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Potato field moisture content [ULT]

This tutorial demonstrates the applicability of PLAXIS 2D to agricultural problems. The potato field tutorial involves a loam layer on top of a sandy base. The water level in the ditches remains unchanged. The precipitation and evaporation may vary on a daily basis due to weather conditions. The calculation aims to predict the variation of the water content in the loam layer in time as a result of time-dependent boundary conditions.

Objectives

- Defining precipitation

Geometry

Due to the symmetry of the problem, it is sufficient to simulate a strip with a width of 15.0 m, as indicated in the image below. The thickness of the loam layer is 2.0 m and the sand layer is 3.0 m deep.

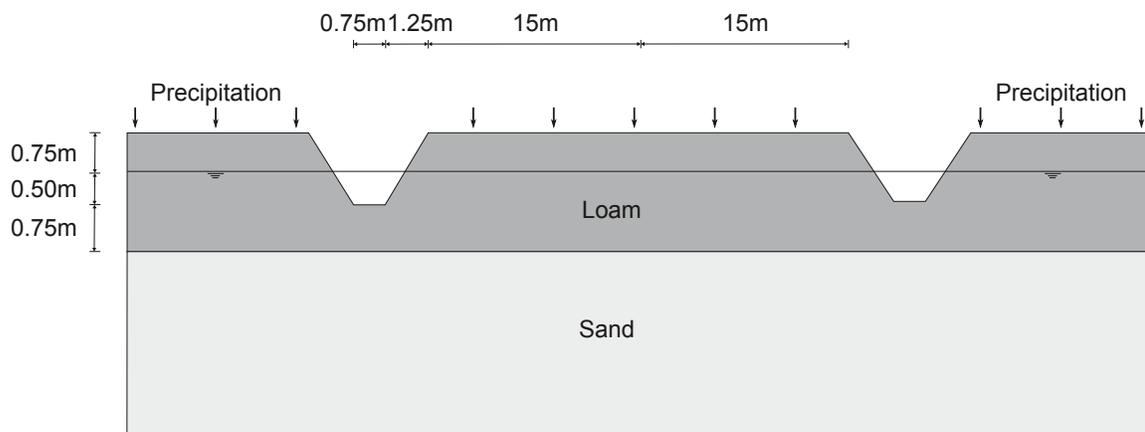


Figure 142: Potato field geometry

12.1 Create new project

To create a new project, follow these steps:

1. Start the Input program and select **Start a new project** from the **Quick select** dialog box.

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Define the soil stratigraphy

2. In the **Project** tabsheet of the **Project properties** window, enter an appropriate title.
3. In the **Model** tabsheet keep the default options for **Model (Plane strain)**, and **Elements (15-Node)**.
4. Set the model dimensions to: $x_{\min} = 0$ m, $x_{\max} = 15$ m, $y_{\min} = 0$ m and $y_{\max} = 5$ m.
5. Keep the default values for units, constants and the general parameters and press **OK**.
The **Project properties** window closes.

12.2 Define the soil stratigraphy

Due to the geometry of the model, the options for snapping should be changed.

1. Click the **Snapping options** button  in the bottom toolbar.

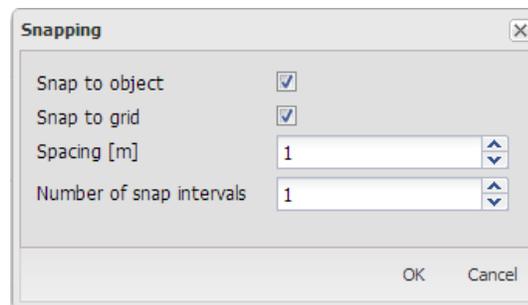


Figure 143: Modification of the *Number of snap intervals*

2. In the appearing window set the **Number of snap intervals** to 100.
3. Click **OK** to close the **Snapping** window.
To define the soil stratigraphy:
 4. Click the **Create borehole** button  and create two boreholes located at $x = 0.75$ and $x = 2$ respectively.
 5. In the **Modify soil layers** window add two soil layers.
 6. In the first borehole set **Top** = 3.75 and **Bottom** = 3 for the uppermost soil layer. Set **Bottom** = 0 for the lowest soil layer.
 7. In the second borehole set **Top** = 5 and **Bottom** = 3 for the uppermost soil layer. Set **Bottom** = 0 for the lowest soil layer.
 8. For both boreholes the **Head** is located at $y = 4.25$.The image below shows the soil stratigraphy defined in the **Modify soil layers** window.

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Create and assign material data sets

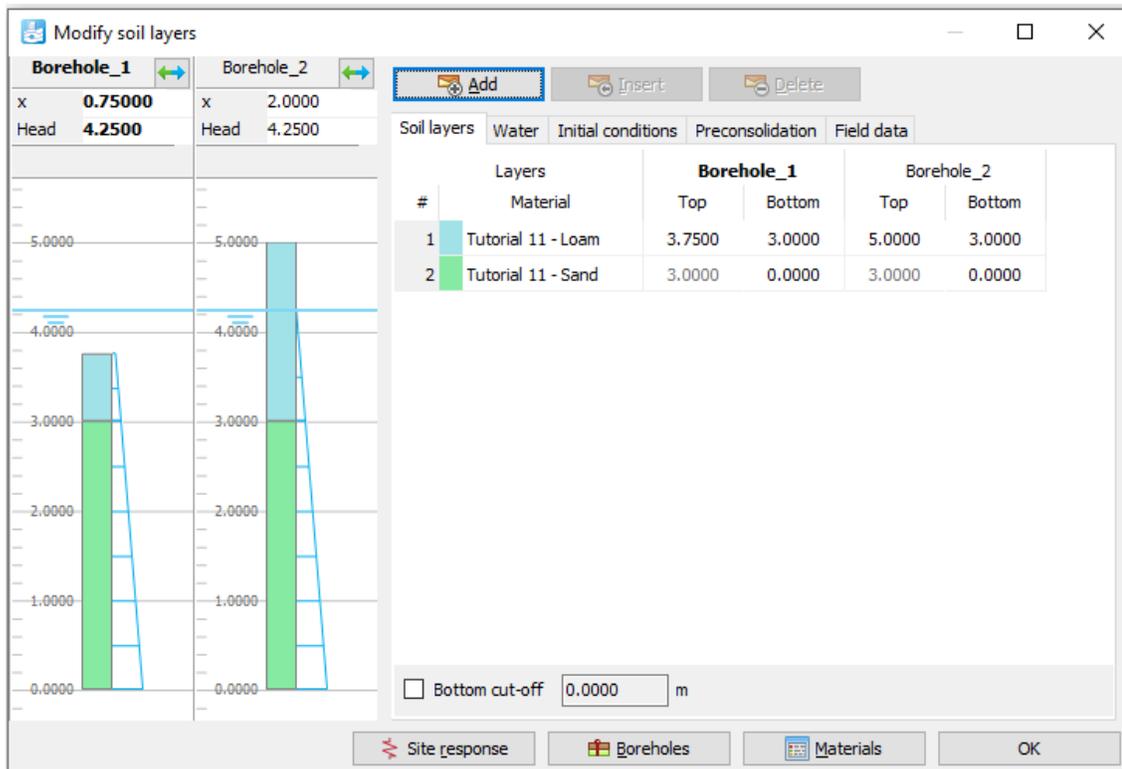


Figure 144: Soil stratigraphy in the **Modify soil layers** window

12.3 Create and assign material data sets

Two material data sets need to be created for the soil layers.

The layers have the following properties:

Table 28: Material properties of the material

Parameter	Name	Loam	Sand	Unit
General				
Material model	Model	Linear elastic	Linear elastic	-
Type of material behaviour	Type	Drained	Drained	-
Soil unit weight above phreatic level	γ_{unsat}	19	20	kN/m ³
Soil unit weight below phreatic level	γ_{sat}	19	20	kN/m ³
Parameters				

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Generate the mesh

Parameter	Name	Loam	Sand	Unit
Stiffness	E'	$1 \cdot 10^3$	$10 \cdot 10^3$	kN/m ²
Poisson's ratio	ν'	0.3	0.3	-
Groundwater				
Data set	Type	Staring	Staring	-
Model	-	Van Genuchten	Van Genuchten	-
Subsoil/Topsoil	-	Topsoil	Subsoil	-
Soil Type	-	Clayey loam (B9)	Loamy sand (O2)	-
Flow parameters - Use defaults	-	From data set	From data set	-
Permeability in horizontal direction	k_x	0.01538	0.1270	m/day
Permeability in vertical direction	k_y	0.01538	0.1270	m/day

To create the material sets, follow these steps:

1.  Create the material data sets according to [Table 28](#) (on page 171).
2. Assign the material data set to the corresponding clusters in the model.

12.4 Generate the mesh

1. Proceed to the **Mesh** mode.
2. Multi-select the line segments composing the upper boundary of the model:

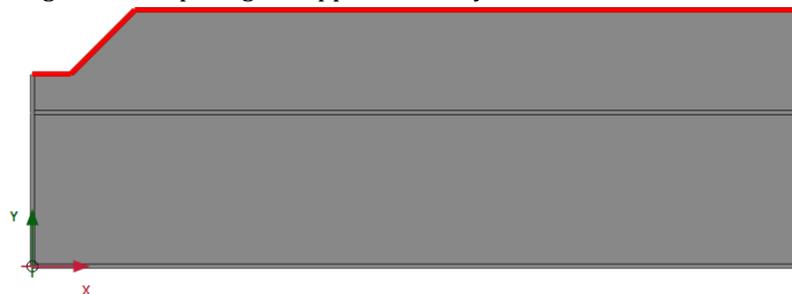


Figure 145: The upper boundary of the model

3. In the **Selection explorer** set the **Coarseness factor** parameter to 0.5.
4. Click the **Generate mesh** button  to generate the mesh. Use the default option for the **Element distribution** parameter (**Medium**).

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Define and perform the calculation

5. Click the **View mesh** button  to view the mesh.

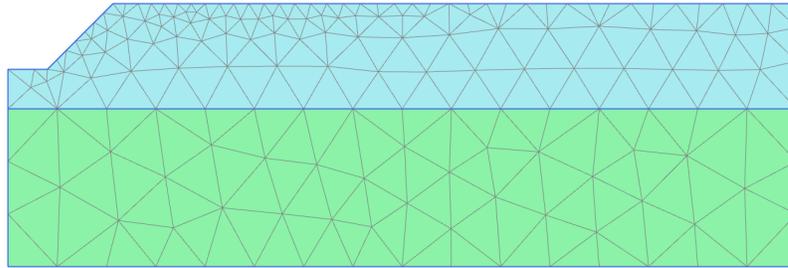


Figure 146: The generated mesh

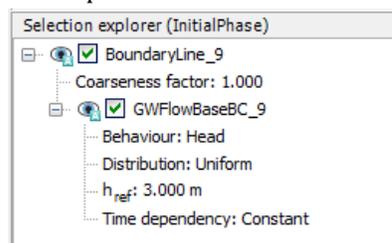
6. Click the **Close** tab to close the Output program.

12.5 Define and perform the calculation

The calculation process consists of two phases. In the initial phase, the groundwater flow in steady state is calculated. In Phase 1, the transient groundwater flow is calculated.

12.5.1 Initial phase

1. Proceed to the **Staged construction** mode. In this project only groundwater flow analysis will be performed.
2. In the **Phases** window select the **Flow only** option as the **Calculation type** in the **General** subtree.
3. The default values of the remaining parameters are valid for this phase. Click **OK** to close the **Phases** window.
4.  Right-click the bottom boundary of the model and select the **Activate** option in the appearing menu.
5. In the **Selection explorer** select the **Head** option in the **Behaviour** drop-down menu and set h_{ref} to 3.0.



6. In the **Model explorer** expand the **Model conditions** subtree.
7. Expand the **GroundwaterFlow** subtree. Set **BoundaryXMin** and **BoundaryXMax** to **Closed**.
8. Expand the **Water** subtree. The borehole water level is assigned to **GlobalWaterLevel**.

Note: Note that the conditions explicitly assigned to groundwater flow boundaries are taken into account. In this tutorial the specified **Head** will be considered for the bottom boundary of the model, NOT the **Closed** condition specified in the **GroundwaterFlow** subtree under the **Model conditions**.

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Define and perform the calculation

12.5.2 Transient phase

In the transient phase the time-dependent variation of precipitation is defined.

A discharge function with the following precipitation data will be defined.

Table 29: Precipitation data

ID	Time [days]	Δ Discharge [m ³ /day/m]
1	0	0
2	1	0.01
3	2	0.03
4	3	0
5	4	-0.02
6	5	0
7	6	0.01
8	7	0.01
9	8	0
10	9	-0.02
11	10	-0.02
12	11	-0.02
13	12	-0.01
14	13	-0.01
15	14	0
16	15	0

1. Click the **Add phase** button  to create a new phase.
2. In **General** subtree of the **Phases** window select the **Transient groundwater flow** as **Pore pressure calculation type**.
3. Set the **Time interval** to 15 days.
4. In the **Numerical control parameters** subtree set the **Max number of steps stored** to 250. The default values of the remaining parameters will be used.

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Define and perform the calculation

5. Click **OK** to close the **Phases** window.
6. **Note:** To define the precipitation data a discharge function should be defined.

In the **Model explorer** expand the **Attributes library** subtree.

7. Right-click on **Flow functions** and select the **Edit** option in the appearing menu. The **Flow functions** window pops up.
8. In the **Discharge functions** tabsheet add a new function.
9. Specify a name for the function and select the **Table** option in the **Signal** drop-down menu.
10. Click the **Add row** button to introduce a new row in the table. Complete the data using the values given in the [Table 29](#) (on page 174).
The following image shows the defined function for precipitation.

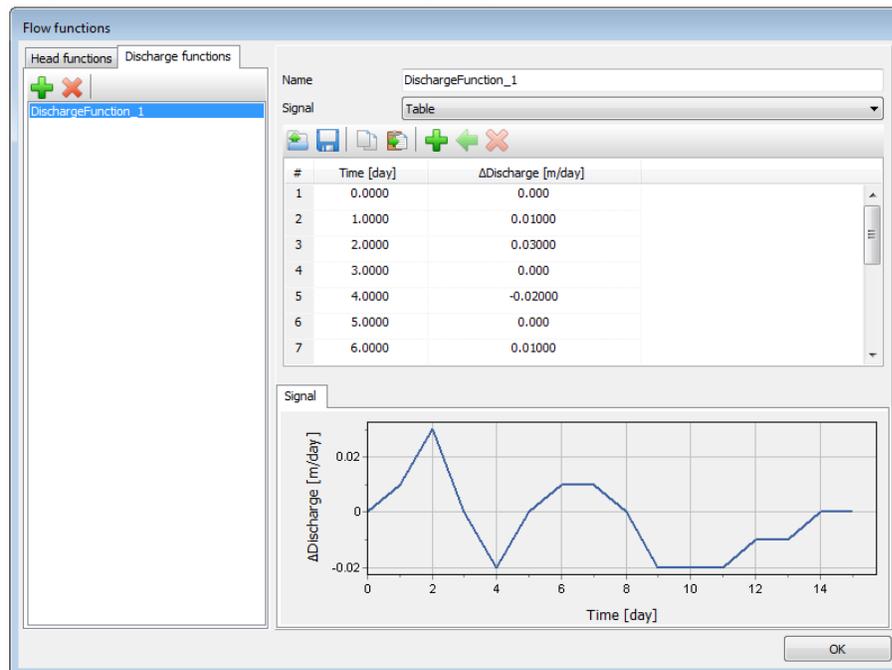


Figure 147: The **Flow function** window displaying the precipitation data and plot

11. Close the windows by clicking **OK**.
12. In the **Model explorer** expand the **Precipitation** subtree under **Model conditions** and activate it. The default values for discharge (q) and condition parameters ($\psi_{\min} = -1.0$ m and $\psi_{\max} = 0.1$ m) are valid.
13. For the precipitation select the **Time dependent** option in the corresponding drop-down menu and assign the defined function.
14. In the **Model explorer** set DischargeFunction_1 under **Discharge function**.

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Results

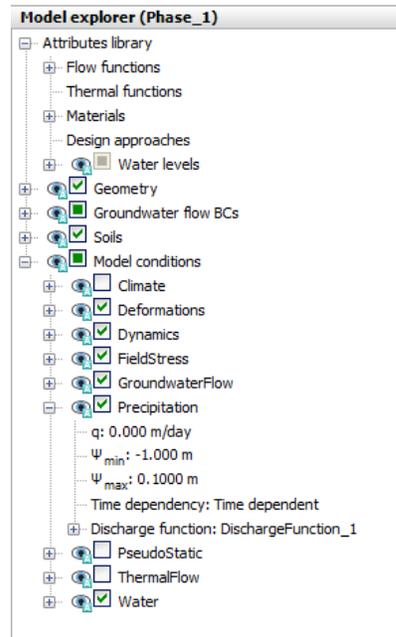


Figure 148: Precipitation in the Model explorer

Note: Negative values of precipitation indicate evaporation.

12.5.3 Execute the calculation

1. Click the **Calculate** button  to calculate the project.
2.  Save the project after the calculation has finished.

12.6 Results

The calculation was focused on the time-dependent saturation of the potato field.

To view the results:

1. Click the menu **Stresses > Groundwater flow > Saturation**.
2. Double click the legend.

The **Legend settings** window pops up. Define the settings as shown:

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Results

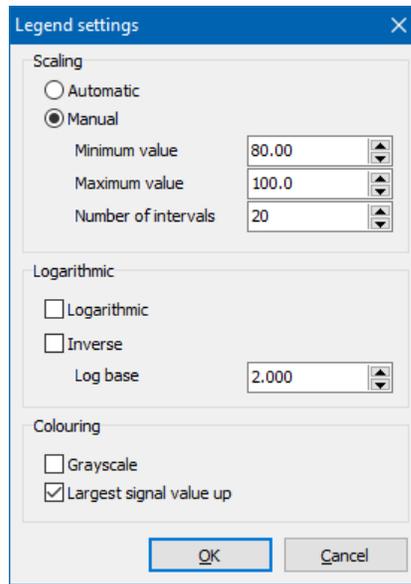


Figure 149: Value for settings

3. The following figure shows the spatial distribution of the saturation for the last time step.

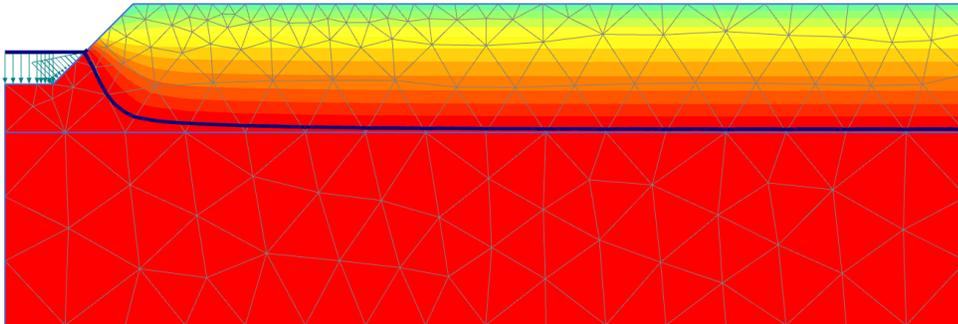


Figure 150: Saturation field at day 15

4. Create an animation of the transient phase for a better visualisation of the results.
5. It is also interesting to create a vertical cross section at $x = 4$ m and draw cross section curves for pore pressure and saturation.