iRIC Software

*Changing River Science*

# Morpho2DH ver.2

# *Tutorial*

## *- Debris/Mud flow -*

*Produced by Hiroshi Takebayashi*

# Contents

# I. Outline

## I.1 Morpho2DH

Morpho2DH is a calculation solver that a debris/mud flow model is added to Morpho2D.
Morpho2D is the unsteady horizontal two dimensional bed deformation analysis solver of bed material load, which is developed by Hiroshi Takebayashi, Kyoto University. The governing equations are written in boundary fitted general coordinate system. In 2009, the solver was installed to RIC-Nays Version 1.0 which is the free software developed by RIC. Some functions are added to the original version and the improved version is installed into iRIC Version2.0 on March 2011. On March 2014, Morpho2D was unified with Nays2D and Nays2DH was developed.

Morpho2DH is the horizontal two dimensional debris/mud flow analysis solver which can reproduce the transport and deposition process of debris/mud flow due to the landslides. Structures (ex. sabo dam, weir, house and so on) and horizontal distribution of maximum erosion depth can be considered in the analysis.
The unsteady horizontal two dimensional bed deformation analysis of bed material load which can be performed as it used to be.

## I.2 Morpho2DH Tutorial – Debris/Mud flow –

The purpose of the tutorial is to show the detailed procedure of the analysis from the beginning to end. Tutorials has enough explanations to perform analysis. However, if you cannot understand the tutorials, please refer iRIC user manual and Morpho2DH manual.

[Contents of Tutorial]

- Chapter II　Transport and deposition process of debris/mud flow
- Chapter III　Debris/Mud flow analysis with structures

## I.3 Open Morpho2DH

1. Startup iRIC, Select [Create New Project] from [iRIC Start Page].

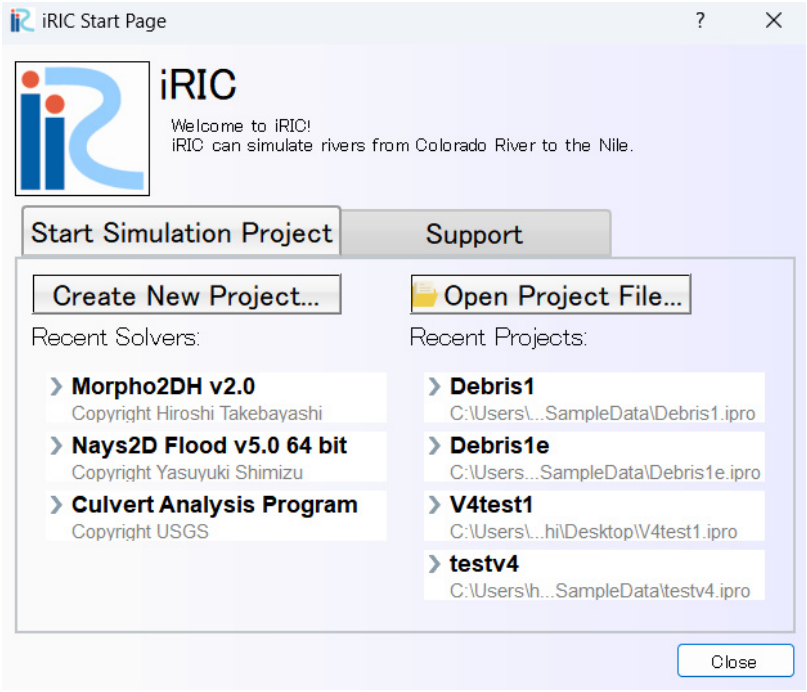



Figure I－1(1)　Start of iRIC

2. Select [Morpho2DH] in [Select Solver] window and press [OK].

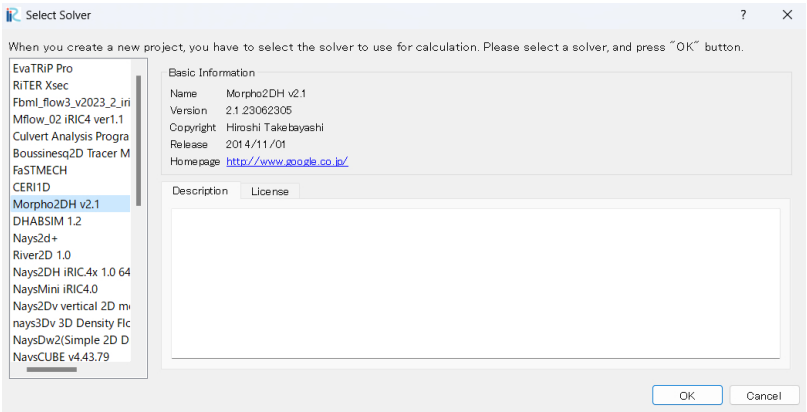



Figure I－1(2)　Selection of Morpho2DH

# II. Transport and deposition process of debris/mud flow

## ◆ Purpose

The purpose of this chapter is for researchers, river engineers and university students who have no (or a few) experience of transport and deposition process of debris/mud flow analysis to learn to perform debris/mud flow analysis by use of Morpho2DH and visualize the calculated results.

## ◆ Procedure

Procedure in this chapter is shown in Figure II－1.

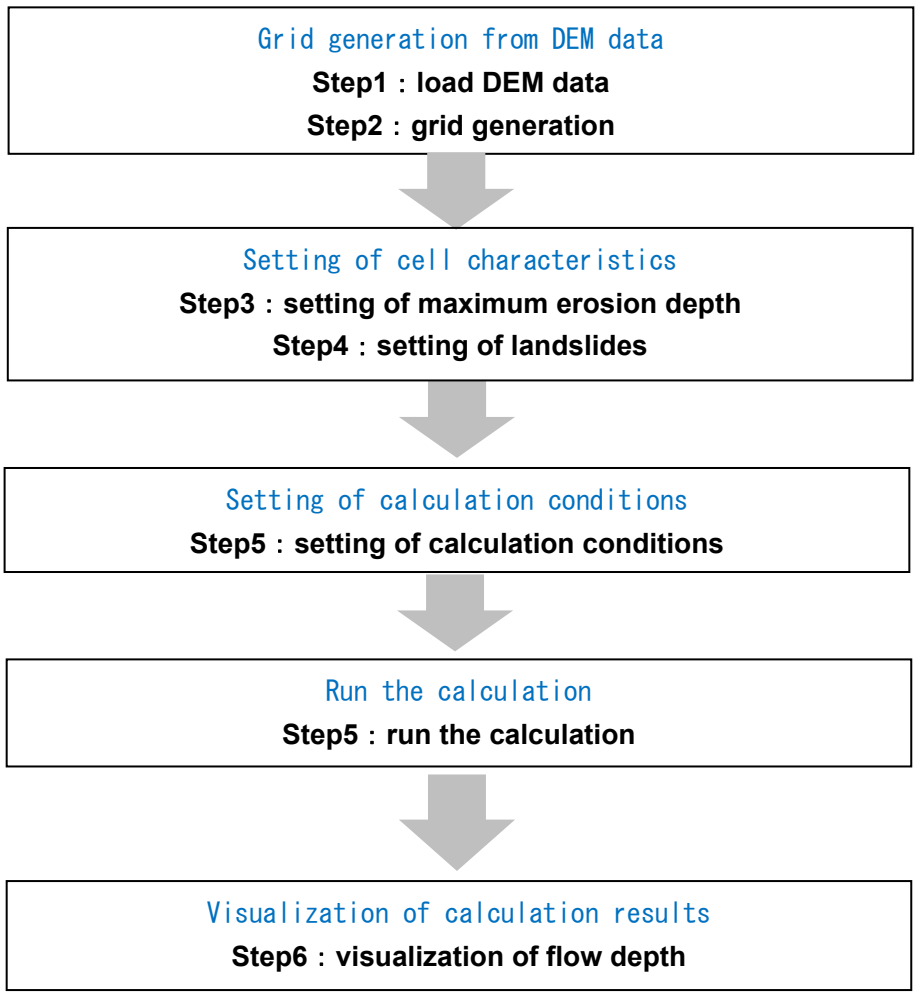



Figure II－1 Procedure in this chapter

# II.1 Grid generation from DEM data

## II.1.1 Load DEM data

### ■Setting of coordinate system

1. Click [Property] in [File].

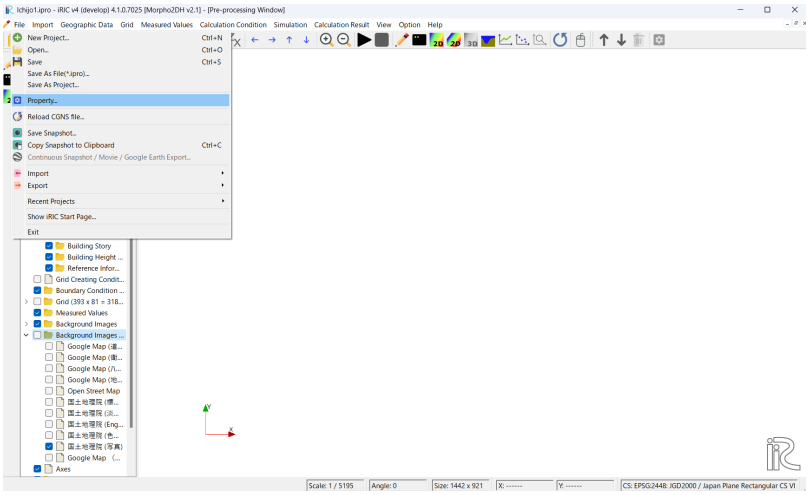



Figure II－2(1)　Open [Property] window

2. When the coordinate system is not specified yet, [Project property] dialog box is popped up. Please click [Edit] in [Coordinate System].

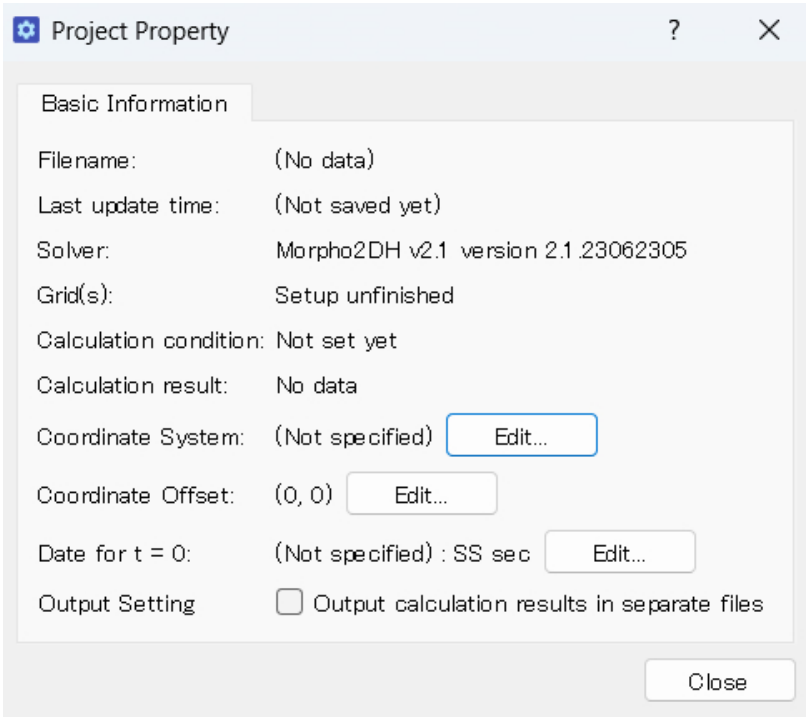



Figure II－4(2)　Specify the coordinate system

3. Target area is the river basin located north of Kyoto University of the Arts in Sakyoku, Kyoto City, Japan. Hence, the coordinate system [EPSG2448:JGD2000/Japan Plane Rectangular CS VI] must be selected. Please click「OK」.

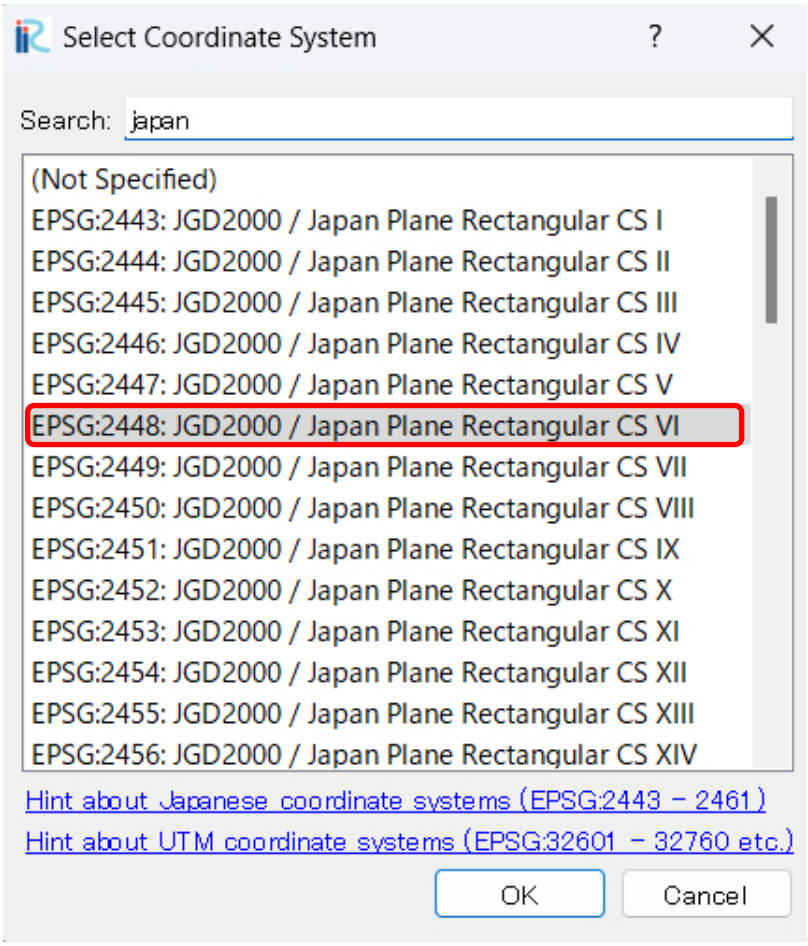



Figure II－2(3)　Selection of coordinate system

4. Please confirm if the coordinate system is set or not in the [Project Property] window and press [Close].

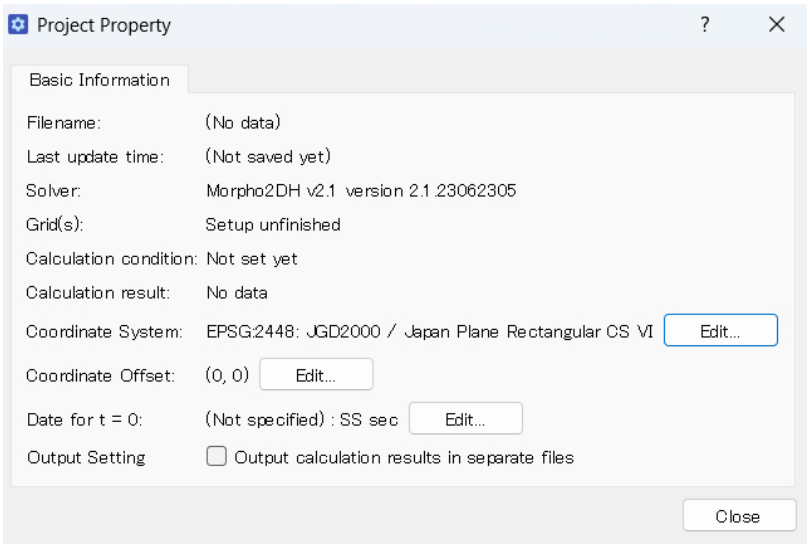



Figure II－4(4)　Setting of coordinate system

DEM data can be loaded from the web or from a file prepared in advance.

## ■ To load DEM data form the web

5. Click [Geographical Data (Elevation from web)]-[Elevation] in [import].

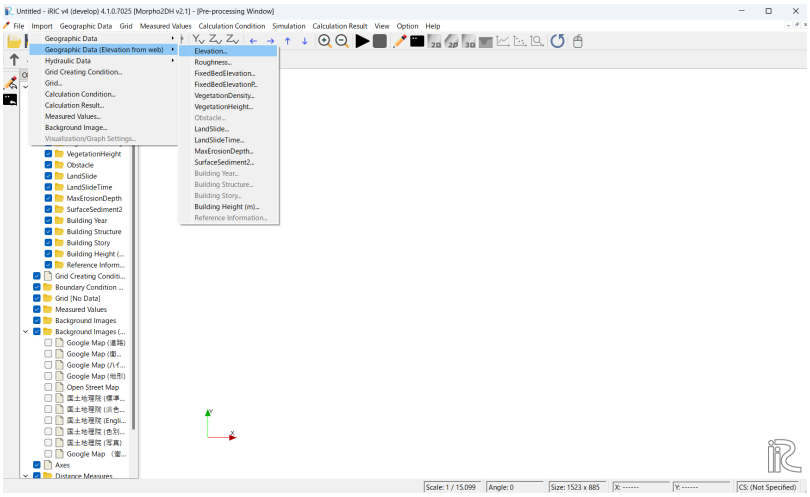


Figure II－3(5)　Load DEM data

6. [Select Region] window will be opened. Move to the target area using [Zoom In] and [Zoom Out]. Background image can be selected from the [Background image] pulldown.

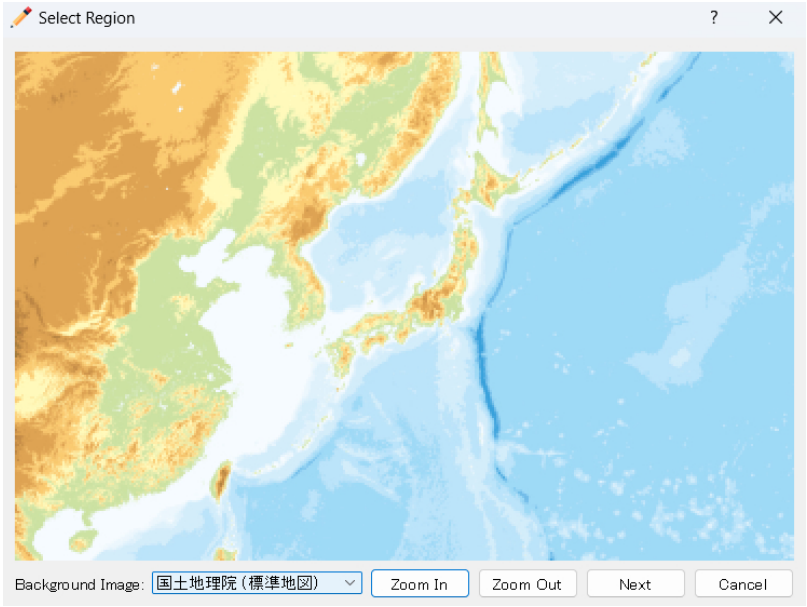



図 II－2(6)　Move to the target area

7. After movement to the target area (circled in red), click the left mouse button to specify one of the corners of the DEM data acquisition area, and then click the diagonal corner of the previously specified corner to set the DEM data acquisition area. After setting the DEM data acquisition area, click [Next].


Figure II－4(7)　Set DEM data region including target area

8. [Zoom Level Setting] window is opened and select DEM data [国土地理院標高タイル(基盤地図情報数値標高モデル DEM5A)].

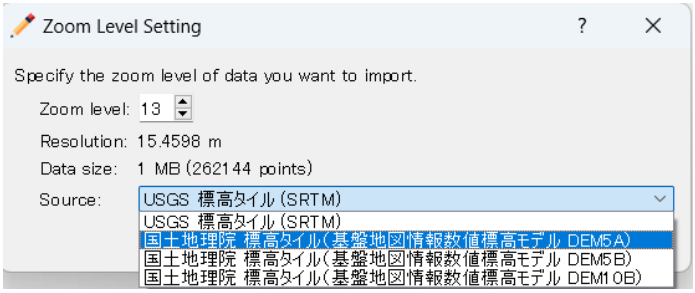



図 II－2 (8)　Selection of DEM data

9. DEM data is displayed.

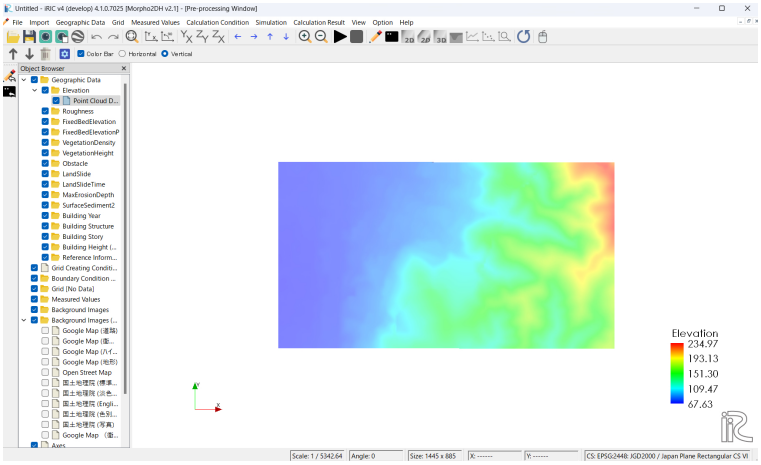



Figure II－4(9)　Display of DEM data

## ■ To load DEM data from a file

10. Click [Geographical Data]-[Elevation] in [import].

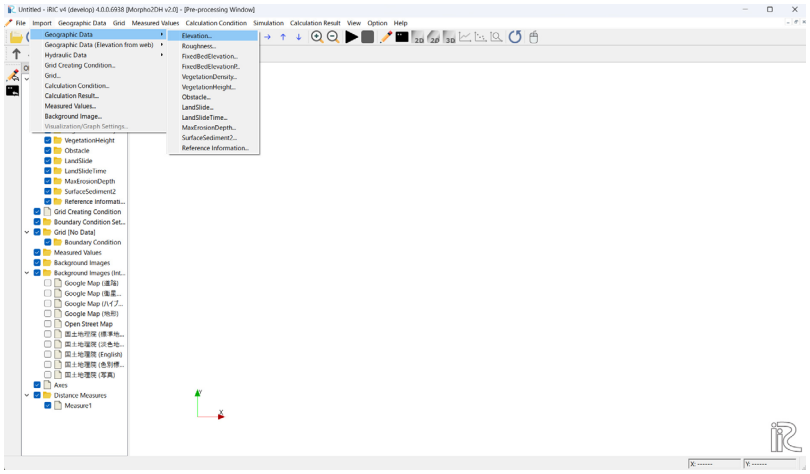


Figure II－4(10)　Load the land elevation data

**※Grid generation method in Morpho2DH**

'Create grid from polygonal line and width', 'Create grid from river survey data', and so on can be used in the calculation using Morpho2DH.
In this chapter, 'Create grid from polygonal line and width' is selected.

11. Load [Ichijo.txt].

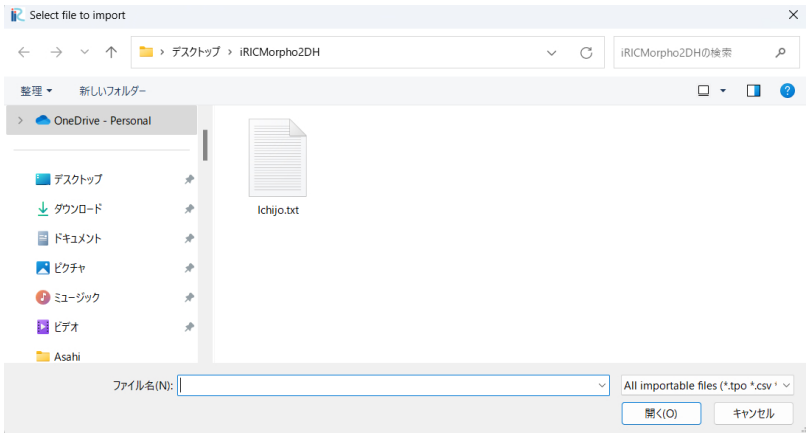



Figure II－4(11)　Load the land elevation data

**※DEM data file**

DEM data file is composed of the data number, x and y coordinate, land elevation data (z).
Format of DEM data file is explained in iRIC manual.

12. [Import Setting] window is opened. [CSV (Comma separated values] in [File Format] is checked and [X: field2, Y: field3, Z: field4] in [Select field] is set and press [OK].

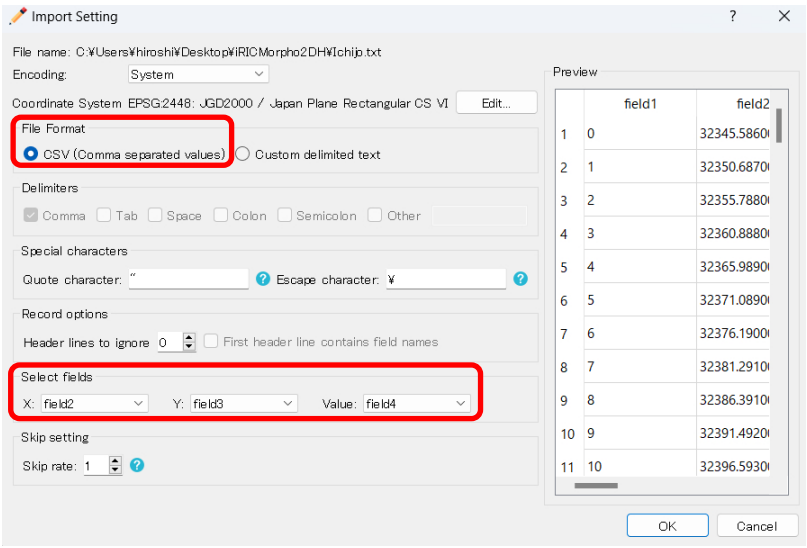



Figure II−4(12)　Load the land elevation data

13. DEM data is shown.

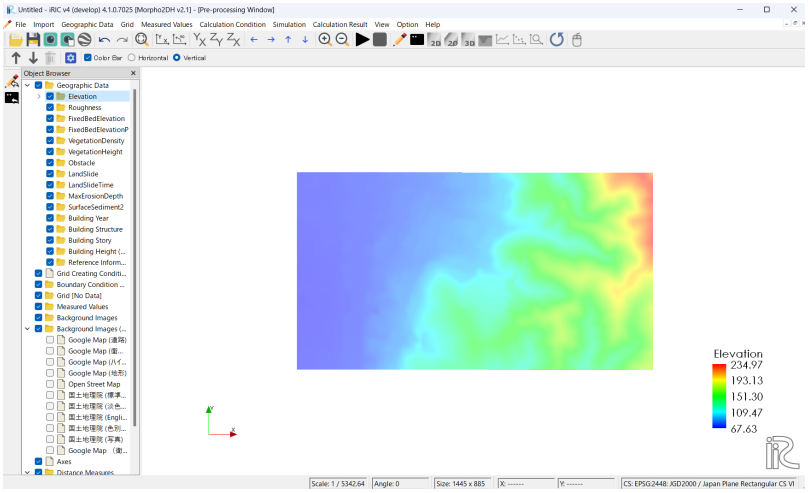



Figure II−4(13)　Load the land elevation data

Background image can be loaded from the web or from a file prepared in advance.

## ■ To load Background image form the web

1. If [Coordinate System] is set, the background image is displayed by checking on the background image (国土地理院（標準地図） in the following image) you want to display from [Background Image (Internet)]. To set the [Coordinate System], select [File]-[Properties], and then refer to [Figure II-2(1)]-[Figure II-2(4)].

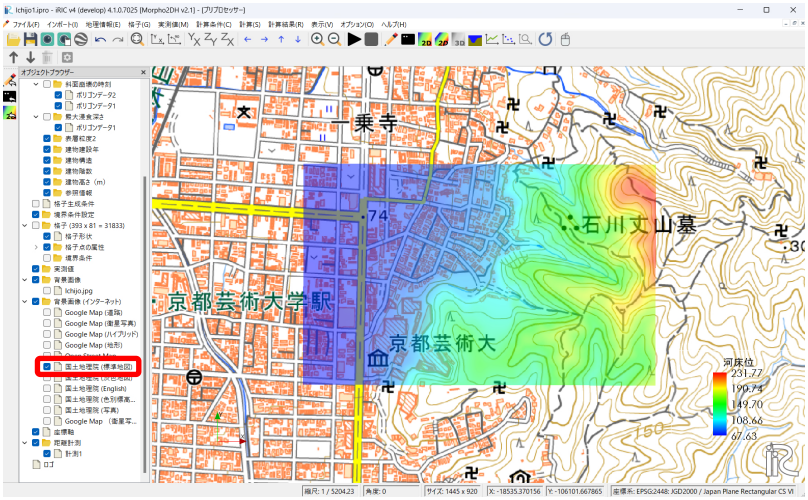



Figure II－3 (1)　Load the background image

**※Background image**

When users create the numerical grids, background images help to identify the location and shape of houses and erosion control structures such as sabo dams or weirs.

## ■Load background image

2. Click [Background Image]-[Add Image] in [Import].

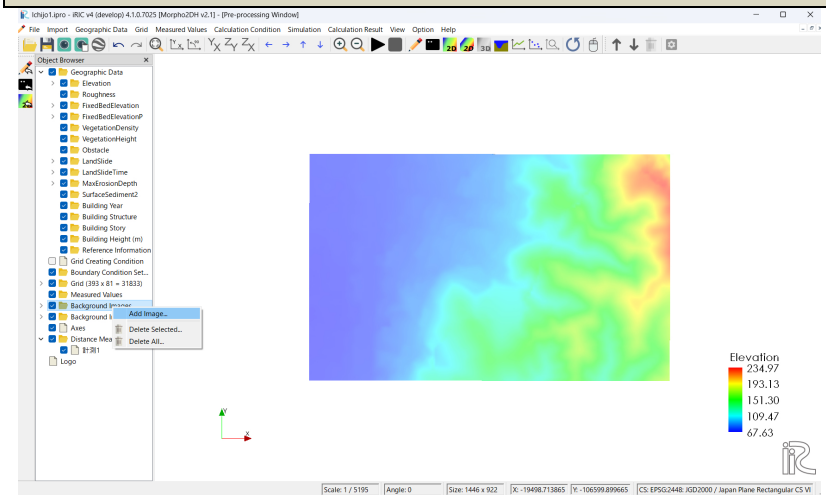



Figure II－3(2)　Load the background image

**※Background image**

When users create the numerical grids, background images help to identify the location and shape of houses and erosion control structures such as sabo dams or weirs.

3. Select [Ichijo.jpg].

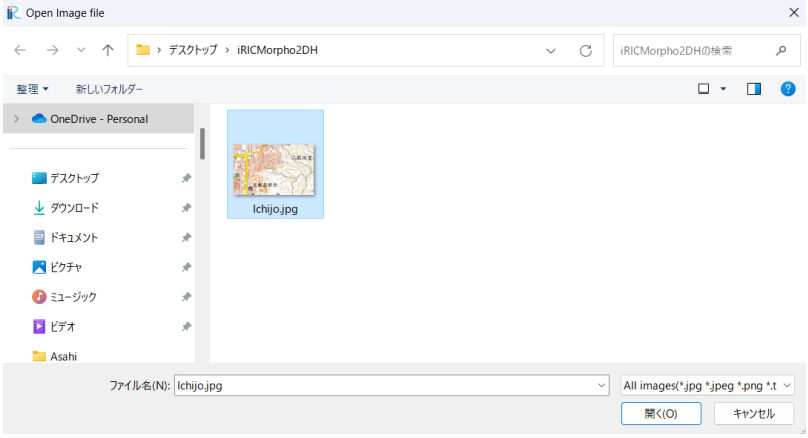
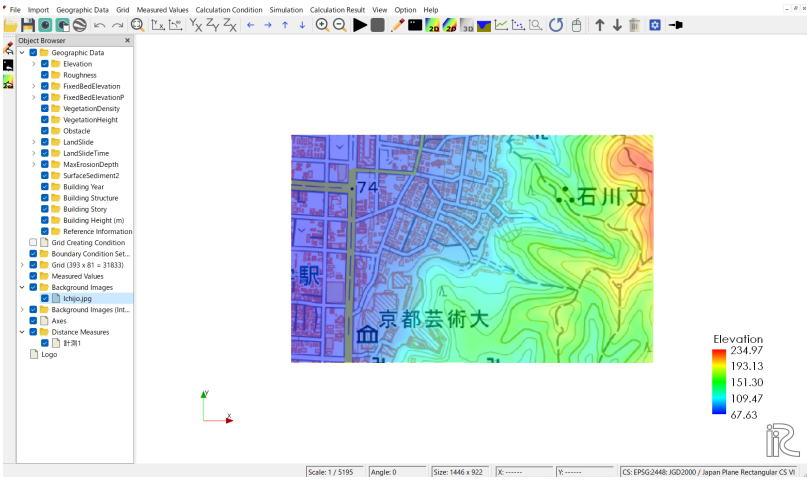



Figure II－3 (3) Load the background image

4. Background image is fitted to land elevation data by use of [Pan], [Rotate] and [Zoom]




※Hints for the fitting

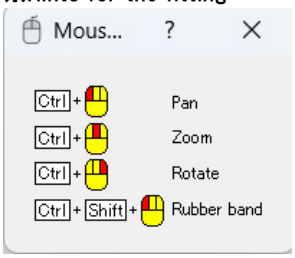



Figure II－3(4) Fit the background image

## II.1.2 Grid generation

### ■Selection of the grid generation algorithm

1. Click [Select Algorithm to Create Grid] in [Grid].

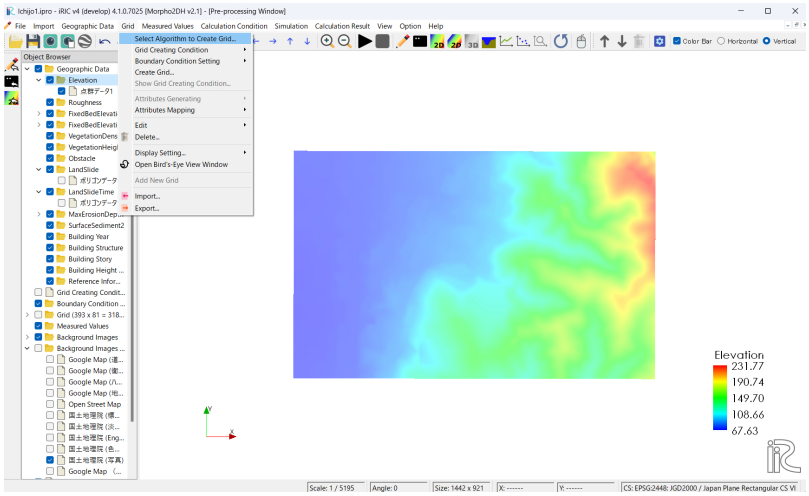



Figure II−4(1) Selection of the grid generation algorithm

2. Select [Create grid from polygonal line and width] in [Algorithm] and press [OK].
3. A small window on information on grid generation algorithm is popped up and press [OK].

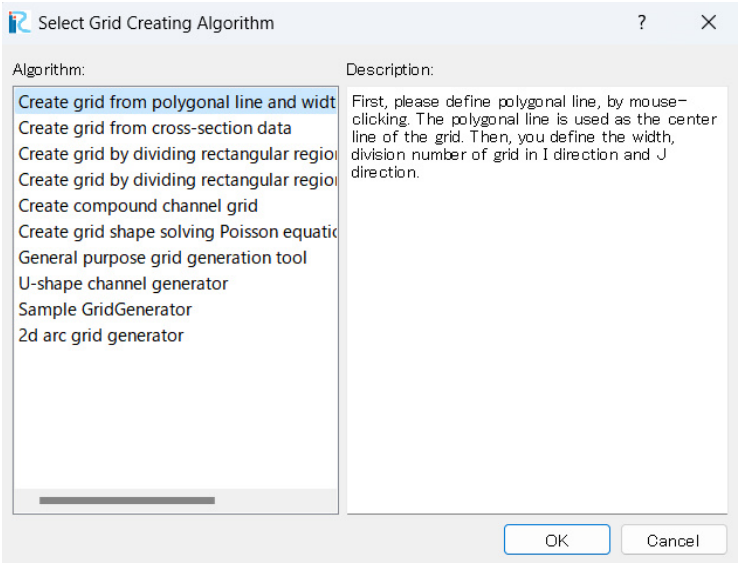



Figure II−4(2) Selection of the grid generation algorithm

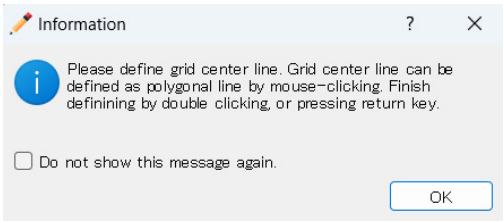



Figure II−4(3) Information on grid generation algorithm

## ■Decision of number and size of grids

| | |
|---|---|
| 1 | Click the upstream and the downstream ends of calculation region and press return key to decide the centerline of the calculation domain. |
| 2 | [Grid Creation] dialog box is popped up. Enter the number of longitudinal grids ($n_I$), the number of transverse grids ($n_J$), the width of calculation domain ($W$). The size of grids ($d_I$, $d_J$) are automatically calculated. |
| 3 | Press OK in the dialog box. |

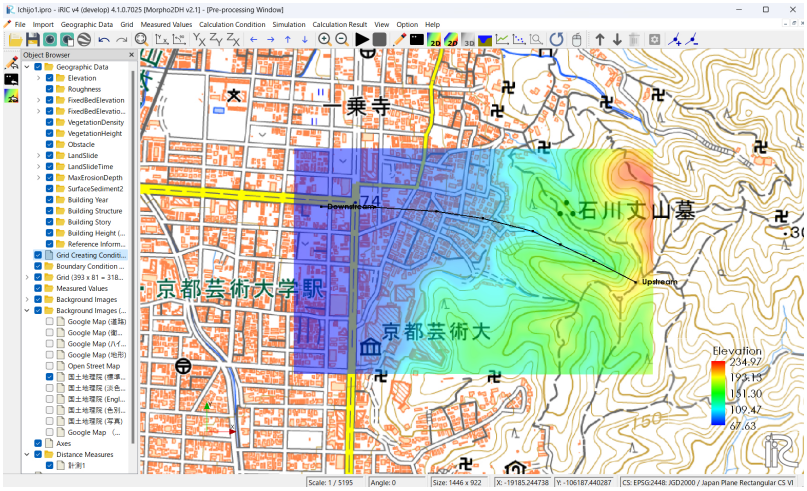



Figure II－4(4)　Decide the centerline of the calculation domain

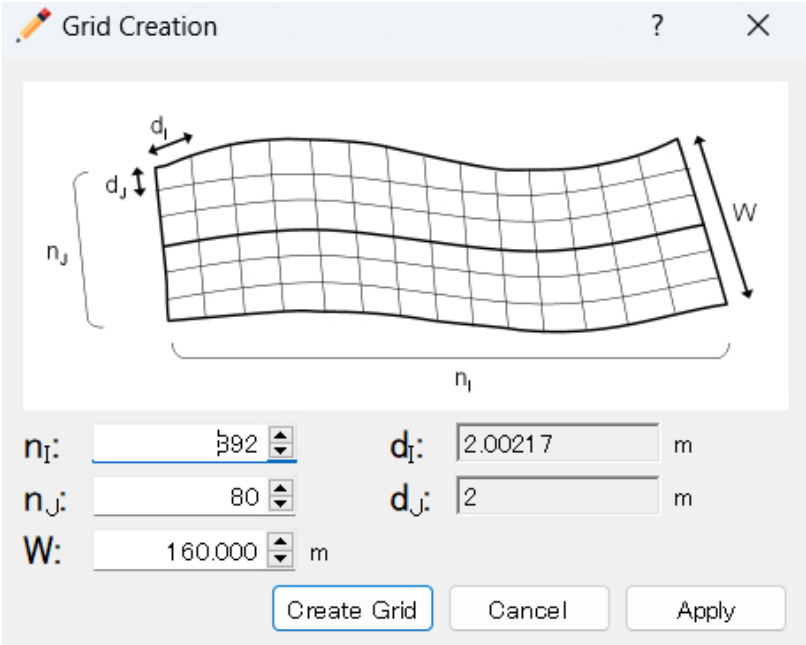



Figure II－4(5)　Enter the number of grids, the width of calculation domain.

| |
|---|
| 4　Press OK in the dialog box for confirmation of mapping |

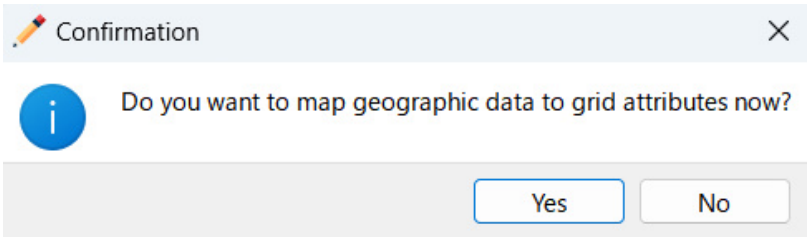



Figure II－4(6)　Confirmation of mapping

| |
|---|
| 5　Grids are formed. |

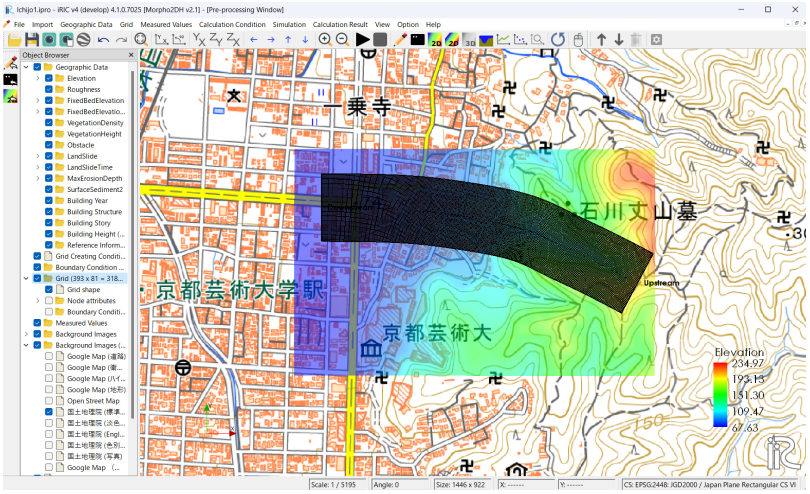



Figure II－4(7)　Add division points in transvers direction

## ■Maximum erosion depth of land surface

| | |
|---|---|
| 1 | Click [MaxErosionDepth] in [Object Browser] by right button and select [Add] and [Polygon]. |

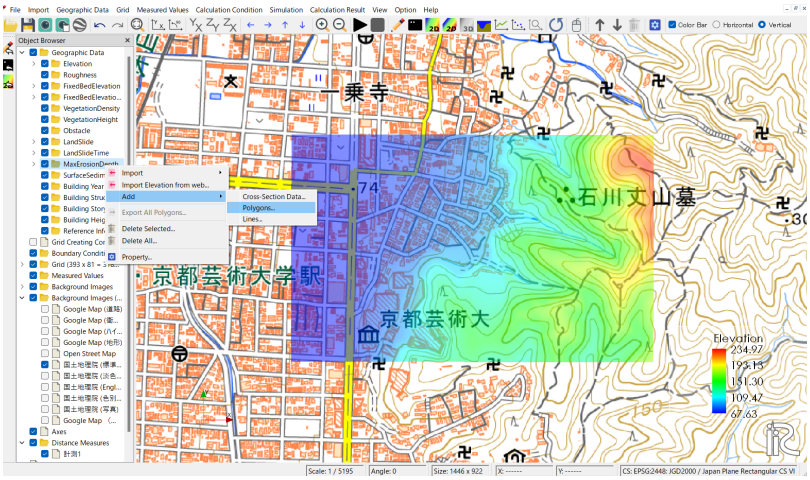



Figure II－5(1)　Create polygon

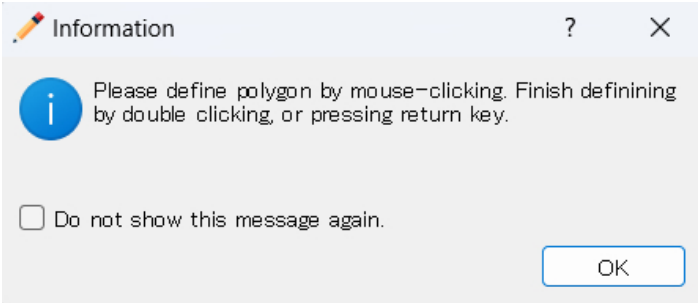



Figure II－5(2)　Creation method of polygon

| | |
|---|---|
| 2 | Make a polygon by clicking at the corners of the polygon. The polygon should cover the whole calculation area. Double clicks stop to make the polygon. |

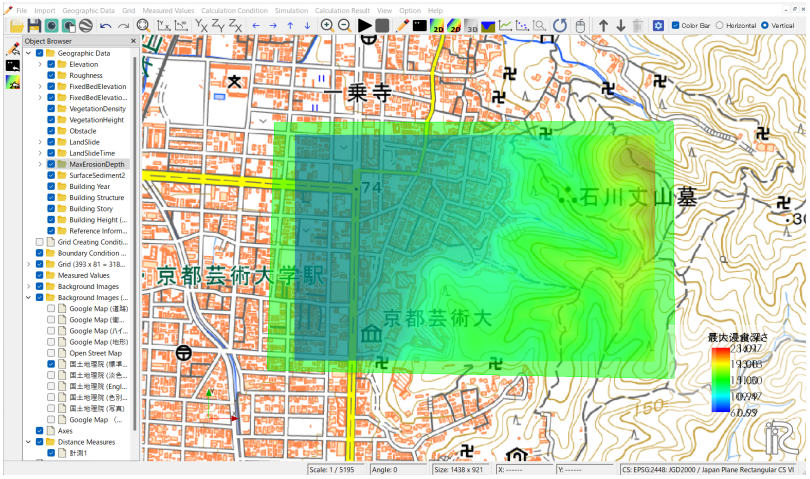
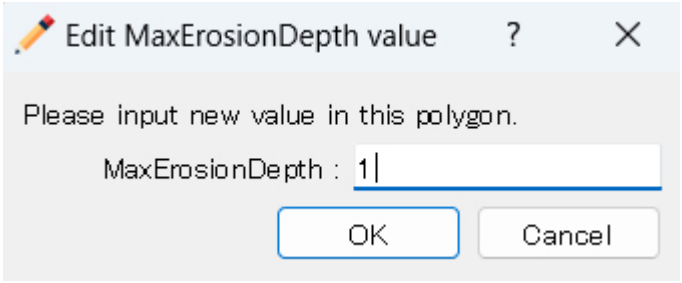



Figure II－5(3)　Create polygon

| |
|---|
| 3　Enter the maximum erosion depth and press [OK] in the small dialog boxes. |




Unit is m.

Figure II－5(4)　Input the maximum erosion depth

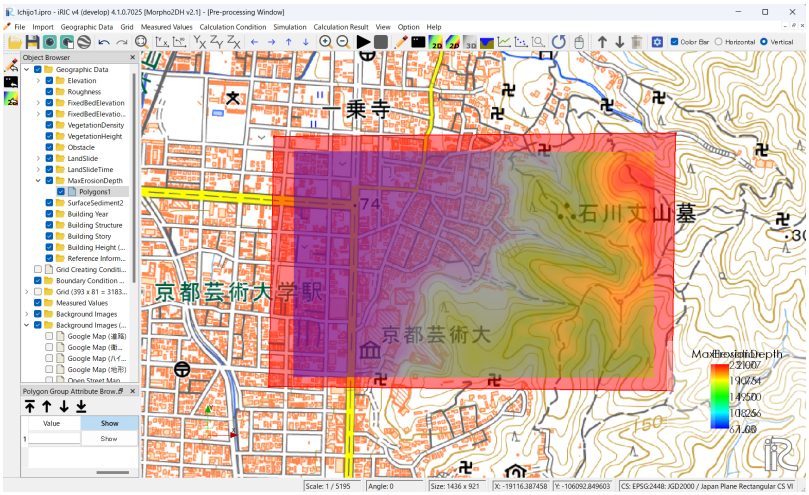



Figure II－5(5)　Create polygon

## ■Location and size of landslides

1　Click [Landslide] in [Object Browser] by right button and select [Add] and [Polygon].

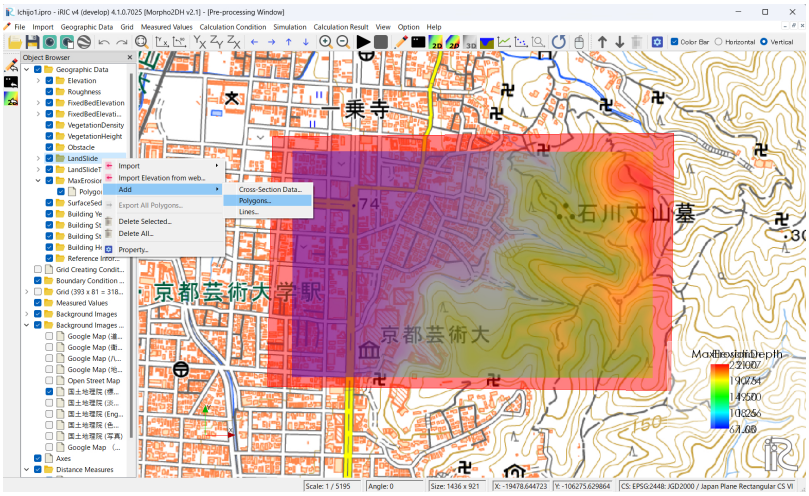



Figure II－6(1)　Create a polygon

2　Make a polygon by clicking at the corners of the polygon. The horizontal shape of the polygon should be the same as the horizontal shape of the landslide. Double clicks stop to make the polygon.

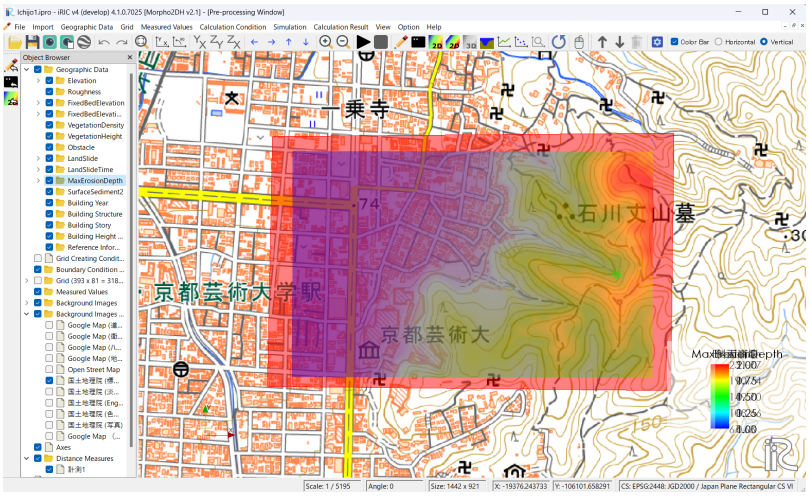
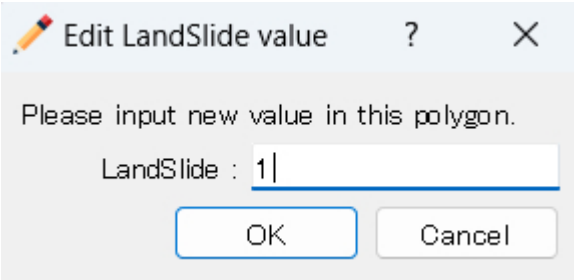



Figure II－6(2)　Create a polygon

| |
|---|
| 3　Enter the landslide depth and press [OK] in the small dialog boxes. |




Unit is m.

Figure II－6(3)　Input the landslide depth

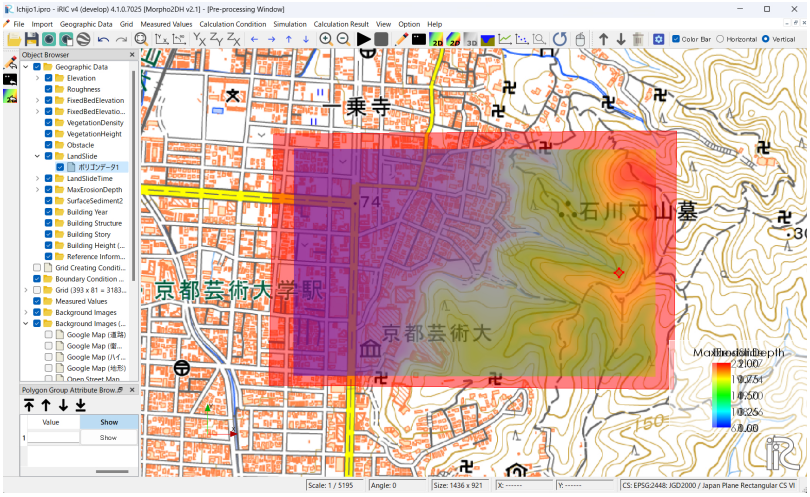



Figure II－6(4)　Create polygon

## ■Mapping

| |
|---|
| 1　Click [Execute] in [Grid]-[Attributes Mapping]. |

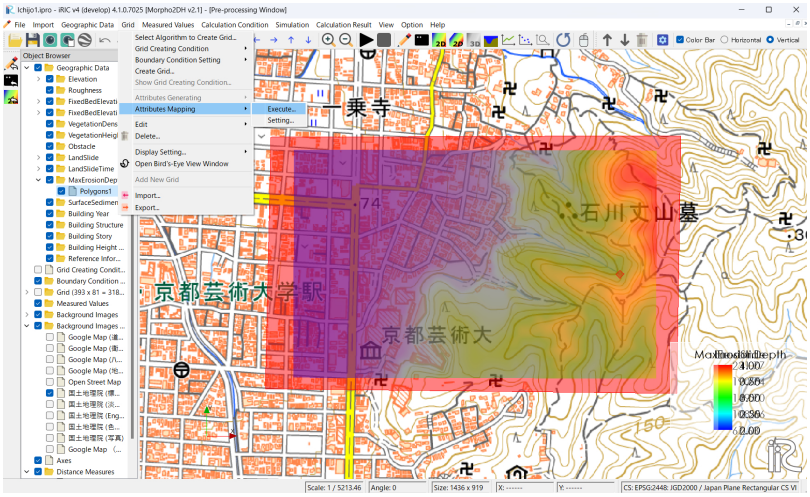



図 II－7(1)　Execute of mapping

| |
|---|
| 2　Checking on the valuables which need to be mapped and click [OK]. If you do not know which valuables need to be mapped, click [Check All] and then click [OK]. |

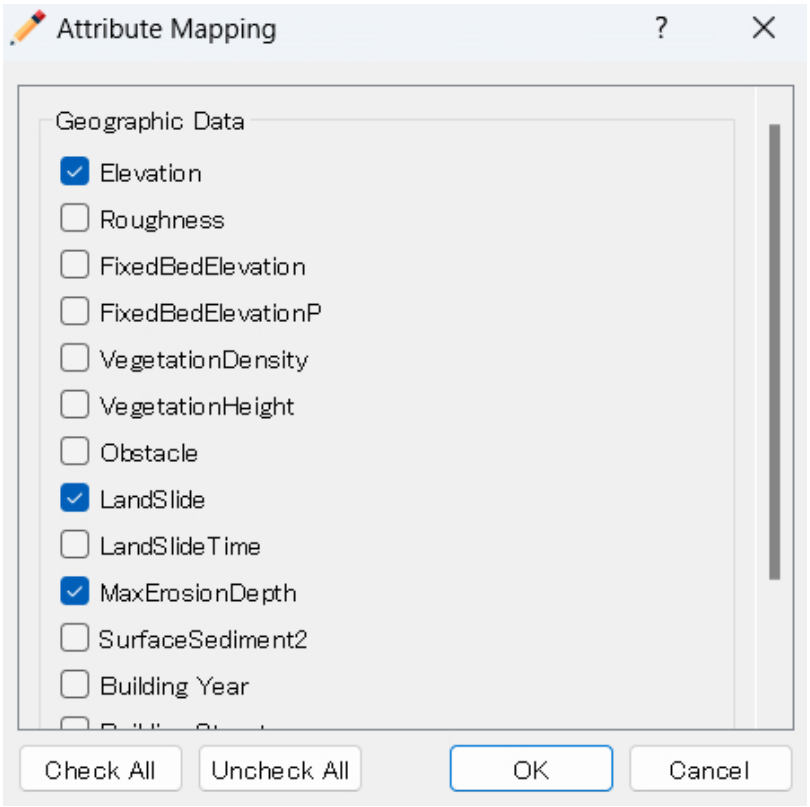



Figure II－7(2)　Selection of valuables which need to be mapped

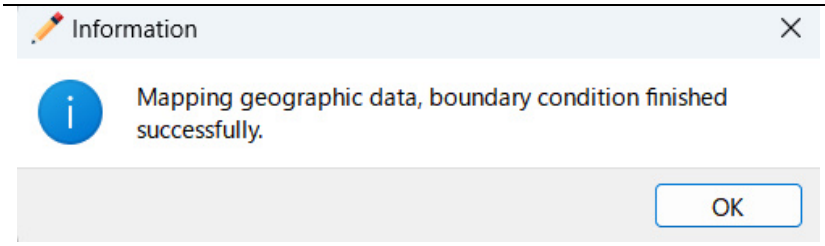



Figure II－7(3)　Information of mapping

| | |
|---|---|
| 3 | Check on each of the [Node attributes] in the [Object Browser]-[Grid] to see if the data is mapped to the grids (whether the grids are given values or not) (in the figure below, [Grid Creating Condition] is checked off to make it easier to see the color contours).. |

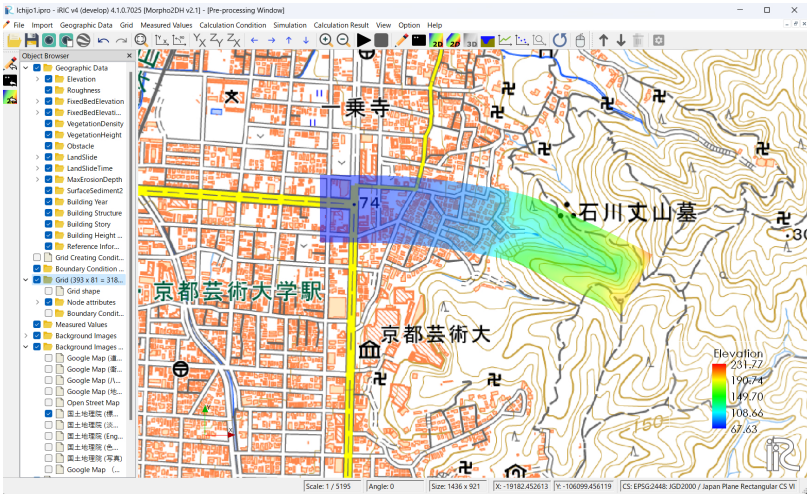



Figure II－7(4)　Confirmation of mapping

# II.2 Setting of calculation conditions

## II.2.1 Setting of calculation conditions

**■Selection of solver type**

1　Click [Setting] in [Calculation Condition].

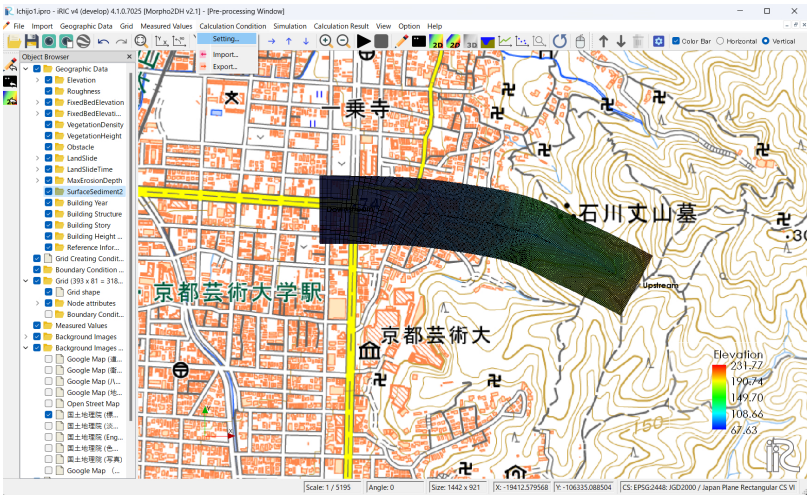



Figure II－8(1)　Setting of calculation conditions

## ■Setting of calculation parameters

```
1   Click [Parameters] in [Calculation Condition] dialog box.
2   Select [Debris/Mud Flow] in [Calculation Type].
3   [Start Time (s)] is 0.
4   [End Time (s)] is 300 (s).
5   [Computational Time Step (s)] is 0.01 (s).
6   [Output Time Step for File (s)] is 1 (s).
7   [Output Time Step for Screen (s)] is 1 (s).
8   [Start Time of Bed Deformation (s)] is 0 (s).
```

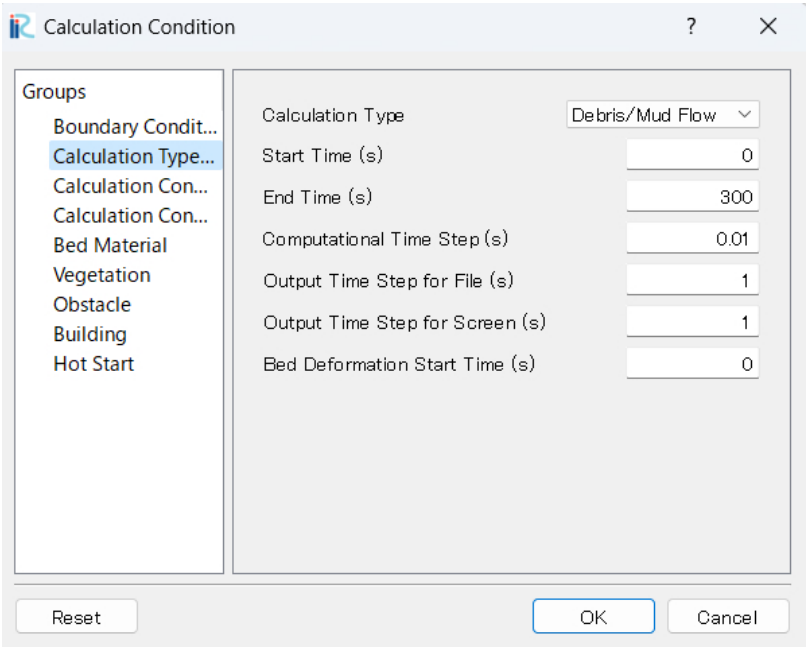



Figure II－8(2)　Setting of calculation parameters

- Select [Debris/Mud flow] for bed deformation analysis by debris/mud flow. [Flow only] is for flow calculation. [Bed material load] is for bed deformation analysis by bed material load.
- Start time of the calculation is set in [Start Time (s)]. Unit is second.
- End time of the calculation is set in [End Time (s)]. Unit is second.
- Time step $\Delta t$ is set in [Computational Time Step (s)]. Unit is second. The time step is decided considering CFL condition.
- Output time step for file is set in [Output Time Step for File (s)]. Short time step makes a smooth animation. Unit is second.
- Output Time Step of calculation condition for Screen is set in [Output Time Step for Screen (s)]. Unit is second.
- Start time of bed deformation is set in [Start Time of Bed Deformation (s)]. Unit is second. When the debris/mud flow calculation is performed, please input 0.

## ■Setting of calculation conditions

1 Open [Calculation Conditions (Debris/Mud Flow)] dialog box.
2 Select [Change] in [Sediment Concentration].
3 Input 1 for [Original Liquid Density].
4 Input 2.65 for [Sediment Density].
5 Input 0.6 for [Static Deposition Sediment Concentration].
6 Input 0.2 for [Liquid Behavior Sediment Ratio].
7 Input 0.01 (m) for [Minimum Flow Depth].
8 Input 34 (degree) for [Internal Friction Angle].
9 Select [Constant] in [Laminar Flow Depth], because spatial change of land slope is not changed well here.
10 Input 0.4 for [Laminar Flow Depth Ratio].
11 Input [Resistance Coefficient]. The value is about 72.
12 Select [Disabled] in [Fixed Bed Elevation].

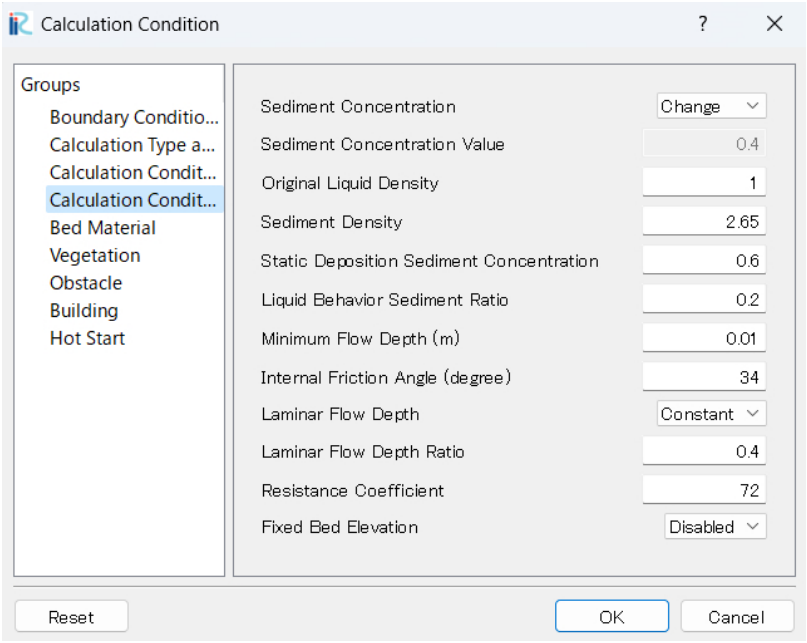



Figure II－8(3) Setting of calculation conditions

- Please select [Change] when you want to consider the spatiotemporal change of sediment concentration.
- The original liquid here is water and 1 is used in [Original Liquid Density].
- [Sediment Density] is 2.65 here.
- Static deposition sediment concentration is between 0.54 and 0.8.
- Fine material behaves as liquid phase. Content rate of 0.2mm and finer diameter is rough standard to decide [Liquid Behavior Sediment Ratio].
- [Minimum Flow Depth] must be set to get stable calculation results. The unit is m.
- When the flow is debris flow, the laminar flow depth ratio is about 1. When the fine material includes in the flow well and turbulence flow layer is formed on the laminar flow layer, the laminar flow depth ratio must be smaller than 1.
- Value of [Resistance Coefficient] must be set to reproduce flow depth.
- When some parts of the bed composed of rock or sabo dams is set in the calculation area, please select [Enable] in [Fixed Bed Elevation]. When [Fixed Bed Elevation] is [Enable], the fixed bed area must be set using polygons.

## ■Setting of bed material conditions

1 Click [Bed Material] in [Calculation Condition] dialog box.
2 Select [Uniform] in [Bed Material Type].
3 [Mean Grain Diameter (m)] is available, when [Uniform] is selected in [Bed Material Type]. Here, please input 0.01 (m).
4 Press [OK] to complete setting of calculation conditions.

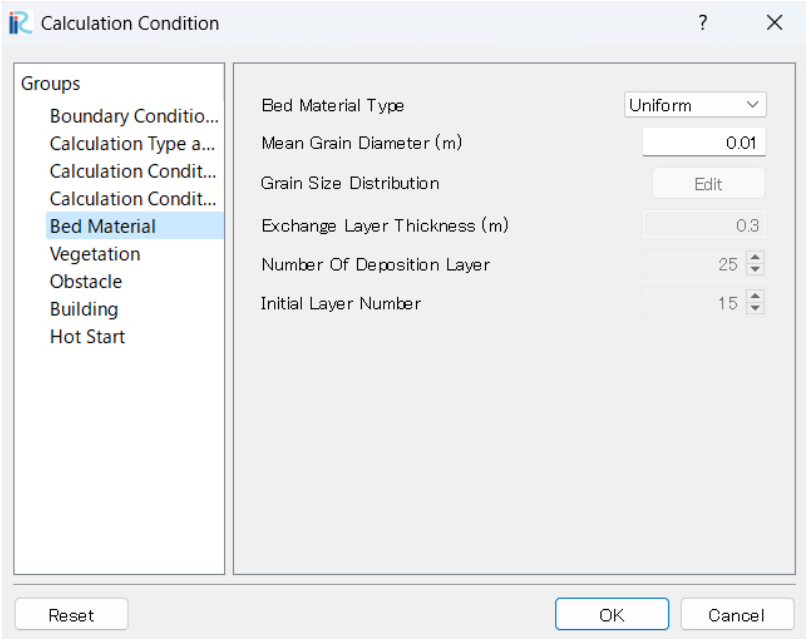



Figure II－8(4) Setting of bed material conditions

□Input mean grain diameter in [Mean Grain Diameter (m)]. This function is available only for uniform sediment

## ■[Vegetation], [Obstructions], [Building], and [Hot Start] are not set here.

## II.2.2 Run the calculation

**■Run the calculation**

1　Press [▶] on the tool bar to run the calculation.

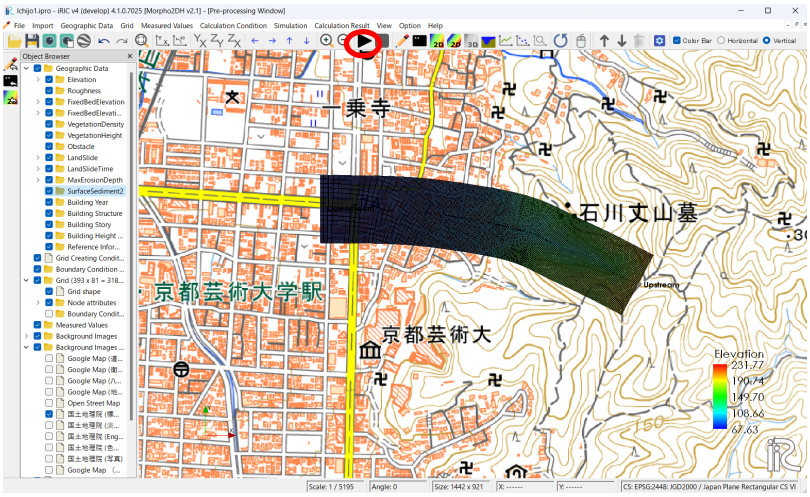



Figure II－9(1)　Run the calculation

2　Press [▶] on the tool bar again. [Information] for save of project is popped up. Please press [Yes].
3　Please select [Save as File (*.ipro)] in the dialog box [Select How to Save Project].

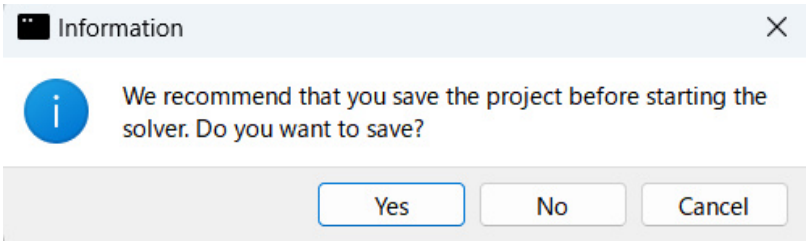



Figure II－9(2)　Save the project

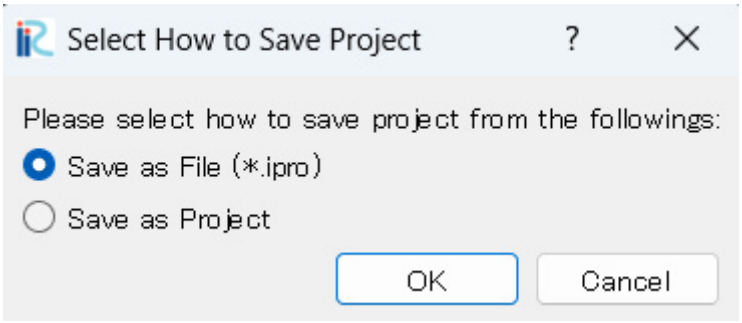



Figure II－9(3)　Save the project

| 4 | [Save iRIC project file] dialog box is popped up. Input file name and press [Save]. |
|---|---|

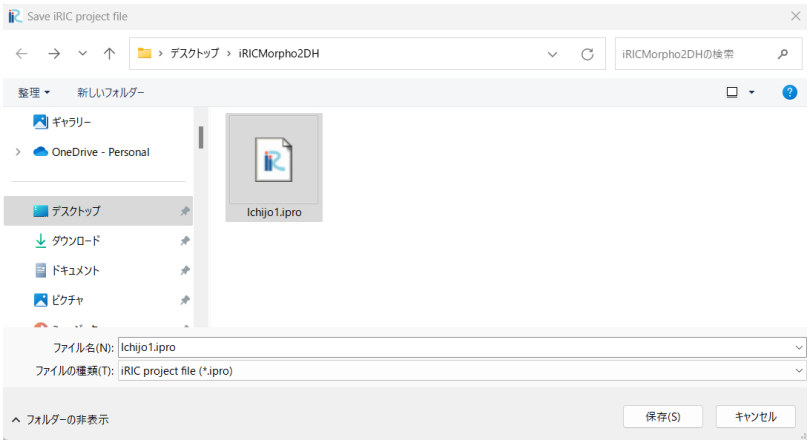



Figure II－9(4)　Save the project

| 5 | Startup the gray colored screen automatically. |
|---|---|

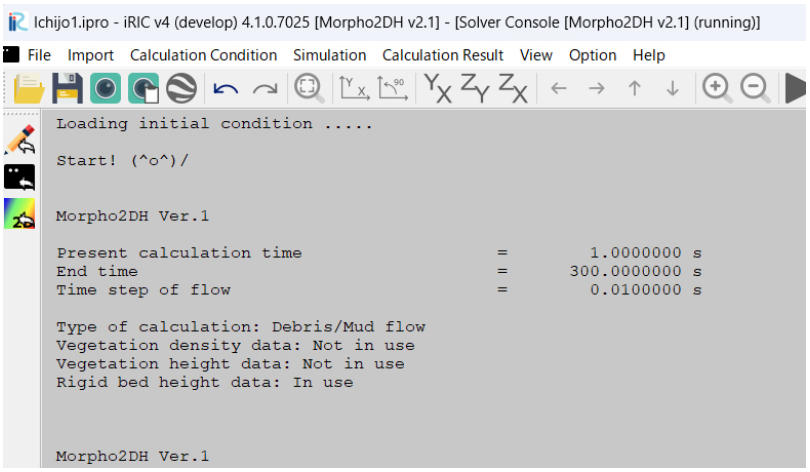



Figure II－9(5)　Information of the run on the screen

**※ Information on the screen**

Present calculation time (s)
End time (s)
Time step of flow (s)
Type of calculation,
Use/No Use of Vegetation density data, Vegetation height data, Rigid bed height data

6 When you want to check the calculation results during the run, please press button. The method to visualize the calculation results is explained in the next section.

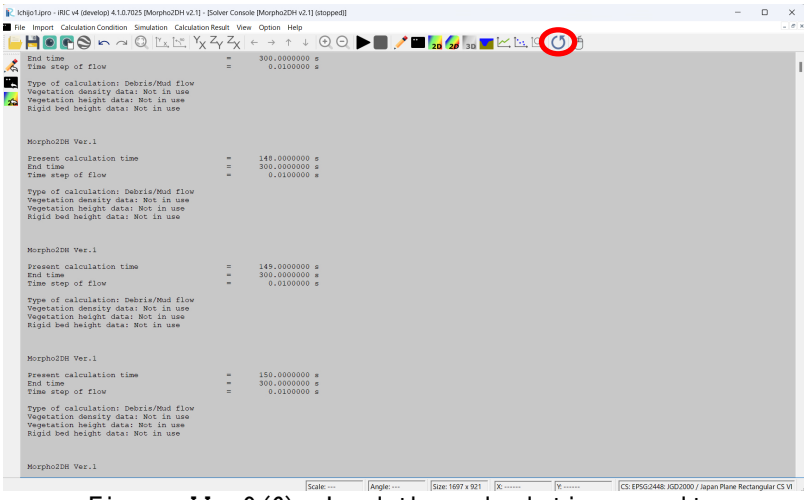


Figure II－9(6) Load the calculation results

7 When [Solver Finished] dialog box is popped up on the screen, press OK.

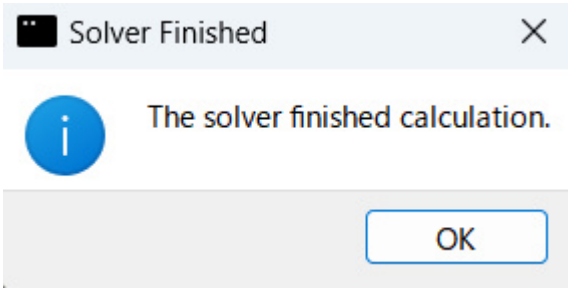



Figure II－9(7) Calculation is finished

# II.3 Visualization of calculation results

## II.3.1 Visualization of calculation results

1　Click  button.

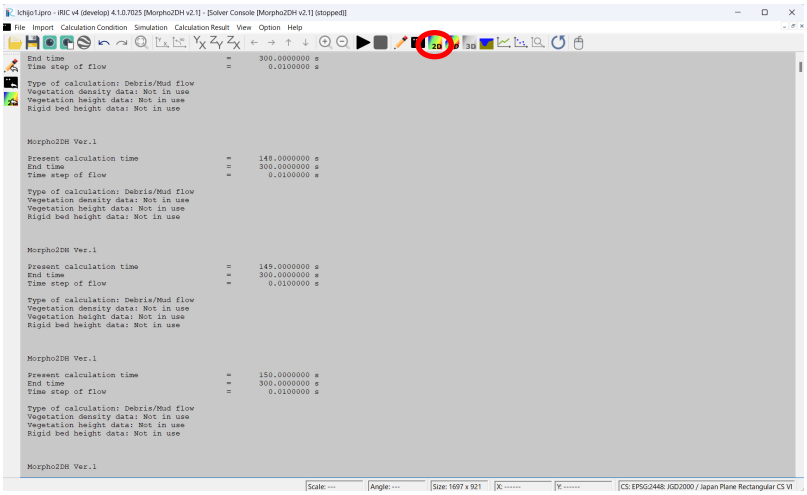


Figure II－10(1)　Open visualization window

**■Contour**

1　Check [Scalar]-[Depth] in [Object Browser]. Horizontal distribution of flow depth is shown.

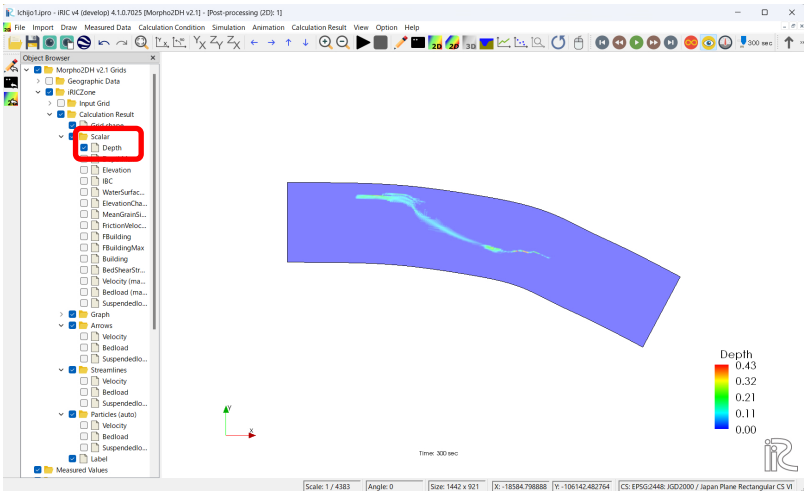



Figure II－10 (2)　Make contour of flow depth

| | |
|---|---|
| 2 | When you want to modify the format of the contour, please open [Property] by clicking [Scalar] by the right button. |
| 3 | If you want to visualize the flow region only, the value about 0 is inputted in [Min] in [Value range] and check off [Fill lower area]. |
| 4 | Modification of labels in the color bar can be made in [Color Bar Setting]. |

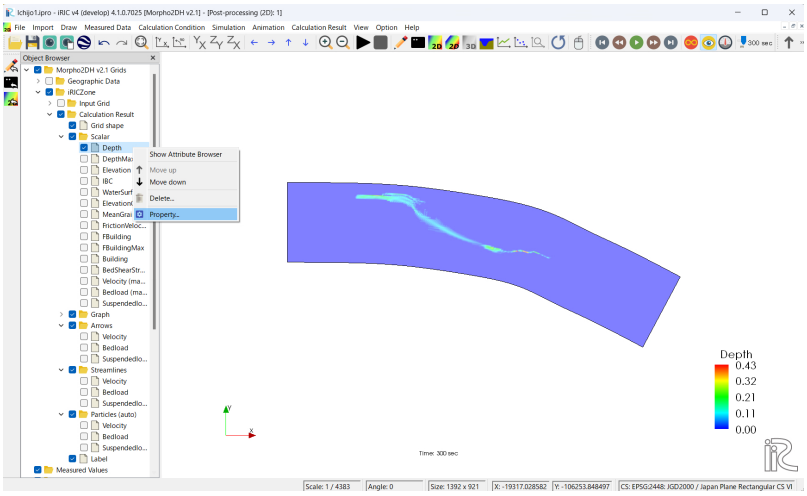



Figure II－10 (3)　Select Property

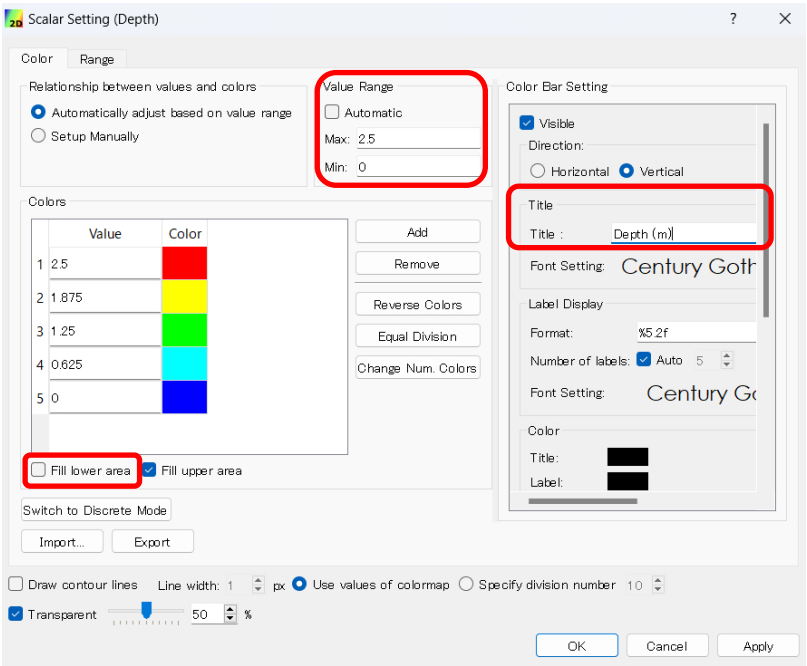



Figure II－10 (4)　Modification of contour

5　Check on [Background Images] in [Object Browser].
6　By using animation tool bar, calculation results can be checked as a movie.

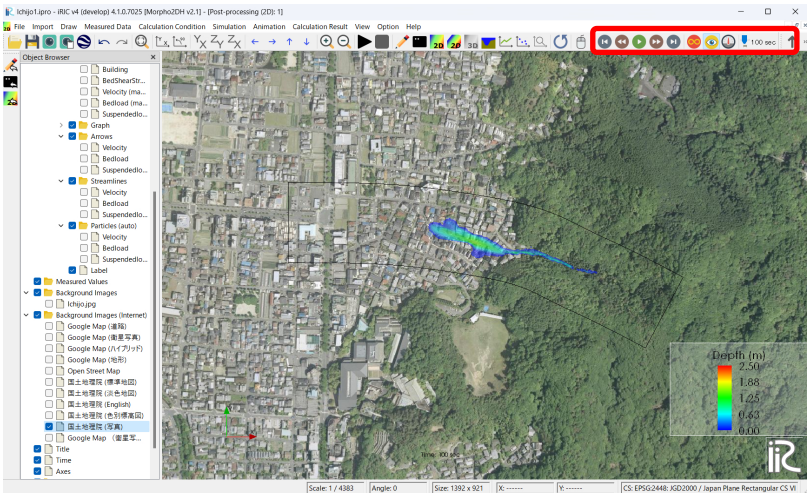



Figure II－10 (5)　Confirmation of the modification

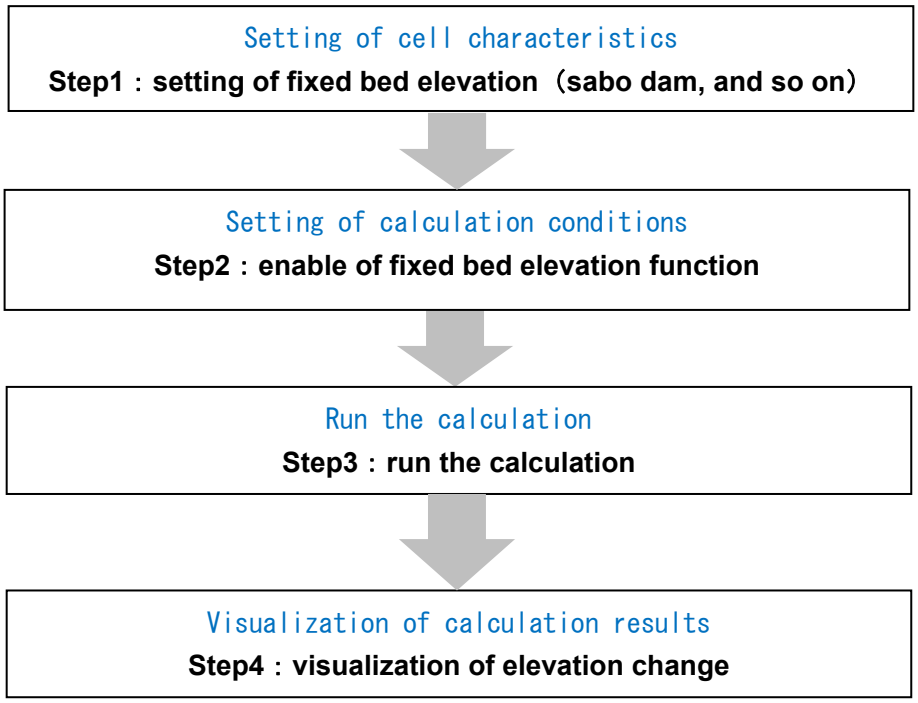
# III. Debris/Mud flow analysis with structures

## ◆ Purpose

The purpose of this chapter is for researchers, river engineers and university students who have no (or a few) experience of transport and deposition process of debris/mud flow analysis to learn to perform debris/mud flow analysis with structures (sabo dam, weir, and so on) by use of Morpho2DH and visualize the calculated results.

## ◆ Procedure

Procedure in this chapter is shown in Figure Ⅱ－1.




FigureⅢ－1　Procedure in this chapter

# III.1 Setting of fixed bed elevation（sabo dam, and so on）

## III.1.1 Setting of fixed bed elevation（sabo dam, and so on）

### ■ Setting of sabo dam

| | |
|---|---|
| 1 | Click [FixedBedElevation] in [Object Browser] by right button and select [Add] and [Polygon]. |

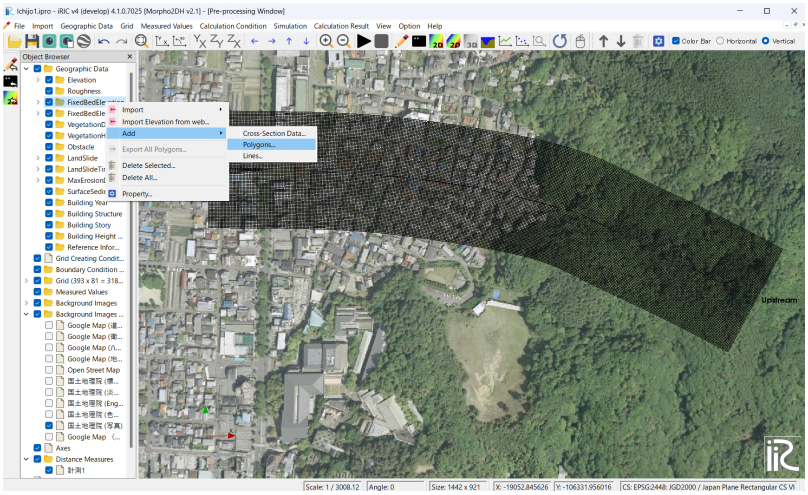



Figure Ⅲ－2(1)　Create polygon

| | |
|---|---|
| 2 | Make a polygon by clicking at the corners of the polygon. The horizontal shape of the polygon should be the same as the horizontal shape of the sabo dam. Double clicks stop to make the polygon. |

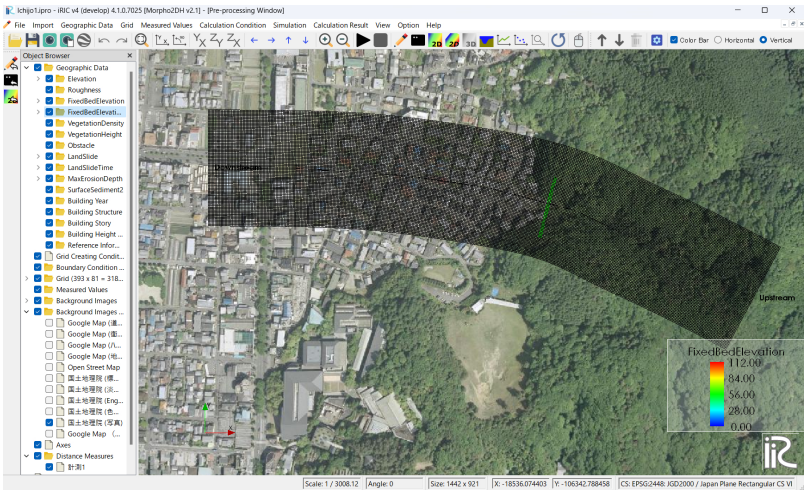
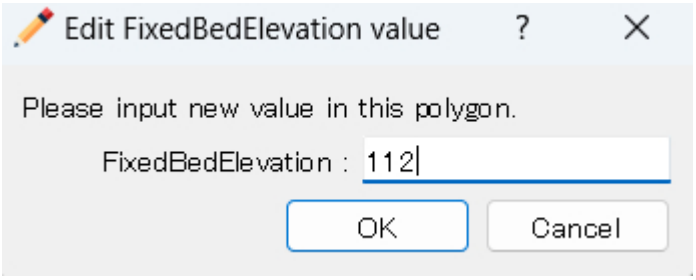



Figure Ⅲ-2(2)　Create polygon

| | |
|---|---|
| 3 | Enter the surface elevation of sabo dam in the small dialog box. (Here, the bed level immediately upstream of the sabo dam is approximately 107 m, so 112 m was entered assuming an approximately 5 m high sabo dam.) |




Unit is m.

Figure Ⅲ-2(3)　Input the surface elevation of sabo dam

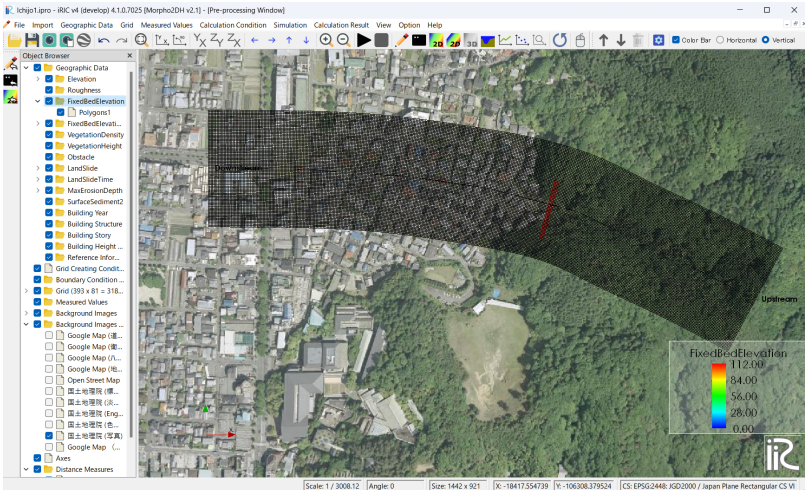


Figure Ⅲ-2(4)　Create polygon

| | |
|---|---|
| 4 | The reference elevation for the [FixedBedElevation] can be either the ground surface or the same reference elevation as the ground elevation data. Right-click the name of the polygon created as [FixedBedElevation] in the [Object Browser] and click [Copy]. |

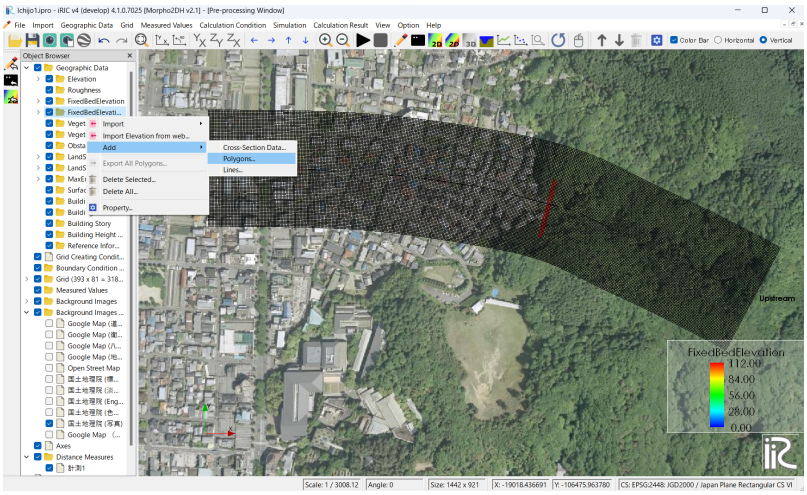


Figure Ⅲ-2(5)　Copy of the fixed bed elevation polygon

**※Fixed bed elevation and fixed bed elevation condition**

User can select the reference elevation for the [FixedBedElevation] from either the ground surface or the same reference elevation as the ground elevation data.

When [FixedBedElevationP] is not specified, the same reference elevation as the ground elevation data is used as the reference elevation for the [FixedBedElevation]

5　Select [FixedBedElevationP] as the destination of the copy.

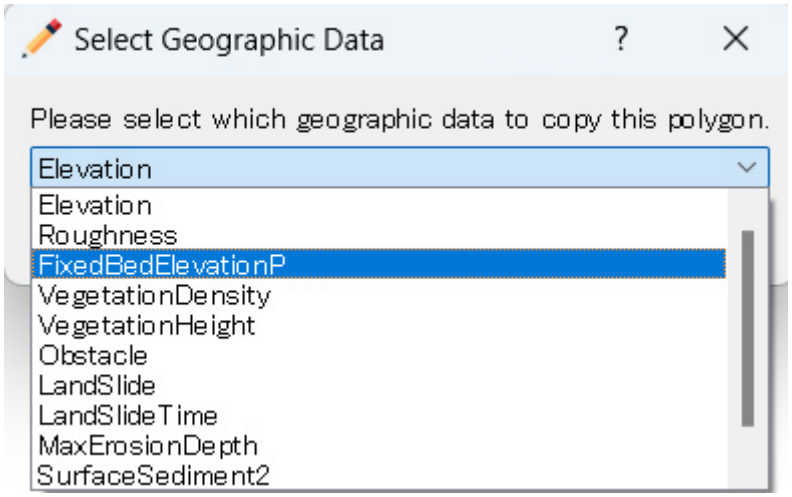



Figure Ⅲ-2(6)　Select the destination of the copy

6　Input [1], because the same reference elevation as the ground elevation data is used as the reference elevation for the [FixedBedElevation] here.

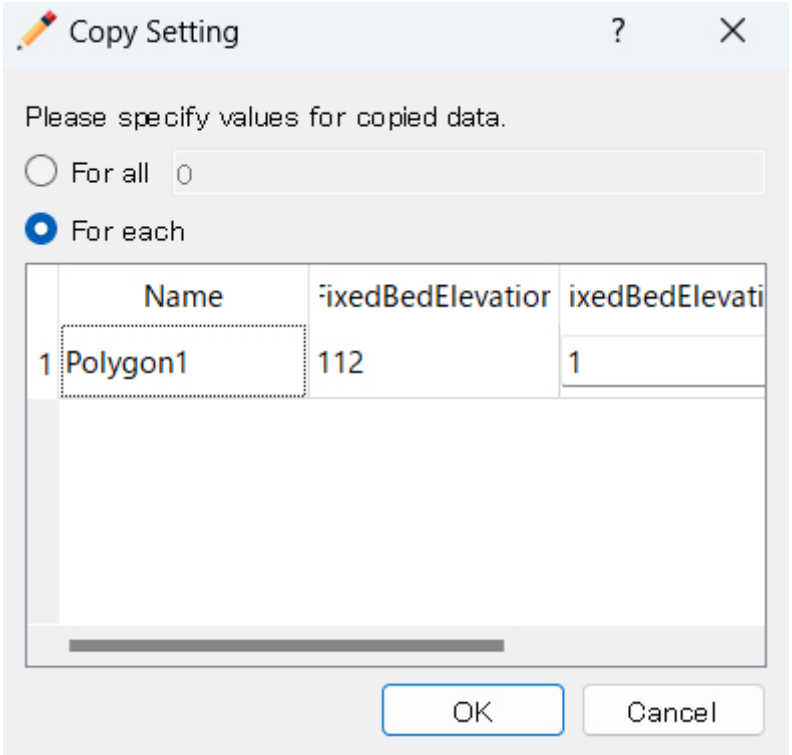



Figure Ⅲ-2(7)　Input fixed bed elevation condition

**※Fixed bed elevation condition**

When the same reference elevation as the ground elevation data is used as the reference elevation for the [FixedBedElevation], please input [1]. When the ground surface is used as the reference elevation for the [FixedBedElevation], please input [2].

## III.1.2 Setting of calculation conditions

### ■ Enable of fixed bed elevation function

1 Click [Setting] in [Calculation Condition] and select [Calculation Conditions (Debris/Mud Flow)] dialog box.
2 Select [Enabled] in [Non-erodible Height].
3 Press [OK] and run the calculation.

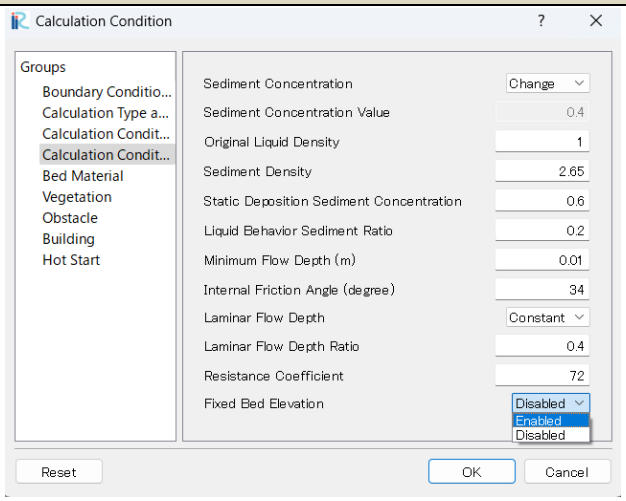



Figure Ⅲ-3 Enable of fixed bed elevation function

# III.2 Visualization of calculation results

## III.2.1 Visualization of elevation change

### ■Contour

1 Horizontal distribution of land elevation change is shown by checking [ElevationChange] in [Scalar] in [Object Browser]. Erosion of Land in the downstream of the landslide and the sediment deposition in the upstream of sabo dam is reproduced. Also, if you check on [Polygons1] in [Geographic Data]-[FixedBedElevation], the sabo dam is displayed. Sediment is deposited in the upstream area of the sabo dam.

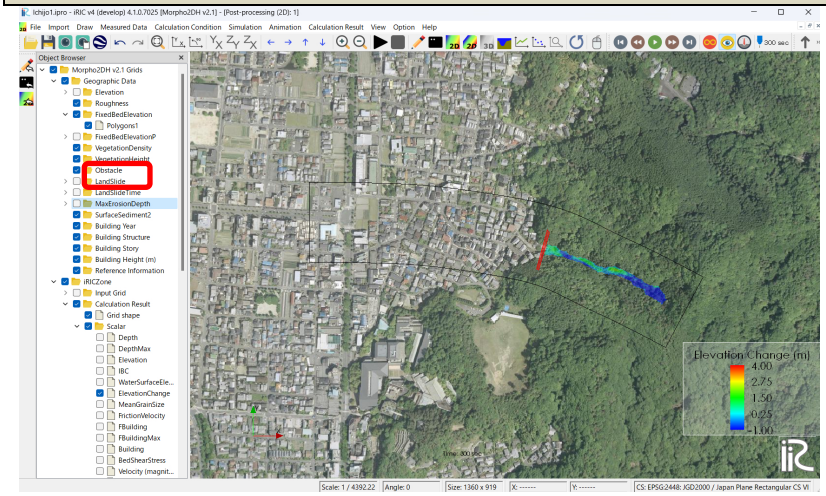



Figure Ⅲ-4 Contour of land elevation change