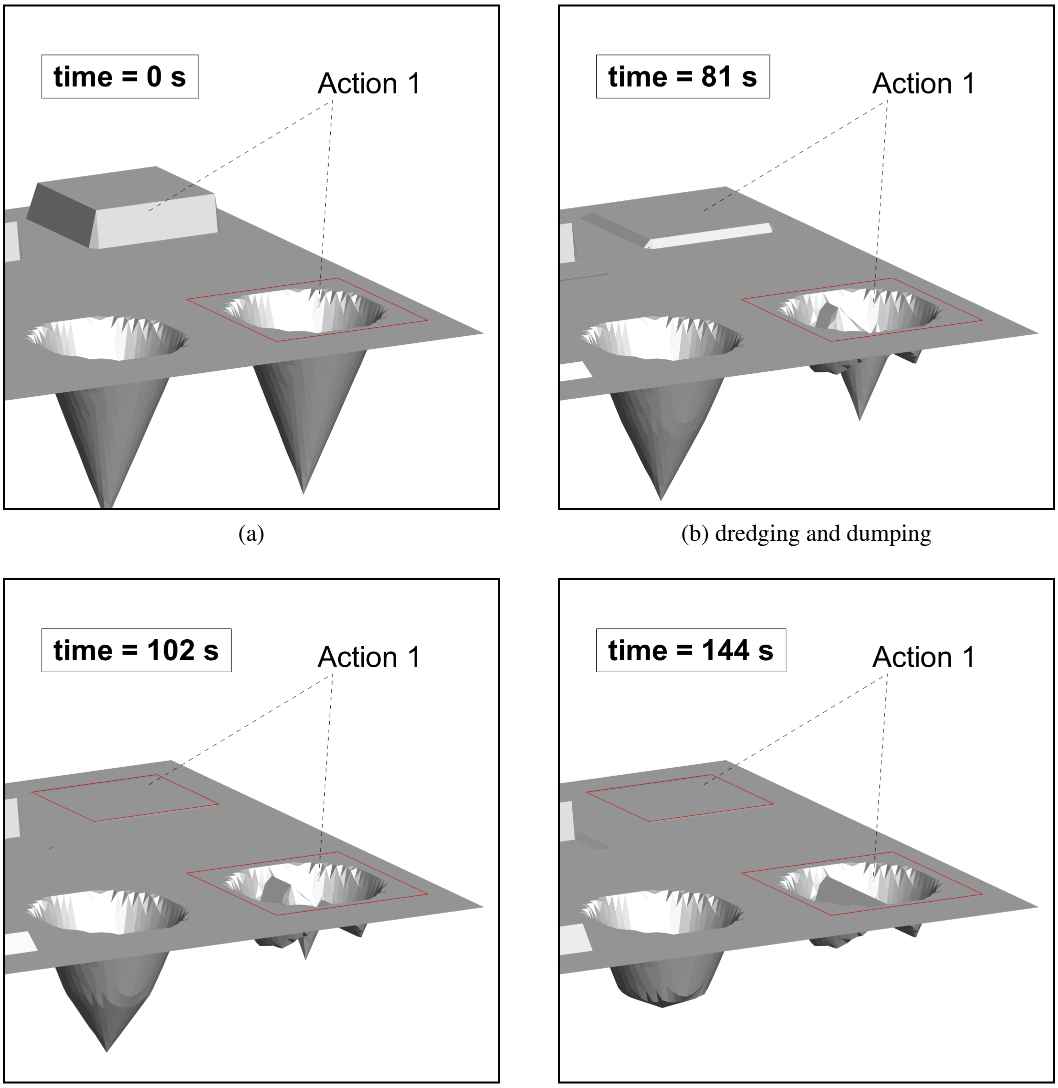
```
# comment line
#    xL      yL     zL        xR     yR     zR       flow length
   100.0    116.0  0.00      100.0  79.0  10.00        0.100
   110.0    116.0  0.00      110.0  79.0  10.00        0.110
    ....
   150.0    116.0  0.00      150.0  79.0  10.00        0.150
   160.0    116.0  0.00      160.0  79.0  10.00        0.160
END
```

4.2.4 Action-1: ActionType = Dig_by_time , ReferenceLevel = GRID

Action-1 : `ActionType = Dig_by_time:` In the flield `431_ri_down` a volume of 300 m^3 will be dredged during a time slot of 100 s. The time slot begins at simulation time 00:00:02 (hh:mm:ss). As a result every node in the field will be lowered by 0.987 m (fig. 4.7c). Simultaneously the dredged material will be dumped into the lower areas of the field `421_le_down`. If there would be no setting for `FieldDump` the dredged volume would not be dumped. Because of the setting `DumpRate=0.045`, the pacing of dumping is limited and takes 140 s to dump all of the dredged volume (fig. 4.7d). Consequently Nestor is still dumping even though the dredging is finished.
Because of the setting `DumpPlanar=TRUE` and `ReferenceLevel=GRID` the surface which is available in the GEOMETRY FILE is used as reference level. The bottom where the dumping happened is shaped like a roof referring to the shape of the reference level above the dump field (grey surface in fig. 4.5).

Excerpt from the action file where the Action-1 is defined:

```
/=================================================================
ACTION
  ActionType      = Dig_by_time
  ReferenceLevel  =  GRID
  TimeStart       =  2000.01.01-00:00:02  / [yyyy.mm.dd-hh:mm:ss]
  TimeEnd         =  2000.01.01-00:01:42  / [yyyy.mm.dd-hh:mm:ss]

  FieldDig        =  431_ri_down
  DigVolume       =  300.0                / [m^3]

  FieldDump       =  421_le_down
  DumpPlanar      =  TRUE
  DumpRate        =  0.045                / [m/s]
ENDACTION
/=================================================================
```



(a)

(b) dredging and dumping

(c) dredging just finished, still dumping

(d) dumping finished

Figure 4.7: Changes of the bottom while executing Action-1

4.2.5 Action-2: ActionType = Save_water_level , ReferenceLevel = WATERLVL1

Action-2 : `ActionType = Save_water_level` At simulation time 00:00:45 the water level which was calculated at the last time step will be stored to be used later as reference level. It is assigned to `WATERLVL1`.

Excerpt from the action file where the Action-2 is defined:

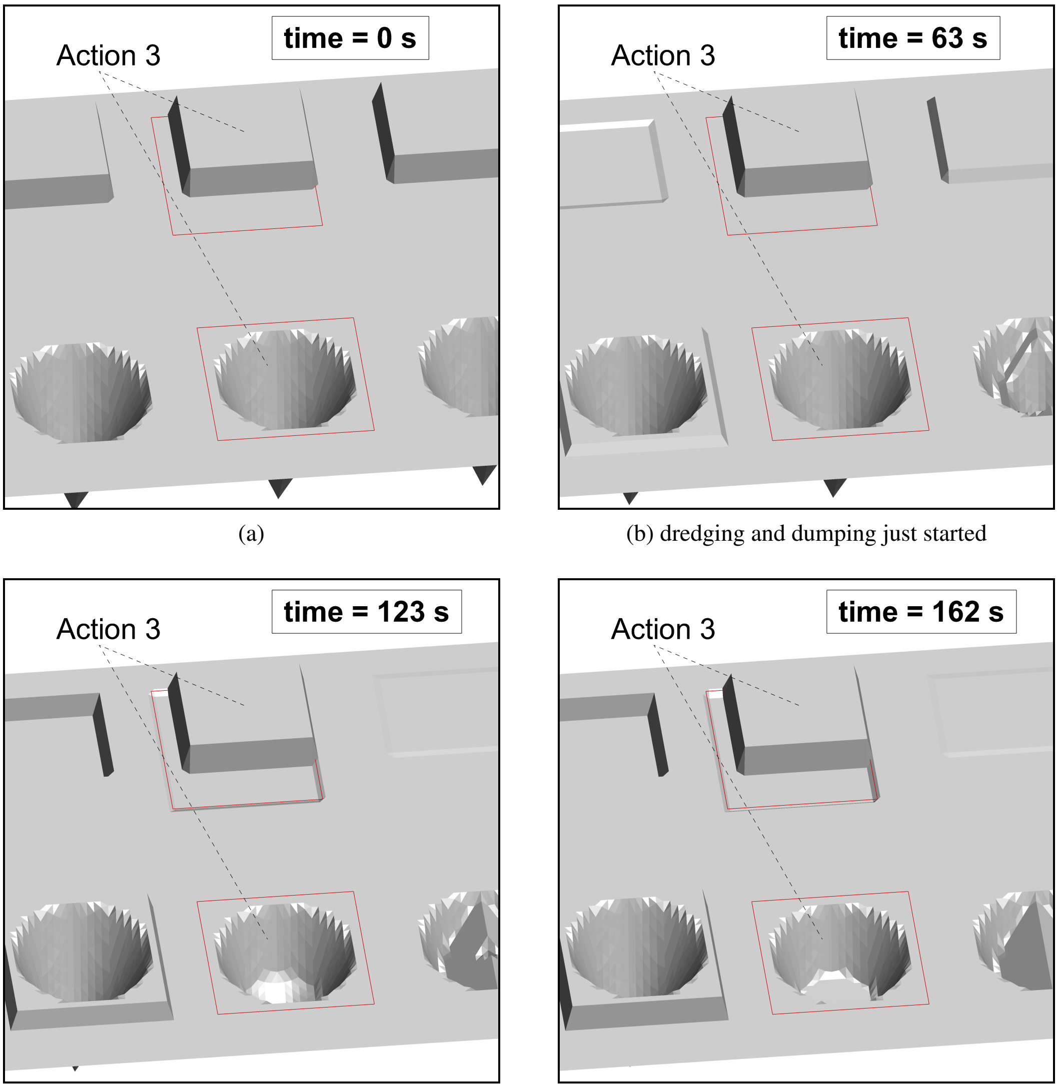
```
/================================================================
ACTION
  ActionType      = Save_water_level
  ReferenceLevel  =  WATERLVL1
  TimeStart       =  2000.01.01-00:00:45  / [yyyy.mm.dd-hh:mm:ss]
ENDACTION
/================================================================
```

4.2.6 Action-3: ActionType = Dig_by_time , ReferenceLevel = WATERLVL1

Action-3 : `ActionType = Dig_by_time` In the flield `432_ri_middle_low` a volume of 100 m^3 will be dredged during the next 100 s. The time slot begins at simulation time 00:01:02 (hh:mm:ss). Because there is no setting for the dump rate, the dumping into the flield `422_le_middle_low` will be executed completely while dredging.
Because of the setting `DumpPlanar=TRUE` and `ReferenceLevel=WATERLVL1`, the water level is used as reference level. The water level was saved beforehand in Action-2. The bottom, where the dumping happened is shaped nearly flat (fig. 4.8d) referring to the shape of the water level.

Excerpt from the action file where the Action-3 is defined:

```
/================================================================
ACTION
  ActionType      = Dig_by_time
  ReferenceLevel  =  WATERLVL1
  TimeStart       =  2000.01.01-00:01:02  / [yyyy.mm.dd-hh:mm:ss]
  TimeEnd         =  2000.01.01-00:02:42  / [yyyy.mm.dd-hh:mm:ss]

  FieldDig        =  432_ri_middle_low
  DigVolume       =  100.0                / [m^3]

  FieldDump       =  422_le_middle_low
  DumpPlanar      =  TRUE
ENDACTION
/================================================================
```



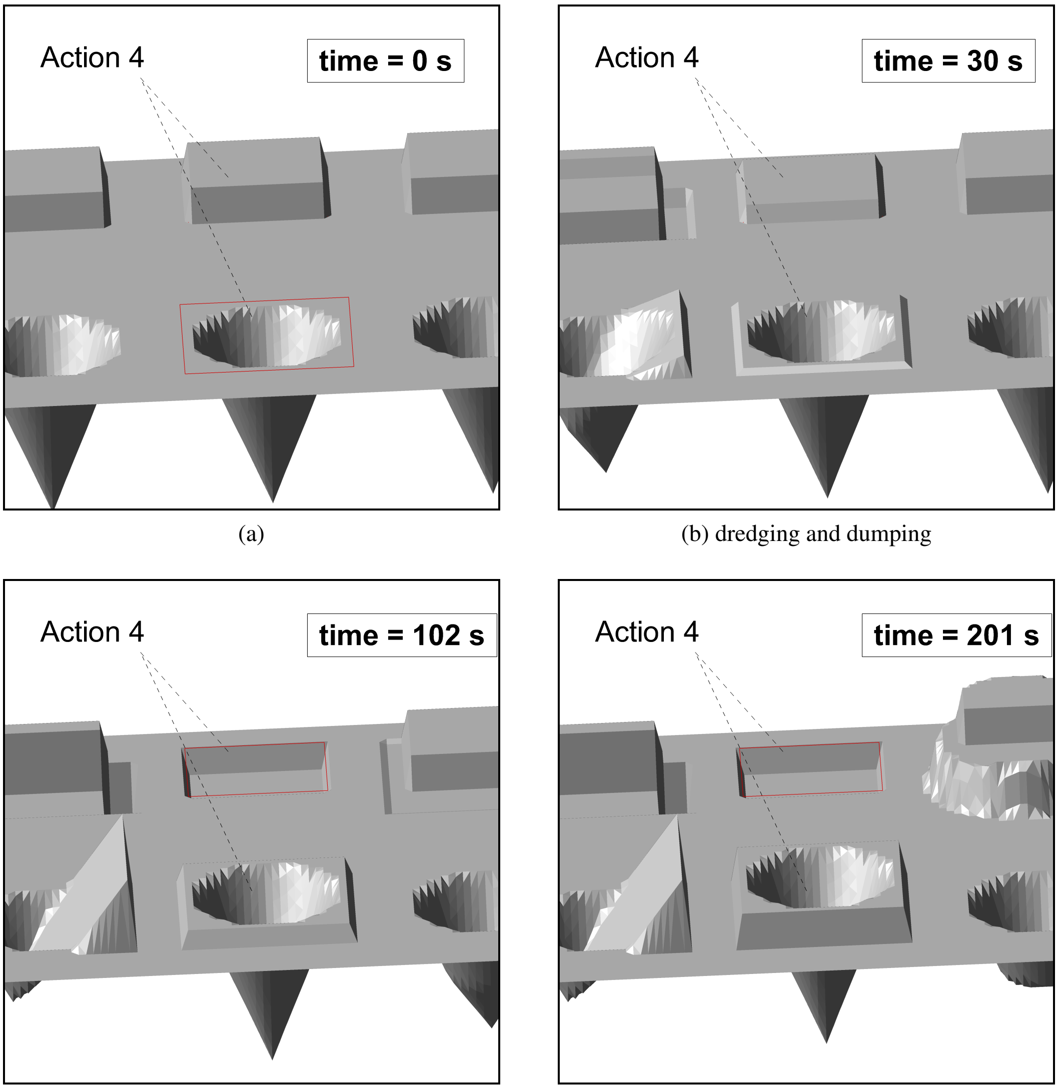
(a) (b) dredging and dumping just started

(c) dredging and dumping (d) dredging and dumping just finished

Figure 4.8: Changes of the bottom while executing Action-3

4.2.7 Action-4: ActionType = Dig_by_time , ReferenceLevel not used

Action-4 : `ActionType = Dig_by_time` In the flield `433_ri_middle_high`, beginning at simulation time 00:00:02, a volume of 529 m^3 will be dredged during the next 100 s. Every node in the field will be lowered by 1.74 m (fig. 4.9c). Simultaneously the dredged material will be dumped into the field `423_le_middle_high_down`. Because of the setting `DumpPlanar=FALSE`, a reference level is not used. As a result, every node in the dump field will be elevated by the same value, in this case 1.0 m (fig. 4.9c). Due to the setting `DumpRate=0.005`, the dumping is slow and it takes 200 s to dump all of the dredged volume (fig. 4.9d).



(a) (b) dredging and dumping (c) dredging just finished, still dumping (d) dumping just finished

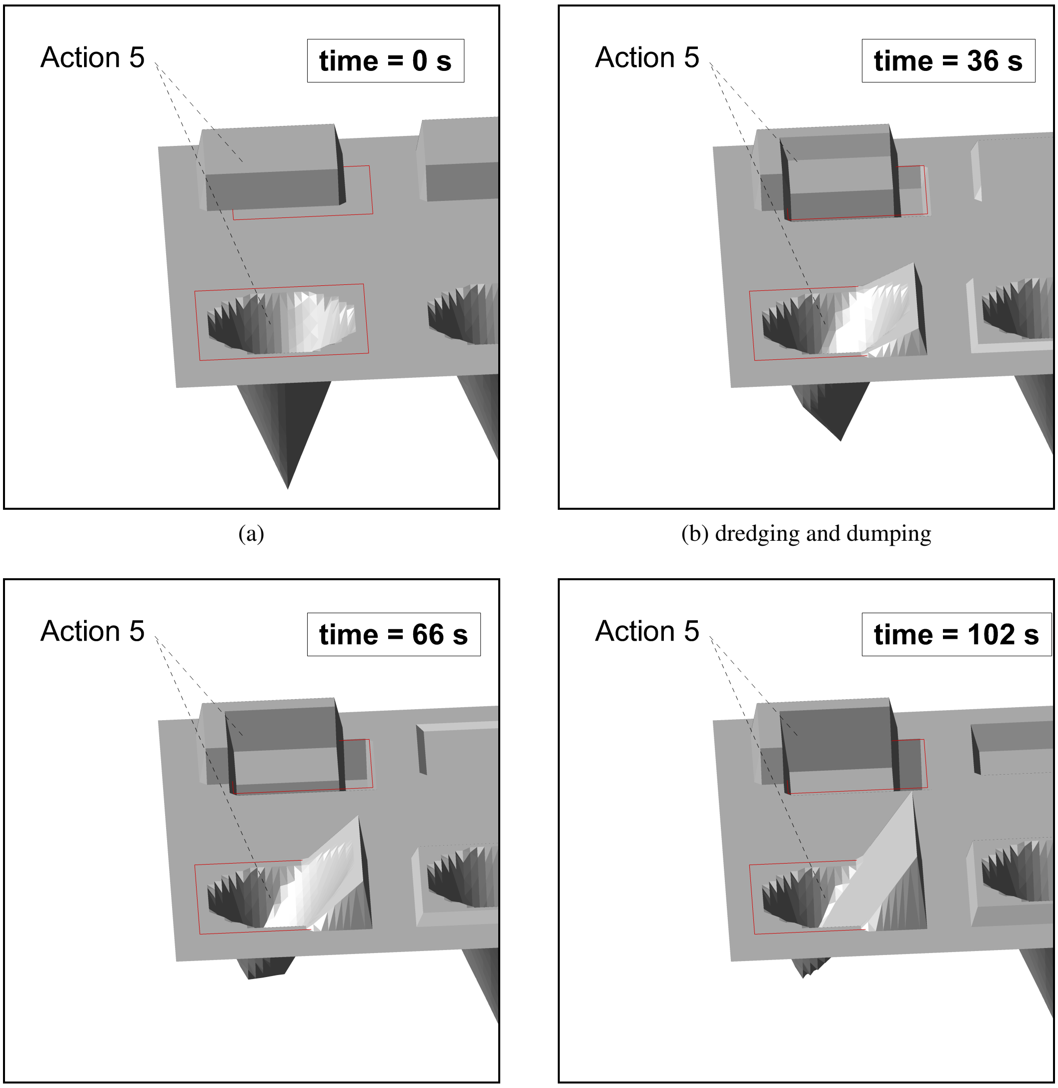
Figure 4.9: Changes of the bottom while executing Action-4

Excerpt from the action file where the Action-4 is defined:

```
/===============================================================
ACTION
  ActionType      = Dig_by_time
  TimeStart       =  2000.01.01-00:00:02  / [yyyy.mm.dd-hh:mm:ss]
  TimeEnd         =  2000.01.01-00:01:42  / [yyyy.mm.dd-hh:mm:ss]

  FieldDig        =  433_ri_middle_high
  DigVolume       =  529.0                / [m^3]

  FieldDump       =  423_le_middle_high
  DumpPlanar      =  FALSE
  DumpRate        =  0.005                / [m/s]
ENDACTION
/===============================================================
```

4.2.8 Action-5: ActionType = Dig_by_time , ReferenceLevel = SECTIONS

Action-5 : `ActionType = Dig_by_time` In the flield `434_ri_top`, beginning at simulation time 00:00:02, a volume of 529 m^3 will be dredged during the next 100 s. Every node in the field will be lowered by 1.74 m (fig. 4.10d). Simultaneously the dredged material will be dumped into the field `424_le_top`. The dumping will be executed completely while dredging because there is no setting for the dump rate.
Because of the setting `DumpPlanar=TRUE` and `ReferenceLevel=SECTIONS`, the sections will be read from the file `_DigRefLevel.dat` and used as reference level. Therefore the bottom where the dumping happened is shaped like a sloped plane referring to the shape of the reference level above the dump field (blue surface in fig. 4.5).



(a) (b) dredging and dumping

(c) dredging and dumping (d) dredging and dumping just finished

Figure 4.10: Changes of the bottom while executing Action-5

Excerpt from the action file where the Action-5 is defined:

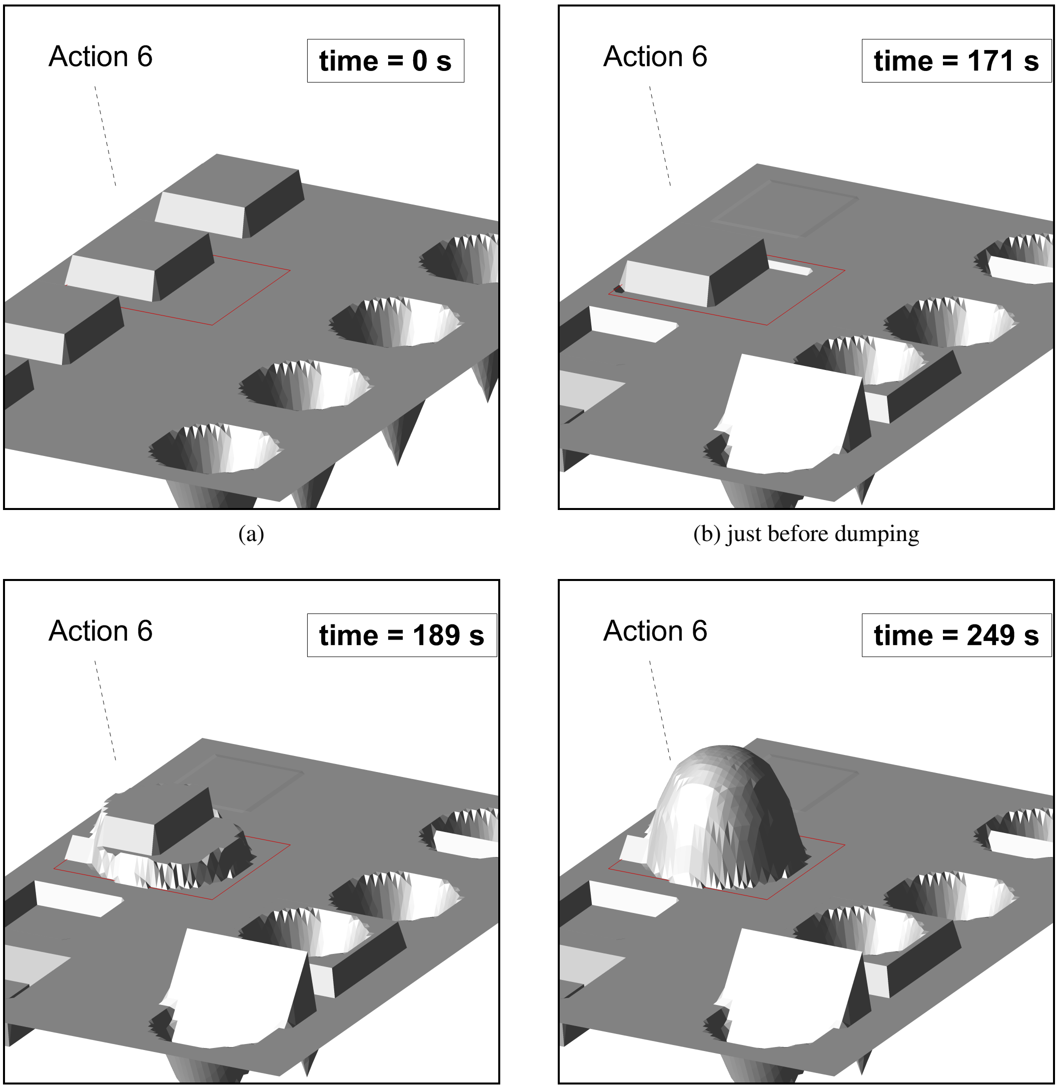
```
/====================================================================
ACTION
  ActionType      = Dig_by_time
  ReferenceLevel  =  SECTIONS
  TimeStart       =  2000.01.01-00:00:02  / [yyyy.mm.dd-hh:mm:ss]
  TimeEnd         =  2000.01.01-00:01:42  / [yyyy.mm.dd-hh:mm:ss]

  FieldDig        =  434_ri_top
  DigVolume       =  529.0                / [m^3]

  FieldDump       =  424_le_top
  DumpPlanar      =  TRUE
ENDACTION
/====================================================================
```

4.2.9 Action-6: ActionType = Backfill_to_level , ReferenceLevel = GRID

Action-6 : `ActionType = Backfill_to_level` begins at simulation time 00:02:52. During the next 90 s the nodes in the flield `532_ri_middle_low_2` are elevated to the height: reference level minus `CritDepth`.
Because of the setting `ReferenceLevel = GRID` the surface which is available in the GEOMETRY FILE is used as reference level. Although Nestor is now coupled to telemac2d it operates internally in the single grain mode. Because of this `GrainClass = 1.0` must be set.

There is the option to control the backfilling by rate, to do so use the keyword `DumpRate` .

As a result, the bottom where the back filling happened, is shaped like a spherical segment referring to the shape of the reference level (grey surface in fig. 4.5).



(a) (b) just before dumping

(c) dumping (d) just finished dumping

Figure 4.11: Changes of the bottom while executing Action-5

Excerpt from the action file where the Action-6 is defined:

```
/=================================================================
ACTION
  ActionType      = Backfill_to_level
  ReferenceLevel  =  GRID
  TimeStart       =  2000.01.01-00:02:52  / [yyyy.mm.dd-hh:mm:ss]
  TimeEnd         =  2000.01.01-00:04:22  / [yyyy.mm.dd-hh:mm:ss]

  FieldDump       =  532_ri_middle_low_2
  CritDepth       =  10.00                / [m]
  GrainClass      =   1.00
ENDACTION
/=================================================================
```