POLLUTE

Version 8

Example 4: Finite Mass Source

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Description

In this example the input data file from Case 3 will be edited to include a source with a finite mass of waste and a leachate collection system. The hydrogeology is comprised of a 4 m thick layer with a finite mass source at the top, and an underlying aquifer at the base with fixed outflow as discussed in Case 3. All of the parameters are the same as in Case 3, except the vertical Darcy velocity will be 0.03 m/a, the horizontal inflow velocity will be 4 m/a and there will be a finite mass top boundary condition. The finite mass top boundary condition requires the input of the Reference Height of Leachate (H_r), Rate of Increase in Concentration (C_r), and the Volume of Leachate Collected (Q_c).

It is assumed in this example that the waste has an average thickness of 6.25 m and a density of 600 kg/m^3, and that chloride represents 0.2% of the total mass of the waste. Thus, the total mass of chloride per unit area of the landfill (m_{tc}) is calculated by multiplying the proportion of chloride by the density of the waste and the thickness of the waste.

$$\text{i.e. } m_{tc} = 0.002 * 600 * 6.25 \text{ kg/m}^2$$

A peak concentration (c_o) for chloride of 1000 mg/L (i..e., 1 kg/m^3) is assumed. The Reference Height of Leachate is then:

$$H_r = m_{tc} / c_o = 0.002 * 600 * 6.25 / 1 = 7.5 \text{ m}$$

If the peak concentration is reached relatively early in the life of the landfill and the analysis starts at this time, then there will be no increase in concentration with time. The Rate of Increase in Concentration (C_r) would then be zero.

The Volume of Leachate (Q_c) collected is equal to the difference between the infiltration through the cover (q_o = 0.3 m/a here) and the exfiltration through the base (v_a = 0.03 m/a here), and is given by:

$$Q_r = q_o - v_a = 0.3 - 0.3 = 0.27 \text{ m/a}$$

In this example the inflow in the aquifer at the up gradient edge of the landfill will be 4 m/a and the outflow at the down gradient edge (v_b) is then:

$$v_b = (v_b(in)*h*W + v_a*L*W)/(h*W) = v_a(in) + v_a*L/h = 4 + 0.03*200/3 = 6 \text{ m/a}$$

The following parameters are assumed for the example:

Property	Symbol	Value	Units
Darcy Velocity	v_a	0.03	m/a
Diffusion Coefficient	D	0.01	m^2/a
Distribution Coefficient	K_d	0	cm^3/g
Soil Porosity	n	0.4	-
Dry Density		1.5	g/cm^3
Soil Layer Thickness	H	4	m
Number of Sub-layers		4	-
Source Concentration	c_o	1000	mg/L
Rate of Increase in co	c_r	0	mg/L/a
Ref. Height of Leachate	H_r	7.5	m
Volume Collected	Q_c	0.27	m/a

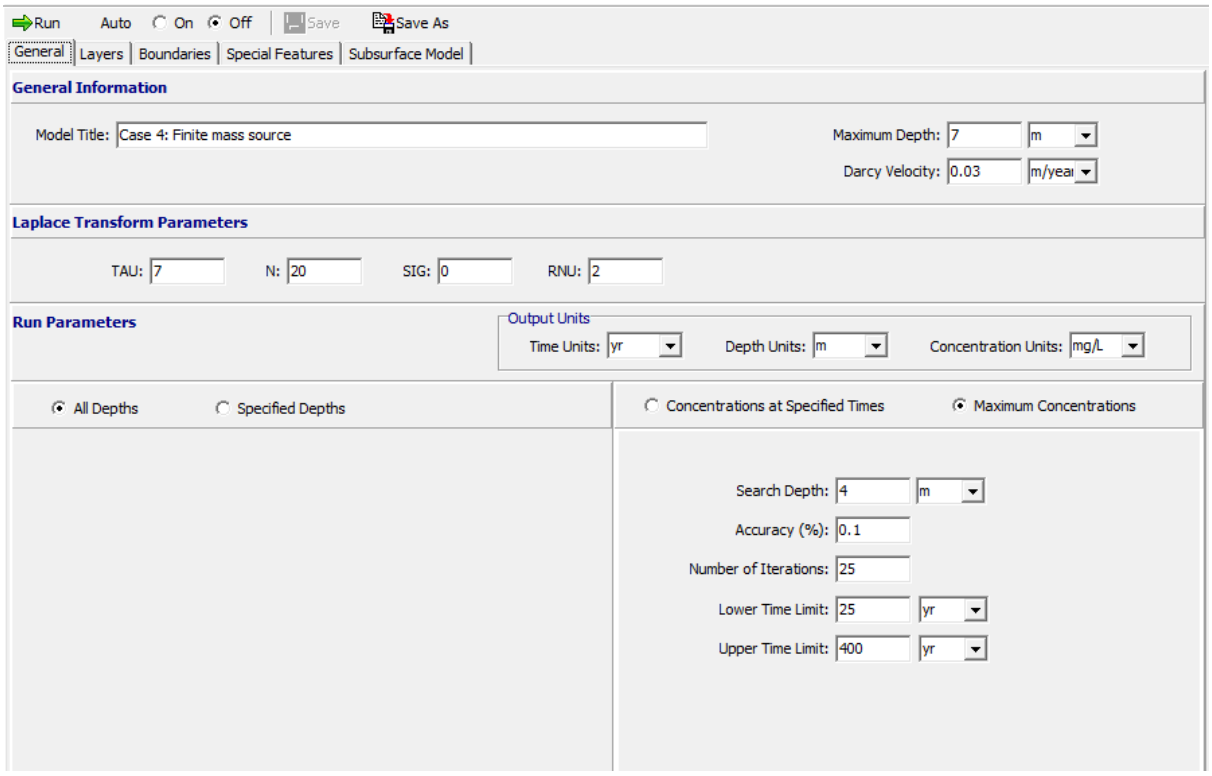
Landfill Length	L	200	m
Landfill Width	W	300	m
Thickness of Aquifer	h	3	m
Porosity of Aquifer	n_b	0.3	
Base Outflow Velocity	v_b	6	m/a
Upper and Lower Time Limits		25, 400	a

The landfill length is measured in the direction parallel to groundwater flow. And the landfill width is the direction perpendicular to groundwater flow, since this is not a 3D analysis this parameter has no effect on the results.

Data Entry

Open the Examples project and open Case 4.

General Tab

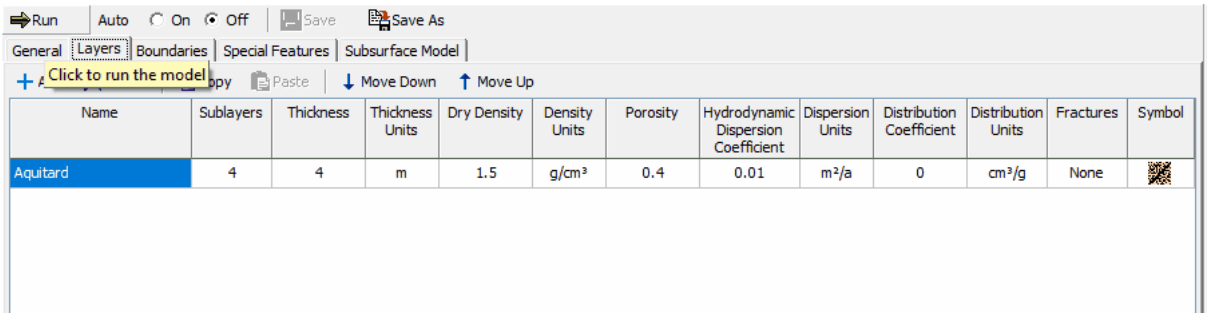


The general data for this example is the same as in Case 3, except for the Darcy velocity. To edit the Darcy velocity either click on the title or select the General Data menu item from the Data Entry menu. On the General Data form below the Darcy velocity of 0.03 m/a can be specified.

Provided the initial estimate for these time limits are reasonable the program will find the maximum even if it lies outside these limits. The default values for the Accuracy and Maximum number of Search Attempts should prove sufficient for this example and most other problems.

The run parameters for this model are the same as in Case 4.

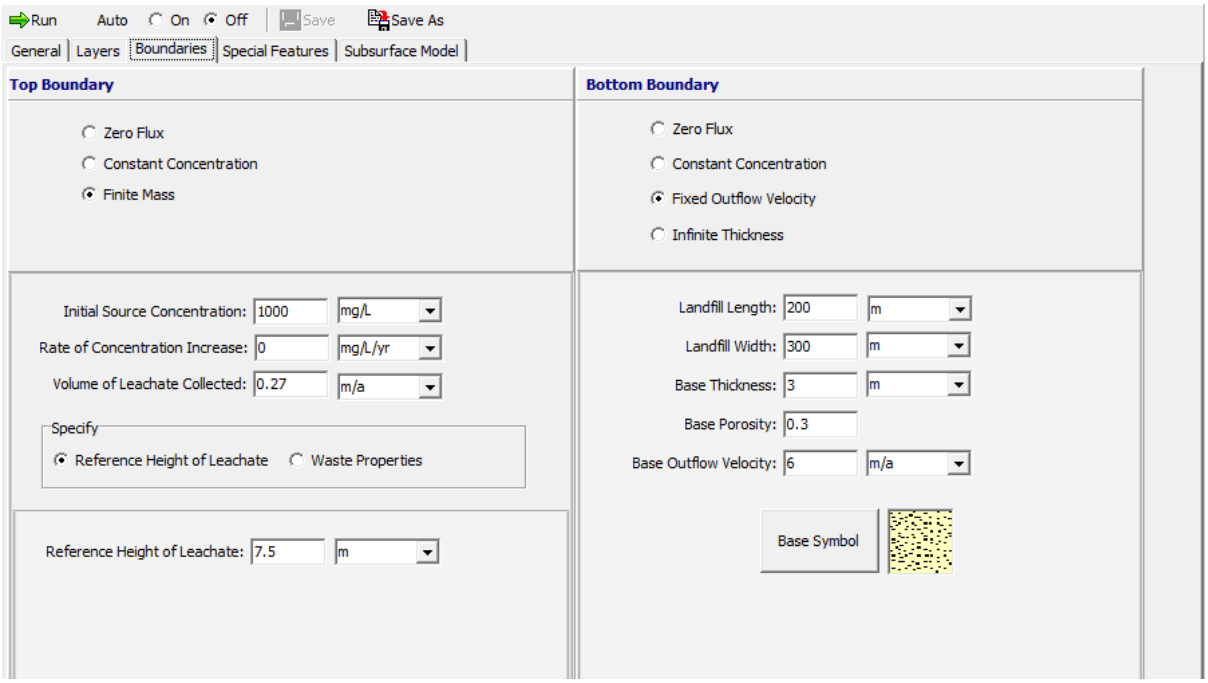
Layers Tab



Name	Sublayers	Thickness	Thickness Units	Dry Density	Density Units	Porosity	Hydrodynamic Dispersion Coefficient	Dispersion Units	Distribution Coefficient	Distribution Units	Fractures	Symbol
Aquitard	4	4	m	1.5	g/cm³	0.4	0.01	m²/a	0	cm³/g	None	

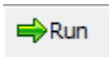
The layer data for this model is the same as that in Case 3.

Boundaries Tab



The boundary conditions for the model can be specified on the Boundaries tab. In this example, the top boundary has a finite mass and the bottom boundary is represented as an aquifer with a fixed outflow velocity.

Model Execution



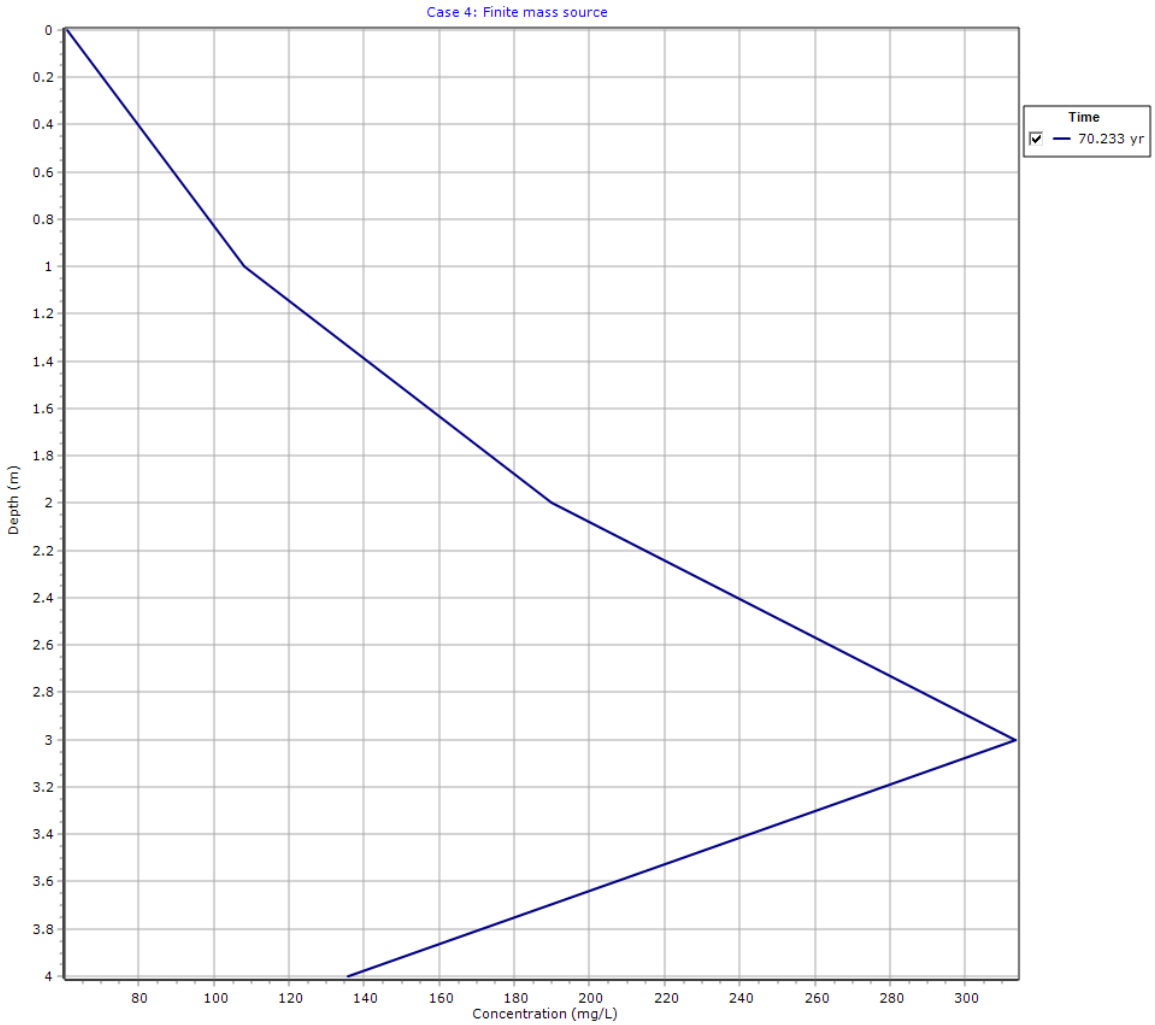
To run the model and calculate the concentrations press the Run button on the toolbar.

Model Output

After the model has been executed, the output for the model will be displayed.

Depth vs Concentration

The Depth vs Concentration chart can be displayed by selecting the Depth vs Concentration item for the Chart Type.



Output Listing

To display the output as a text listing that will show the calculated concentrations as numbers, click on the List tab.The maximum concentration in the aquifer in this example is 136 mg/L. This peak occurs at 70 years.

POLLUTEv8

Version 8.00 Beta

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Case 4: Finite mass source

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS Va = 0.03 m/year

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Aquitard	4 m	4	0.01 m²/a	0.4	0 cm³/g	1.5 g/cm³

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 1000 mg/L
Rate of Increase = 0 mg/L/yr
Volume of Leachate Collected = 0.27 m/a
Thickness of Waste = 0 m
Waste Density = 0 kg/m³
Proportion of Mass = 0
Volumetric Water Content = 0
Conversion Rate Half Life = 0 year
Reference Height of Leachate = 7.5 m

Fixed Outflow Bottom Boundary

Landfill Length = 200 m
Landfill Width = 300 m
Base Thickness = 3 m
Base Porosity = 0.3
Base Outflow Velocity = 6 m/a

Laplace Transform Parameters

TAU = 7 N = 20 SIG = 0 RNU = 2

Maximum Base Concentration Parameters

Depth to Search = 4 m

Lower Time Limit = 25 yr
Upper Time Limit = 400 yr
Base Concentration Accuracy = 0.1
Maximum Search Attempts = 25

Maximum Base Concentration and Time of Occurrence

Time yr	Depth m	Concentration mg/L	Preceeding Time	Preceeding Concentration	Exceeding Time	Exceeding Concentration
7.0233E+01	0.0000E+00	6.1040E+01				
	1.0000E+00	1.0820E+02				
	2.0000E+00	1.8998E+02				
	3.0000E+00	3.1335E+02				
	4.0000E+00	1.3589E+02	6.8517E+01	1.3550E+02	7.1949E+01	1.3548E+02

Number of Search Attempts = 5