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GrundRisk Landfill User Guideline

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Sources must be acknowledged

Forbehold

Denne rapport er en del af "Metodik til stedsspecifik risikovurdering ved deponering af affald". Rapporten er foreløbig og af oplysende karakter, og indholdet kan på nuværende tidspunkt ikke alene danne grundlag for en konkret sagsbehandling og myndighedsafgørelse. Baggrunden for dette er, at Miljøstyrelsen arbejder for at afklare særlige forhold omkring vandrammedirektivets betydning for stedsspecifik vurdering af deponeringsanlæg og påvirkningen heraf i receptor. Afklaringerne kan give anledning til konsekvensrettelser i metodikken, som den er formuleret for nuværende, og det kan være nødvendigt at rettelserne skal indarbejdes i metodikkens værktøjer herunder modelværktøjer, brugervejledninger og dokumentationsrapporter. Således må offentliggjorte rapporter og værktøjer under metodikken for nuværende betragtes som foreløbige.

Miljøstyrelsen offentliggør rapporter og indlæg vedrørende forsknings- og udviklingsprojekter inden for miljøsektoren. Det skal bemærkes, at en sådan offentliggørelse ikke nødvendigvis betyder, at det pågældende indlæg giver udtryk for Miljøstyrelsens synspunkter. Offentliggørelsen betyder imidlertid, at indlægget udgør et væsentligt indlæg i debatten omkring den danske miljøpolitik.

Risikovurderingsværktøjet er beregningsteknisk forberedt til at kunne regne med nedbrydning når et bedre datagrundlag er tilvejebragt. Derfor indgår nedbrydning i sammenfatningen, brugervejledninger og som en del af transportmodellen. Miljøstyrelsen finder på nuværende tidspunkt ikke tilfredsstillende dokumentation for at nedbrydning kan indgå som en aktiv del i sagsbehandlingen ved brug af værktøjet. Såfremt at der på et senere tidspunkt tilvejebringes ny viden er Miljøstyrelsen åben for at lade nedbrydning indgå. Det betyder at metoden er forberedt til at inkludere nedbrydning, men at Miljøstyrelsen mangler den nødvendige viden for at kunne vurdere denne i sagsbehandlingen. Ny viden kan bl.a. bestå i en opdateret samlet videnskabelig rapport, hvor det er beskrevet, hvorledes der kan regnes med nedbrydning konkret i perkolfaner fra deponeringsanlæg.

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1. Introduction

This is a guidance document to assist the use of the user interface GrundRisk landfills. The models of the interface are described in Miljøstyrelsen, 2018. The user interface includes 2 different models (Affald-A and Affald-B) to simulate contaminant transport from landfills. Each model has 2 different graphical user interfaces: one to simulate contaminant transport from a single source unit and one for multiple source units since landfills can be made either of a single or multiple units.

The following sections describe the details of the user interface. This user manual includes some practical tutorials/examples so that the user can see how to set up a similar case study. The input files for these tutorials are provided together with the model.

The models simulate the contaminant water phase concentration and mass discharge in the aquifer downstream the landfill. The concentrations are simulated over a 2 m well screen at a user specified distance (Point of compliance) downstream the landfill/unit. The input time series of concentration and water discharge from the landfill are obtained from the Kildestyrke-model (2017).

2. System requirements

The program was implemented in MATLAB and it is distributed in a standalone version that does not require a MATLAB license. The program is compatible with Microsoft Windows systems and it might not work with other operating systems. An internet connection is required during the installation process. Once the program is installed it can be used without internet.

3. How to install

The program needs to be installed in order to be used. The user needs to run the distributed .exe file by double clicking on it (it can take few minutes until the installation window pops up). The installation procedure will download approximately 600 MB and therefore an internet connection is required during the process. The user needs to follow the instruction similarly to other software.

4. Model input parameters

The input model parameters of the model Affald-A are shown in the following table. The report of Miljøstyrelsen (2018) shows some examples about setting the parameter values (it was recommended that the groundwater velocity u should be the one at the most downstream point of the landfill).

TABLE 1. Input parameters of the model Affald-A (from Miljøstyrelsen, 2018)

	Parameter	Description
Single source parameters	$C_0(t)$ [M/L ³]	Concentration time series in the water phase at the source, this is provided by the Kildestyrkemodel
	$Q_0(t)$ [L ³ /T]	Landfill water discharge time series through the source area, this is provided by Kildestyrkemodel
	Z [L]	Distance between the bottom of the landfill unit and the top of the aquifer
	L_x [L]	Source length, this is provided by Kildestyrkemodel
	L_y [L]	Source width, this is provided by Kildestyrkemodel
Vertical model	k_v [T ⁻¹]	First order degradation rate
	θ_v [-]	Water content (fraction of the total volume)
	R_v [-]	Retardation factor
Horizontal model	H [L]	Thickness of the aquifer
	I [L/T]	Groundwater recharge
	u [L/T]	Groundwater velocity
	k [T ⁻¹]	First order degradation rate
	n [-]	Porosity
	α_L [L]	Longitudinal dispersivity (x direction)
	α_T [L]	Transversal dispersivity (y direction)
	α_V [L]	Vertical dispersivity (z direction)
	R [-]	Retardation factor
	POC [L]	Distance to the point of compliance

Similarly, the input model parameters of the model Affald-B are shown in the following table.

TABLE 2. Input parameters of the model Affald-B (from Miljøstyrelsen,2018)

	Parameter	Description
Single source parameters	$C_o(t)$ [M/L ³]	Concentration time series in the water phase at the source, this is provided by Kildestyrke-model model
	$Q_o(t)$ [L ³ /T]	Landfill water discharge time series through the source area, this is provided by Kildestyrke-model model
	L_z [L]	Source depth, this is provided by Kildestyrkemodel model
	L_y [L]	Source width, this is provided by Kildestyrkemodel model
Horizontal model	H [L]	Thickness of the aquifer
	u [L/T]	Groundwater velocity
	k [T ⁻¹]	First order degradation rate
	n [-]	Porosity
	α_L [L]	Longitudinal dispersivity (x direction)
	α_T [L]	Transversal dispersivity (y direction)
	α_V [L]	Vertical dispersivity (z direction)
	R [-]	Retardation factor
	POC [L]	Distance to the point of compliance

5. Start the program. The main window

Once the program has been successfully installed it can be launched from the main Windows menu.

The main window of the user interface is shown in the figure below.

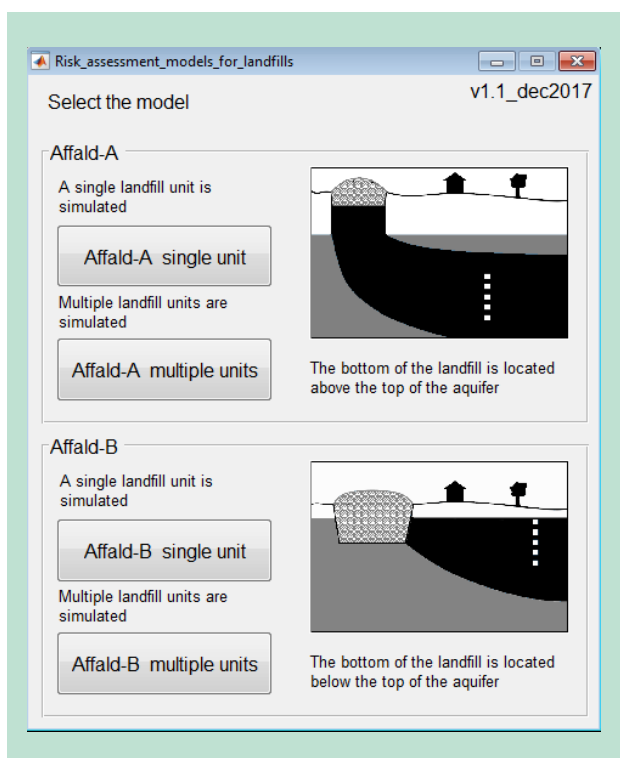


FIGURE 1. The main window of the user interface.

The main window of the user interface allows the user to choose between 4 different options. Each of the 2 models (Affald-A and Affald-B) has 2 options: the first simulates a single source unit of a landfill, the second a landfill made of several source units.

The following figure shows the 4 models (from Miljøstyrelsen, 2018).

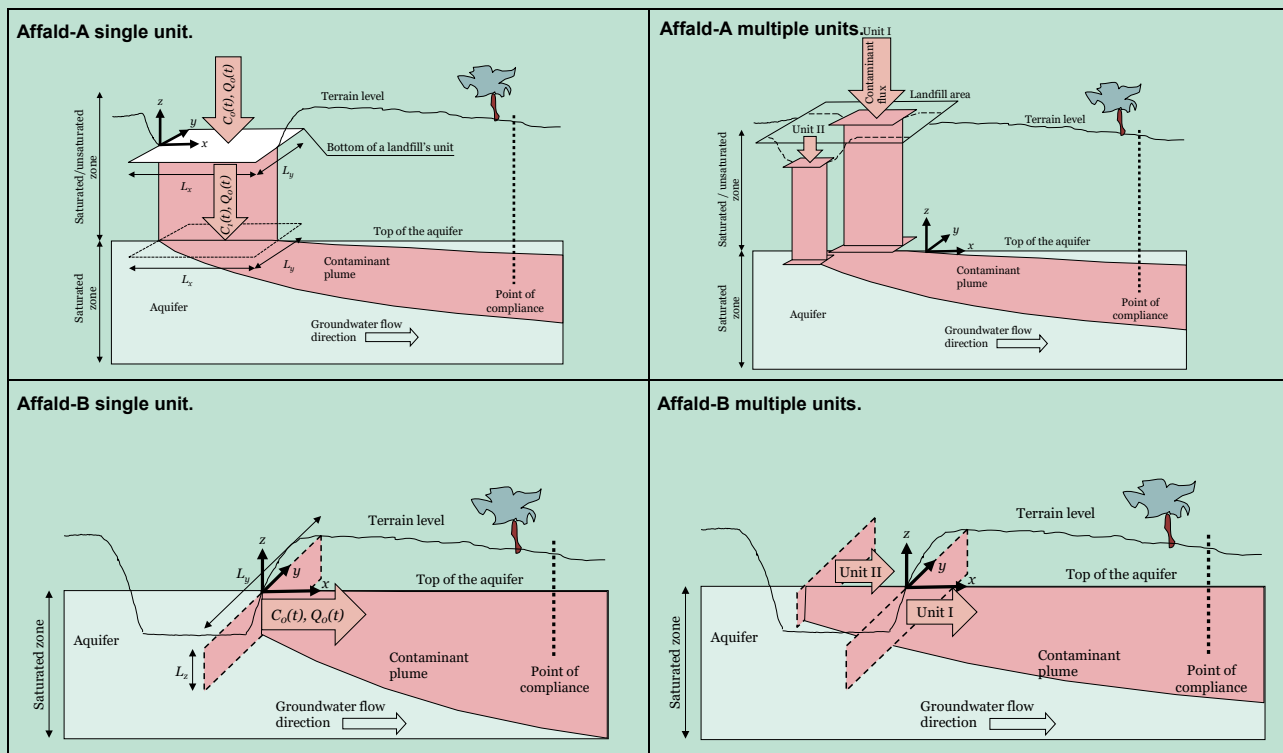


FIGURE 2. Overview of the different models (from Miljøstyrelsen, 2018).

6. Affald-A single unit

The model “Affald-A single unit” (Figure 2) can be used to simulate concentration and mass discharge downstream a single landfill unit that is located above the aquifer (the bottom of the unit is above the top of the aquifer).

The interface of the model “Affald-A single unit” is shown in the following figure. The user has different options (Back to the main menu; Load model inputs).

First of all, the user must enter the input time series of concentration and water discharge that are provided by the Kildestyrkemodel (2017) (see the section “How to create the input .txt file”). The user needs to press “Browse” within the “Source inputs” box. A new window pops up where the user needs to select the input .txt file. The input file must be created correctly according to the instructions given in the section “How to create the input .txt file”. If the input .txt file is made correctly the user will be able to see the 2 graphs of the input time series (water discharge and concentration) in the user interface.

Once the input time series is included then the user can save (this is optional) the input parameters by pressing “Save” in the “Save all the inputs” box. The user can also load previously saved inputs by pressing “Load model inputs”. When all the input parameters are given the user can select the result file name. The result file name is recommended to have the case study name and the compound being modeled (i.e. Ryparken_Ammonium.txt). Finally, the user can run the model by clicking on the “RUN” button. The model will run and automatically pop-up a result window and write the output .txt file in the same location as the selected .txt input file.

The screenshot shows the 'Affald_A_single' model interface. It includes sections for 'Source inputs', 'Vertical transport parameters', 'Horizontal transport parameters', 'Save all the inputs (optional)', and 'Outputs'. The 'Source inputs' section has fields for length (200) and width (120) and a 'Browse' button. The 'Vertical transport parameters' section has fields for retardation factor (2.5), first order degradation rate (1.0e-4), vertical distance to aquifer (5), and water content (0.3). The 'Horizontal transport parameters' section has fields for point of compliance (100), thickness of the aquifer (15), groundwater velocity (80/365), first order degradation rate (1.0e-4), porosity (0.25), longitudinal dispersivity (1.0), transversal dispersivity (0.01), vertical dispersivity (0.005), recharge (0.3/365), and another retardation factor (2.5). The 'Save all the inputs (optional)' section has a 'Save' button. The 'Outputs' section has an 'Out' field and a 'RUN' button. Two graphs are shown: 'Q [m3/y]' and 'Source concentration [mg/L]' both plotted against 'Time [year]' from 0 to 1. The graphs are currently blank.

FIGURE 3. Screenshot of the model “Affald-A single unit”.

a. Affald-A single unit. Step by step tutorial

In the following we show a step by step example of how to use the model:

- 1) Open the "Affald-A single unit" window.
- 2) Load the provided input file "EX_1_Source_inputs_AffaldA_SingleUnit_constantQ_varyingC" (4 different examples are provided and the user can choose among them).
- 3) Let us type a case study name, i.e. "CASE_AAA" as shown in the following figure (at the bottom of the windows).

The screenshot shows the 'ModelAsingle' window with the following sections:

- Source inputs:**
 - 200 [m] Source length
 - 120 [m] Source width
 - Browse button
 - select the input txt file:
 - tab delimited txt file with 2 heading lines and 3 columns
 - decimal separator: point (not comma)
 - 1st column = Time [years]
 - 2nd column = Water flux [m3/y]
 - 3rd column = Concentration [mg/L]
 - File path: C:\Users\lulo\Desktop\User_Interface\Examples\Affald-A single unit\EX_1_Source_inputs_AffaldA_SingleUnit_constantQ_varyingC.txt
 - Check that the input time series are correct. If the following graphs are blank the input file is wrong.
 - Two graphs:
 - Q [m3/y] vs Time [year]: A line graph showing a constant value of 10000 over 400 years.
 - Source concentration [mg/L] vs Time [year]: A line graph showing a concentration that starts at 40 mg/L and drops to 0 by year 100.
- Vertical transport parameters:**
 - Include vertical transport: ☐ Yes/No
 - 2.5 [-] Retardation factor
 - 1.0e-4 [1/day] First order degradation rate
 - 5 [m] Vertical distance to aquifer
 - 0.3 [-] Water content
- Horizontal transport parameters:**
 - 100 [m] Point of compliance
 - 15 [m] Thickness of the aquifer
 - 80/365 [m/day] Groundwater velocity
 - 1.0e-4 [1/day] First order degradation rate
 - 0.25 [-] Porosity
 - 1.0 [m] Longitudinal dispersivity
 - 0.01 [m] Transversal dispersivity
 - 0.005 [m] Vertical dispersivity
 - 0.3/365 [m/day] Recharge
 - 2.5 [-] Retardation factor
- Save all the inputs (optional):**
 - Choose the file name (The input time series is not saved). The file is saved in the same folder as the input time series file
 - Inputs_ CASE_AAA Save
- Outputs:**
 - Choose Output file name. The output is saved in the same folder as the input file
 - Out_ CASE_AAA .txt RUN

FIGURE 4. Screenshot for the step by step tutorial of the model "Affald-A single unit". The input time series are properly displayed and the user has called the case study "CASE_AAA".

- 4) The user can save the inputs (this is optional) by pressing the "Save" button. Saved inputs can then be loaded with the "Load model inputs" button.
- 5) The user can change the input parameters (remember to use a dot as decimal separator and not a comma).
- 6) Run the model by pressing the button 'RUN' and wait until the results pop-up. The result window that pops up is shown in the following.

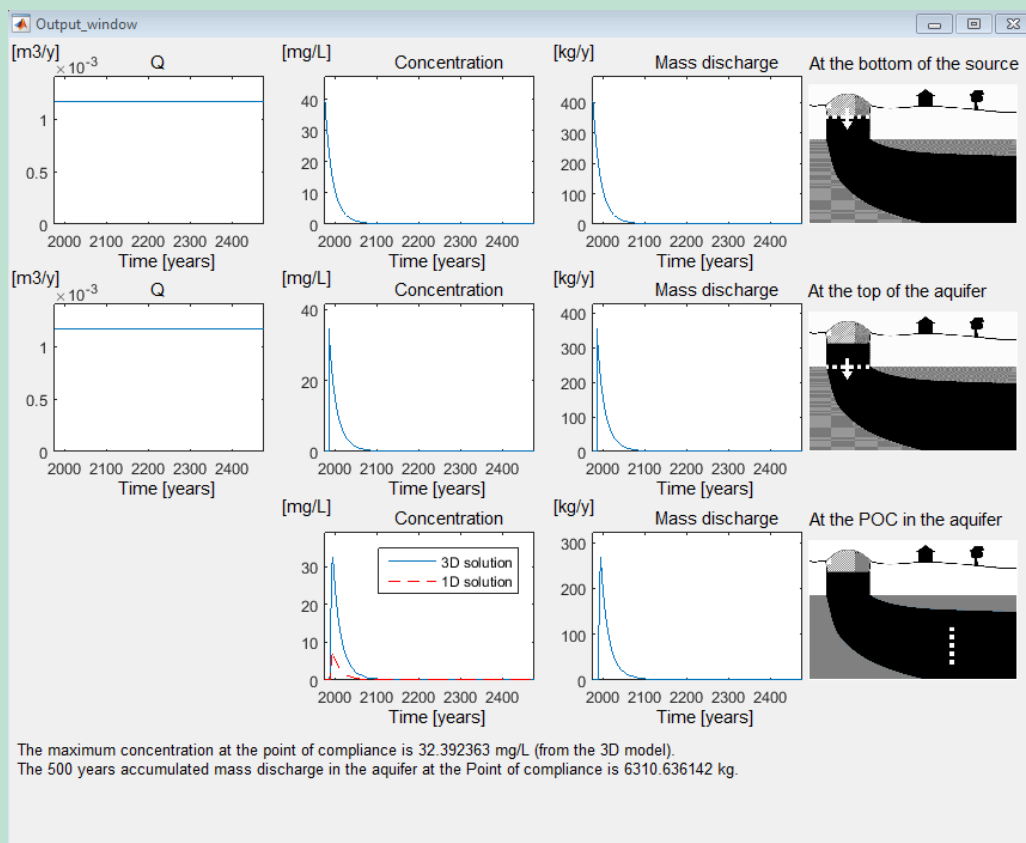


FIGURE 5. Example of a result window of Affald-A single unit.

7) Reading the results from the pop-up window.

The top 3 graphs show the water discharge Q , the concentration and the contaminant mass discharge at the source.

The middle 3 graphs show the water discharge Q , the concentration and the contaminant mass discharge after vertical transport (at the top of the aquifer).

The 2 bottom graphs show the concentration over a 2 m well screen at the point of compliance and the contaminant mass discharge over an infinite plane (perpendicular to the groundwater flow direction) located at the point of compliance. The concentration at the POC is always computed using both a 3D model and a 1D model. The model giving the highest concentrations is the one to be used. The idea is that the 3D model is suitable for thick aquifers whereas in the case of thin aquifers the 1D model is more accurate (because the 3D model is designed for aquifers of infinite extent). Further details can be found in the main report.

At the bottom of the result window there are 2 sentences reporting the maximum concentration at the point of compliance and the 500 year accumulated contaminant mass discharge.

8) A result file called "Out_CASE_AAA.txt" is automatically created in the same folder as the input time series file. The output file contains all the output time series and it is shown in the following (the tab delimited .txt file can be opened in Excel). Each column of the output file include a time series:

Column 1. Time vertical trans. [y]. Time of the vertical transport model outputs.

Column 2. Conc. vertical trans. [mg/L]. Concentration after vertical transport (the related time is in column 1).

Column 3. Mass vertical trans. [kg/y]. Mass discharge to the aquifer after vertical transport (the related time is in column 1).

Column 4. PoC_t_3D. [y]. Time of the 3D model outputs of the horizontal transport.
 Column 5. PoC_c_3D. [mg/L]. Concentration at the Point of compliance from the 3D model (the related time is in column 4).
 Column 6. PoC_t_1D. [y]. Time of the 1D model outputs of the horizontal transport.
 Column 7. PoC_c_1D. [mg/L]. Concentration at the Point of compliance from the 1D model (the related time is in column 6).
 Column 8. PoC_Mass_1D. [kg/y]. Mass discharge at a plane at the Point of compliance distance from the 1D model (the related time is in column 6).

```

Out_CASE_AAA - Notepad
File Edit Format View Help
Affald-A. Single unit.
This .txt file is tab delimited and can be opened in Excel.
The values -999.0000 are to be ignored

Simulation time: 18.3937 seconds
Input file: C:\Users\lulo\Desktop\User_Interface_v1\Input_files_exam

The maximum concentration at the point of compliance is 32.392363 mg/

Lx [m] 200.000000
Ly [m] 120.000000
I [m/day] 0.000822
POC [m] 100.000000
k_v [1/day] 0.000100
theta_v [-] 0.300000
R_v [-] 2.500000
Z_v [m] 5.000000
B [m] 15.000000
u [m/day] 0.219178
k [1/day] 0.000100
n [-] 0.250000
alpha [m] 1.000000
alpha_t [m] 0.010000
alpha_v [m] 0.005000
R [-] 2.500000

Time vertical trans. Conc. vertical trans. Mass vertical trans.
[y] [mg/L] [kg/y] [y] [mg/L] [y] [mg/L] [kg/y]
1976.0 0.0000000000 0.0000000000 1976.0 0.0000000000 1976.
1984.8 0.0000000000 0.0000000000 1985.8 0.0000000000 1984.
1984.8 34.5691817208 353.6427290038 1986.8 0.0007044508 1984.
1985.0 34.0982334451 348.8249281432 1987.8 1.2630477089 1985.
1985.3 33.6272851694 344.0071272825 1988.8 8.5669859745 1985.
1985.5 33.1563368936 339.1893264219 1989.8 16.0075867010 1986.
1985.8 32.6853886179 334.3715255613 1990.8 21.7757408487 1986.
1986.0 32.2416885523 329.8324738904 1991.8 26.3139876422 1987.
1986.3 31.7979884867 325.2934222194 1992.8 29.9102103936 1987.
1986.5 31.3542884212 320.7543705484 1993.8 32.2584178166 1988.
1986.8 30.9105883556 316.2153188775 1994.8 32.3923631528 1988.
1987.0 30.4924757760 311.9380271886 1995.8 31.0316813567 1989.
  
```

FIGURE 6. Example of an output .txt file from the model "Affald-A single unit". This .txt tab delimited file can be opened in Excel, where it will be easier to read.

7. Affald-A multiple units

The model “Affald-A multiple units” (Figure 2) can be used to simulate concentration and mass discharge downstream a landfill made of several units that are located above the aquifer (the bottom of the landfill is above the top of the aquifer).

The interface of the model “Affald-A multiple units” is shown in the following figure. The user has different options (Back to the main menu; Save all the inputs; Load model inputs).

Affald_A_multiple

<< Back to the main menu Load model inputs

Source inputs

4 Select the number of different units of the landfill

200; 120; 260; 130 [m] Source length. Lx1; Lx2; etc.

100; 240; 160; 210 [m] Source width. Ly1; Ly2; etc.

10; 5; 13; 11 [m] Vertical distance to aquifer. z1; z2; etc.

100; 250; 400; 130 [m] Point of compliance

Select the number of units first and then load the time series:

C:\xxxx\input_file.txt

Load the input time series

Specify the units overlapping in the groundwater flow direction creating different aggregated plumes. Each unit must be entered at least once.

Plume 1 1;2;3

Plume 2 4

Plume 3 None

Plume 4 None

Plume 5

Plume 6

Vertical transport parameters

2.5 [-] Retardation factor

1.0e-4 [1/day] First order degradation rate

0.35 [-] Water content

Horizontal transport parameters

10 [m] Thickness of the aquifer

100/365 [m/day] Groundwater velocity

1.0e-4 [1/day] First order degradation rate

0.25 [-] Porosity

1.0 [m] Longitudinal dispersivity

0.01 [m] Transversal dispersivity

0.005 [m] Vertical dispersivity

0.3/365 [m/day] Recharge

2.5 [-] Retardation factor

Save all the inputs (optional)

Choose the file name (The input time series is not saved). The file is saved in the same folder as the input time series file

Inputs_ CaseStudyXX_compoundXX Save

Outputs

Choose Output file name. The output is saved in the same folder as the input file

Out_ CaseStudyXX_compoundXX .txt RUN

FIGURE 7. Screenshot of the model “Affald-A multiple units”. This model does not have the user friendly option to omit the vertical transport, nevertheless the user can set the “Vertical distance to aquifer” to zero (for one or more units).

First of all the user must enter the right number of units to be simulated using the drop-down menu in the “Source inputs” window. Then the fields “Source length”, “Source width”, “Vertical distance to the aquifer” and “Point of compliance” must be entered. Note that there must be the same number of entries as the number of units (i.e. if there are 4 units then there must be 4 numbers in the field “Source length” and in the other fields). The number of entries must be separated by a semicolon. For instance, the landfill of Tandskov (one of the examples included Miljøstyrelsen, 2018) has 4 different units and the following figure shows how to input the 4 unit geometries, distances to the PoC, etc.

The screenshot shows the 'Affald_A_multiple' software window. On the left is a map of a landfill with 4 units outlined in green. A yellow arrow indicates the 'GW flow direction' from top-left to bottom-right. A red dashed line marks the 'POC=100m'. Coordinates are shown: X = 529,824 m, Y = 6,232,142 m and X = 529,891 m, Y = 6,231,812 m. The main window contains the following sections:

- Source inputs:**
 - Select the number of different units of the landfill: 4
 - 381; 330; 173; 308 [m] Source length. Lx1; Lx2; etc.
 - 142; 84.8; 179.2; 178.6 [m] Source width. Ly1; Ly2; etc.
 - 25; 28.5; 28; 22 [m] Vertical distance to aquifer. z1; z2; etc.
 - 100; 113; 362; 375 [m] Point of compliance
 - Select the number of units first and then load the time series: C:\xxxx\input_file.txt
 - Load the input time series button
 - Specify the units overlapping in the groundwater flow direction creating different aggregated plumes. Each unit must be entered at least once.
 - Plume 1: 1,4
 - Plume 2: 2,3
 - Plume 3: None
 - Plume 4: None
 - Plume 5:
 - Plume 6:
- Vertical transport parameters:**
 - It can be omitted by setting vertical distances (z1, z2, etc.) = 0 m
 - 5 [-] Retardation factor
 - 0 [1/day] First order degradation rate
 - 0.15 [-] Water content
- Horizontal transport parameters:**
 - 13 [m] Thickness of the aquifer
 - 116/365 [m/day] Groundwater velocity
 - 0 [1/day] First order degradation rate
 - 0.3 [-] Porosity
 - 1.0 [m] Longitudinal dispersivity
 - 0.01 [m] Transversal dispersivity
 - 0.005 [m] Vertical dispersivity
 - 0.11/365 [m/day] Recharge
 - 5 [-] Retardation factor
- Save all the inputs (optional):**
 - Choose the file name (The input time series is not saved). The file is saved in the same folder as the input time series file
 - Inputs_ CaseStudyXX_compoundXX Save
- Outputs:**
 - Choose Output file name. The output is saved in the same folder as the input file
 - Out_ CaseStudyXX_compoundXX .txt RUN


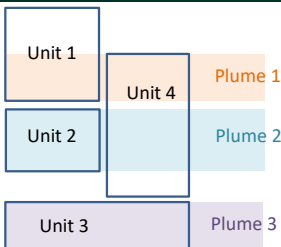

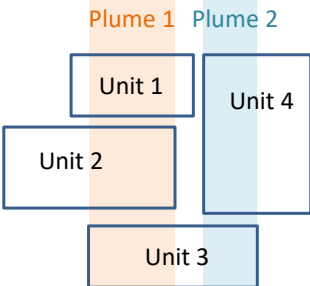

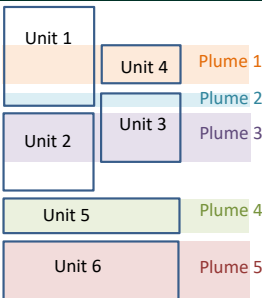

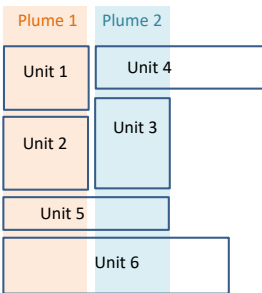
FIGURE 8. Example of how to enter the 4 units of the landfill of Tandskov. The input data are provided together with the model interface and are located in the folder “Input_files_examples_for_the_tutorials”

Now the user must enter the input time series by pressing the “Browse” button within the “Source inputs” box. A new window will open where the user needs to select the input .txt file. The input file must be created correctly according to the instructions given in the section “How to create the input .txt file”.

Afterwards, the user needs to specify how the different source units overlap in the groundwater flow direction forming aggregated plumes. The following figure gives some examples that show how to specify the different plumes resulting from the overlapping of single plumes from single units. The following rules apply in order to specify the overlapping in the groundwater flow direction:

- The unit numbers must be separated by a semicolon
- Each unit must appear at least once
- If a unit does not overlap with others then the user should specify a plume made of that single unit; however, if that unit already overlap with other units, the user must not specify another plume made of that single unit.
- If there are not further plumes then the user must type “None”

TABLE 3. Examples of how to specify the overlapping of different units in the case of multiple source units.

Groundwater flow direction	Plan view of the different units of a landfill and the aggregated plumes.	How to specify the overlapping of units in the user interface	Comments												
		<table><tr><td>Plume 1</td><td>1;4</td></tr><tr><td>Plume 2</td><td>2;4</td></tr><tr><td>Plume 3</td><td>3</td></tr><tr><td>Plume 4</td><td>None</td></tr></table>	Plume 1	1;4	Plume 2	2;4	Plume 3	3	Plume 4	None	<p>The user should not specify another plume made of Unit 1 alone; or Unit 4 alone.</p> <p>These units are already included in the other plumes.</p>				
Plume 1	1;4														
Plume 2	2;4														
Plume 3	3														
Plume 4	None														
		<table><tr><td>Plume 1</td><td>1;2;3</td></tr><tr><td>Plume 2</td><td>3;4</td></tr><tr><td>Plume 3</td><td>None</td></tr><tr><td>Plume 4</td><td>None</td></tr></table>	Plume 1	1;2;3	Plume 2	3;4	Plume 3	None	Plume 4	None	<p>The user should not specify other plumes made of Unit 2 alone; or Unit 1+2; or Unit 1+3; or for Unit 4 alone).</p> <p>These combinations are already included in the other plumes.</p>				
Plume 1	1;2;3														
Plume 2	3;4														
Plume 3	None														
Plume 4	None														
		<table><tr><td>Plume 1</td><td>1;4</td></tr><tr><td>Plume 2</td><td>1;3</td></tr><tr><td>Plume 3</td><td>2;3</td></tr><tr><td>Plume 4</td><td>5</td></tr><tr><td>Plume 5</td><td>6</td></tr><tr><td>Plume 6</td><td>None</td></tr></table>	Plume 1	1;4	Plume 2	1;3	Plume 3	2;3	Plume 4	5	Plume 5	6	Plume 6	None	<p>Unit 1 and 3 slightly overlap. Therefore, the user could choose to run a further scenario where the 2 units are assumed to not overlap.</p>
Plume 1	1;4														
Plume 2	1;3														
Plume 3	2;3														
Plume 4	5														
Plume 5	6														
Plume 6	None														
		<table><tr><td>Plume 1</td><td>1;2;5;6</td></tr><tr><td>Plume 2</td><td>3;4;5;6</td></tr><tr><td>Plume 3</td><td>None</td></tr><tr><td>Plume 4</td><td>None</td></tr><tr><td>Plume 5</td><td>None</td></tr><tr><td>Plume 6</td><td>None</td></tr></table>	Plume 1	1;2;5;6	Plume 2	3;4;5;6	Plume 3	None	Plume 4	None	Plume 5	None	Plume 6	None	<p>The user should not specify other plumes made of Unit 4 alone; or Unit 4+6).</p> <p>These combinations are already included in the other plumes.</p>
Plume 1	1;2;5;6														
Plume 2	3;4;5;6														
Plume 3	None														
Plume 4	None														
Plume 5	None														
Plume 6	None														

It must be kept in mind that the source geometry Lx and Ly is simplified as discussed in the Kildestyrkemodel. The source geometry is always (1) rectangular and (2) aligned with the groundwater flow direction. This means that complex shapes and even rectangular shapes not aligned with the groundwater flow direction are always simulated as rectangular and aligned with the groundwater flow direction. This can affect the way the overlapping of the plumes is simulated. Discussion about the effect of a simplified source geometry is given in the following section.

Once the input time series is included then the user can save (this is optional) the input parameters. When all the input parameters are given the user can select the result file name and run the model by clicking on the "RUN" button. The model will run and automatically pop-up a result window and write the output .txt file in the same location as the selected .txt input file.

a. Discussion about the effects of a simplified source geometry

The simplified source (unit) geometry (always rectangular and aligned with the groundwater flow direction as discussed in the Kildestyrkemodel) can influence the way units overlap to form aggregated plumes. Therefore, the user interface was designed to give the user the possibility to choose how the plumes from single units overlap forming aggregated plumes.

The following figure shows an example of a real case study. The simulated units (the blue and yellow continuous lines) do not overlap with each other in the groundwater flow direction. Therefore the user will specify 2 different aggregated plumes (in the user interface), one made of Unit 1 (DEL 1 in the figure) and one made of Unit 2 (DEL 2). Nevertheless, a further scenario is plausible; in fact the 2 “real” units (the green lines in the figure) do overlap in the groundwater flow direction. Therefore, the user could run a further scenario where an aggregated plume (from Unit 1 and 2) is simulated.

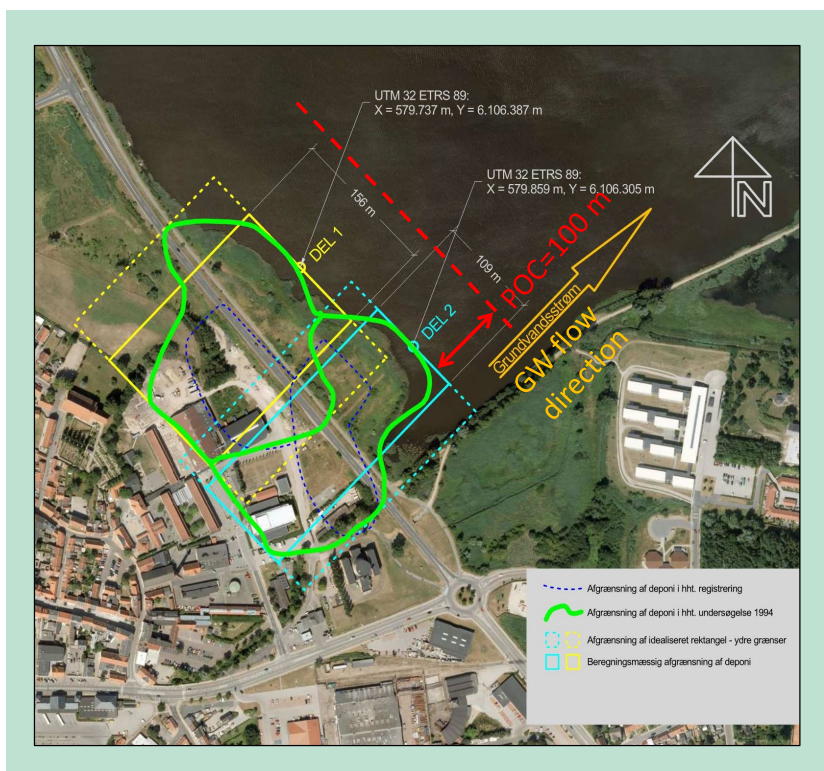


FIGURE 9. Example of a real landfill showing how the source geometry is modified to be rectangular and aligned with the groundwater flow direction in order to be simulated. The green lines show the ‘real’ extension of the units and the blue and yellow continuous lines the simulated geometries of each unit.

b. Affald-A multiple unit. Step by step tutorial

In the following we show a step by step example of how to use the model:

- 1) Open the “Affald-A multiple unit” window.
- 2) Under the field “Select the number of different units of the landfill” choose “5”.
- 3) Click on “Load model inputs” and select the file “EX_4_inputs_AffaldA_MultipleUnits_5_Units.affald_a_multiple”. This example contains 5 different units (Several examples are provided and the user can choose among them).
- 4) Click on “Load the input time series” and load the provided input file “EX_4_Source_inputs_AffaldA_MultipleUnits_5_Units.txt”.
- 5) Let us call the case study “CASE_BBB” as shown in the following figure.

Affald_A_multiple

<< Back to the main menu Load model inputs

Source inputs

5 Select the number of different units of the landfill

200; 120; 250; 100; 100 [m] Source length. Lx1; Lx2; etc.

100; 240; 120; 150; 180 [m] Source width. Ly1; Ly2; etc.

10; 5; 8; 9; 10 [m] Vertical distance to aquifer. z1; z2; etc.

100; 250; 300; 290; 600 [m] Point of compliance

Select the number of units first and then load the time series: Load the input time series

[C:\Users\lulo\Desktop\User_Interface_v1\input_files_examples_for_the_tutorials\Affald-A multiple units\EX_4_Source_inputs_AffaldA_MultipleUnits_5_Units.txt](#)

Specify the units overlapping in the groundwater flow direction creating different aggregated plumes. Each unit must be entered at least once.

Plume 1 1

Plume 2 2;3;4;5

Plume 3 None

Plume 4 None

Plume 5 None

Plume 6

Vertical transport parameters

9 [-] Retardation factor

0.001 [1/day] First order degradation rate

0.35 [-] Water content

Horizontal transport parameters

10 [m] Thickness of the aquifer

50/365 [m/day] Groundwater velocity

0.001 [1/day] First order degradation rate

0.25 [-] Porosity

1.0 [m] Longitudinal dispersivity

0.01 [m] Transversal dispersivity

0.005 [m] Vertical dispersivity

0.3/365 [m/day] Recharge

9 [-] Retardation factor

Save all the inputs (optional)

Choose the file name (The input time series is not saved). The file is saved in the same folder as the input time series file

Inputs_ Case_BBB Save

Outputs

Choose Output file name. The output is saved in the same folder as the input file

Out_ Case_BBB .txt RUN

FIGURE 10. Screenshot for the step by step tutorial of the model "Affald-A multiple units". The user has called the case study "CASE_BBB".

- 6) The user can save the inputs (this is optional) by pressing the "Save" button. Saved inputs can then be loaded with the "Load model inputs" button.
- 7) The user can change the input parameters (remember to use a dot as decimal separator and not a comma).
- 8) Run the model by pressing the button 'RUN' and wait until the results pop-up. The result window that pops up is shown in the following.

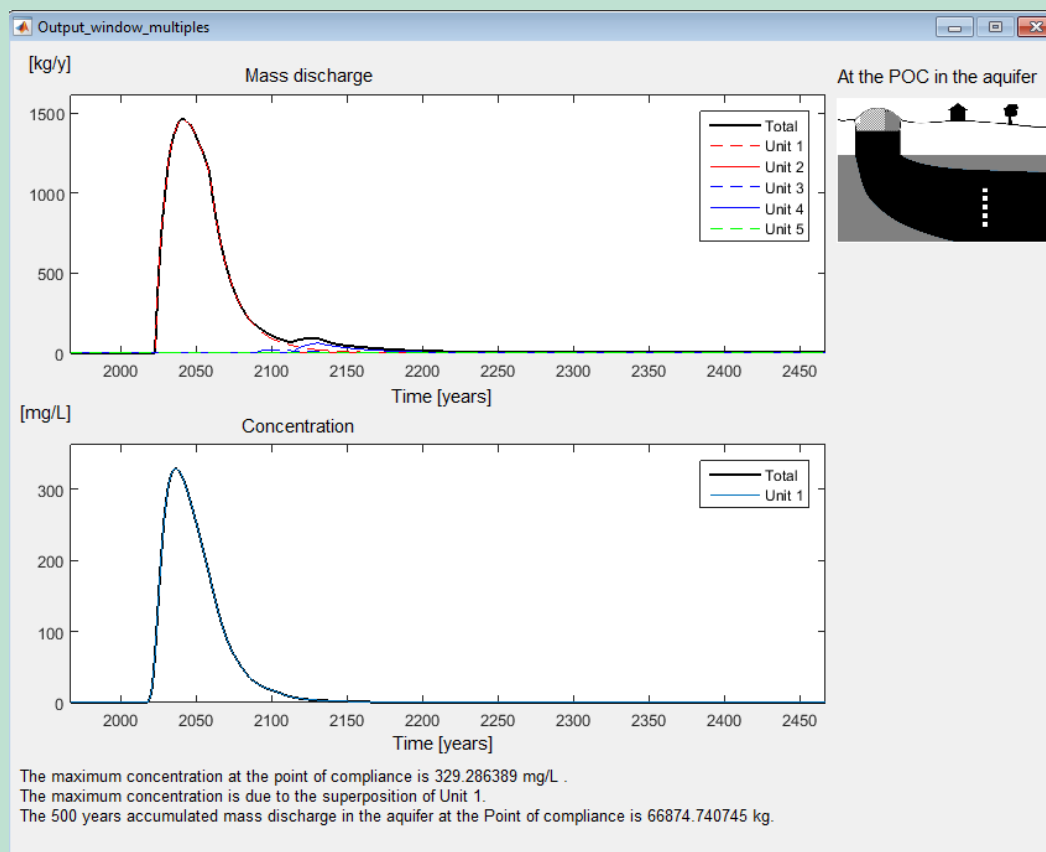


FIGURE 11. Example of a result window of “Affald-A multiple units”.

9) Reading the results from the pop-up window.

The top graph shows the mass discharge in the aquifer at an infinite plane located at the Point of compliance. Both the total mass discharge and the contribution from each unit are shown.

The bottom graph shows the highest concentration (over a 2 m long screen) in the aquifer. Both the total concentration and the contribution from each unit are shown. Nevertheless, in this case the maximum concentrations are given by Unit 1 (the overlapping of the other units produced smaller maximum concentrations).

Note that the total mass discharge always results from all the units contributions, whereas the maximum concentrations can result from fewer units.

At the bottom of the result window there are 3 sentences reporting the maximum concentration at the point of compliance, the units that produce the maximum concentrations and the 500 year accumulated contaminant mass discharge.

10) A result file called “Out_CASE_BBB.txt” is automatically created in the same folder as the input time series file. The output file contains all the output time series and it is shown in the following (the file can also be opened in Excel). The output time series (mass discharge and concentration) for each unit are found by scrolling down in the same file.

```

Out_CASE_BBB - Notepad
File Edit Format View Help
Affald-A. Multiple units.
This .txt file is tab delimited and can be opened in Excel.
The values -999.0000 are to be ignored

Simulation time: 105.5626 seconds
Input file: C:\Users\lulo\Desktop\User_Interface _v1\Input_fi
The maximum concentration at the point of compliance is 329.2

Lx [m] 200; 120; 250; 100; 100
Ly [m] 100; 240; 120; 150; 180
I [m/y] 0.3/365
POC [m] 100; 250; 300; 290; 600
k_v [1/day] 0.001
theta_v [-] 0.35
R_v [-] 9
Z_v [m] 10; 5; 8; 9; 10
B [m] 10
u [m/y] 50/365
k [1/day] 0.001
n [-] 0.25
alpha [m] 1.0
alpha [m] 0.01
alpha [m] 0.005
R [-] 9

time Total mass Total concentration
[y] [kg/y] [mg/L]
1967.0 0.0000000000 0.0000000000
1967.3 0.0000000000 0.0000000000
1967.5 0.0000000000 0.0000000000
1967.8 0.0000000000 0.0000000000
1968.0 0.0000000000 0.0000000000
1968.3 0.0000000000 0.0000000000
1968.5 0.0000000000 0.0000000000
1968.8 0.0000000000 0.0000000000
1969.0 0.0000000000 0.0000000000
1969.3 0.0000000000 0.0000000000
1969.5 0.0000000000 0.0000000000
1969.8 0.0000000000 0.0000000000
1970.0 0.0000000000 0.0000000000

```

FIGURE 12. Example of an output .txt file from the model "Affald-A multiple units"

8. Affald-B single unit

The model “Affald-B single unit” (Figure 2) can be used to simulate concentration and mass discharge downstream a single landfill unit that is partially submerged in the aquifer (the bottom of the unit is below the top of the aquifer).

The interface of the model “Affald-B single unit” is shown in the following figure. The user has different options (Back to the main menu; Save all the inputs; Load model inputs).

First of all the user must enter the input time series. The user needs to press “Browse” within the “Source inputs” box. A new window pops up where the user needs to select the input .txt file. The input file must be created correctly according to the instructions given in the section “How to create the input .txt file”. If the input .txt file is made correctly the user will be able to see the 2 graphs of the input time series (water discharge and concentration) in the user interface.

Once the input time series is included then the user can save (this is optional) the input parameters. When all the input parameters are given the user can select the result file name and run the model by clicking on the “RUN” button. The model will run and automatically pop-up a result window and write the output .txt file in the same location as the selected .txt input file.

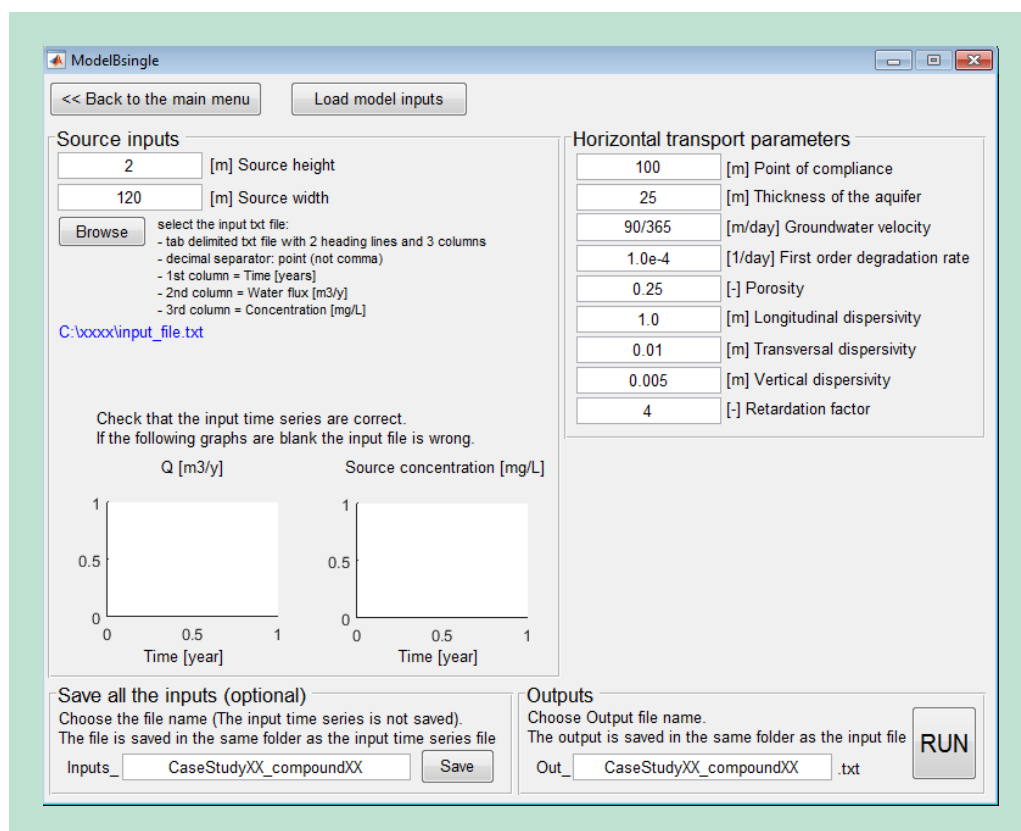


FIGURE 13. Screenshot of the model “Affald-B single unit”.

c. Affald-B single unit. Step by step tutorial

In the following we show a step by step example of how to use the model:

- 9) Open the “Affald-B single unit” window.

- 10) Load the provided input file "EX_1_Source_inputs_AffaldB_SingleUnit_varyingQ_varyingC" (4 different examples are provided and the user can choose among them).
- 11) Let us call the case study "CASE_CCC" as shown in the following figure

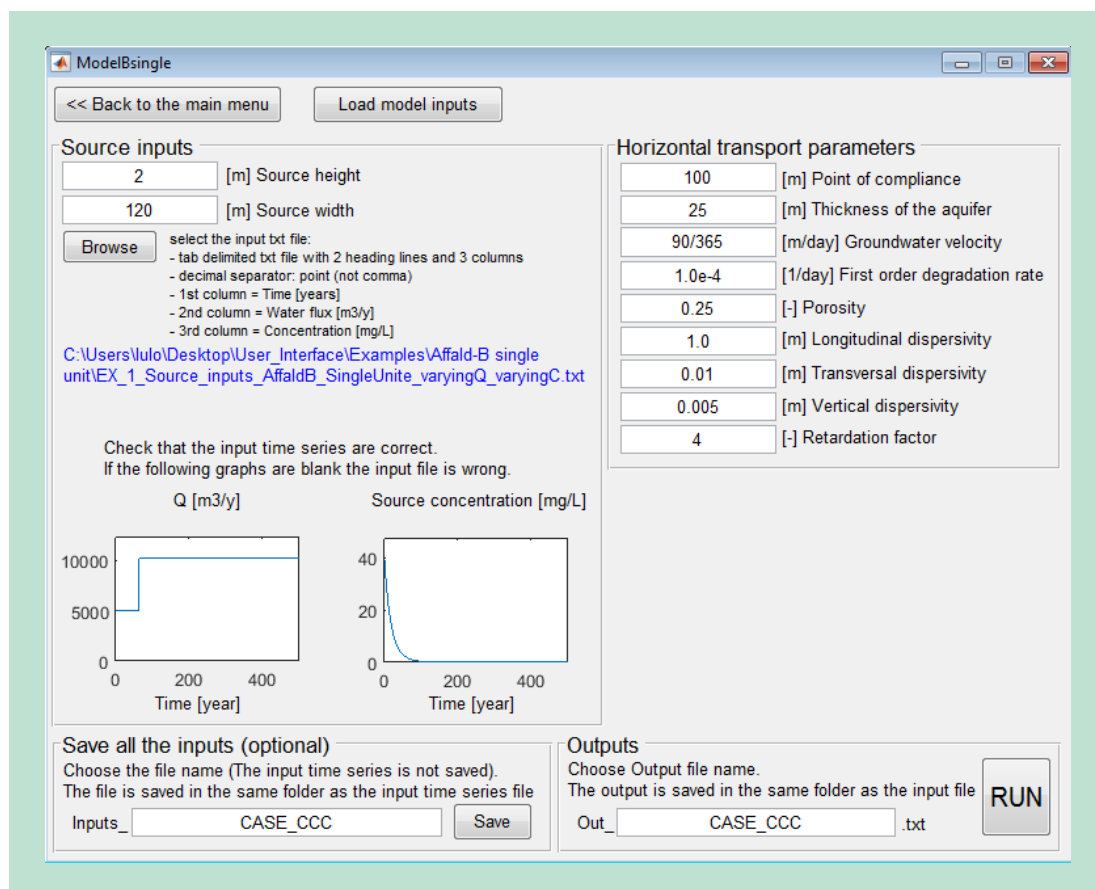


FIGURE 14. Screenshot for the step by step tutorial of model "Affald-B single unit". The input time series are properly displayed and the user has called the case study "CASE_AAA".

- 12) The user can save the inputs (this is optional) by pressing the "Save" button. Saved inputs can be loaded with the "Load model inputs" button.
- 13) The user can change the input parameters (remember to use a dot as decimal separator and not a comma).
- 14) Run the model by pressing the button 'RUN' and wait until the results pop-up. The result window that pops up is shown in the following.

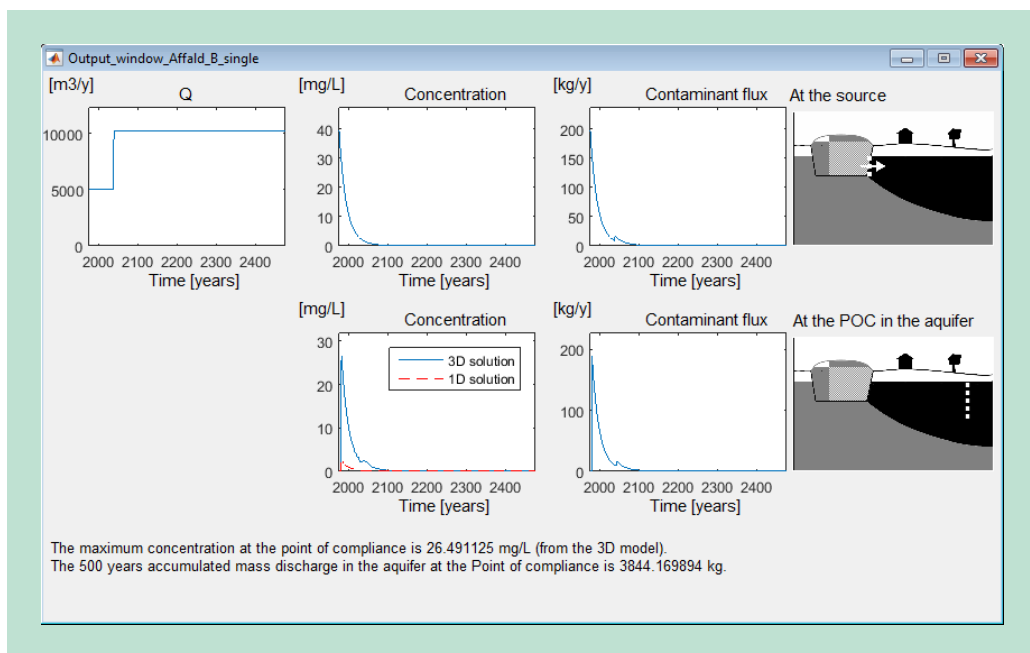


FIGURE 15. Example of a result window of Affald-B single unit.

15) Reading the results from the pop-up window.

The top 3 graphs show the water discharge Q , the concentration and the contaminant mass discharge at the source.

The 2 bottom graphs show the concentration over a 2 m well screen at the point of compliance and the contaminant mass discharge over an infinite plane (perpendicular to the groundwater flow direction) located at the point of compliance. The concentration at the POC is always computed using both a 3D model and a 1D model. The model giving the highest concentrations is the one to be used. The idea is that the 3D model is suitable for thick aquifers whereas in the case of thin aquifers the 1D model is more accurate (because the 3D model is designed for aquifers of infinite extent). Further details can be found in the main report.

At the bottom of the result window there are 2 sentences reporting the maximum concentration at the point of compliance and the 500 year accumulated contaminant mass discharge.

16) A result file called "Out_CASE_AAA.txt" is automatically created in the same folder as the input time series file. The output file contains all the output time series and it is shown in the following (the tab delimited .txt file can also be opened in Excel). Each column of the output file include a time series:

Column 1. PoC_t_3D. [y]. Time of the 3D model outputs of the horizontal transport.

Column 2. PoC_c_3D. [mg/L]. Concentration at the Point of compliance from the 3D model (the related time is in column 1).

Column 3. PoC_t_1D. [y]. Time of the 1D model outputs of the horizontal transport.

Column 4. PoC_c_1D. [mg/L]. Concentration at the Point of compliance from the 1D model (the related time is in column 3).

Column 5. PoC_Mass_1D. [kg/y]. Mass discharge at a plane at the Point of compliance distance from the 1D model (the related time is in column 3).

Out_CASE_CCC - Notepad

File Edit Format View Help

Affald-B. Single unit.
 This .txt file is tab delimited and can be opened in Excel.
 The values -999.0000 are to be ignored

Simulation time: 9.0019 seconds
 Input file: C:\Users\lulo\Desktop\User_Interface\Examples\Affald-B single unit\EX_1

The maximum concentration at the point of compliance is 26.491125 mg/L (from the 3D

LZ	[m]	2.000000
Ly	[m]	120.000000
POC	[m]	100.000000
B	[m]	25.000000
u	[m/y]	0.246575
k	[1/day]	0.000100
n	[-]	0.250000
alpha1	[m]	1.000000
alpha2	[m]	0.010000
alpha3	[m]	0.005000
R	[-]	4.000000

PoC_t_3D	PoC_c_3D	PoC_t_1D	PoC_c_1D	PoC_Mass_1D
[y]	[mg/L]	[y]	[mg/y]	[kg/y]
1976.0	0.0000000000	1976.0	0.0000000000	0.0000000000
1976.1	0.0000000000	1980.4	0.0000000000	0.0000000000
1977.1	0.0000000000	1980.4	2.7959252524	188.7249545353
1978.1	0.0000008664	1981.4	2.6435657100	178.4406854263
1979.1	0.1714313306	1982.4	2.5000214135	168.7514454111
1980.1	8.8068429156	1983.4	2.3647550911	159.6209686524
1981.1	23.9081564974	1984.4	2.2372637652	151.0153041535
1982.1	26.4911254326	1985.4	2.1170764723	142.9026618774
1983.1	25.3264137586	1986.4	2.0037521361	135.2532691886
1984.1	23.9657474657	1987.4	1.8968775901	128.0392373295
1985.1	22.6752310899	1988.4	1.7960657343	121.2344370671
1986.1	21.4632502866	1989.4	1.7009538234	114.8143830784
1987.1	20.3143262973	1990.4	1.6112018634	108.7561257776
1988.1	19.2327358726	1991.4	1.5264911262	103.0381510173
1989.1	18.2175190201	1992.4	1.4465227603	97.6402863194
1990.1	17.2633325017	1993.4	1.3710164962	92.5436134920
1991.1	16.3598491393	1994.4	1.2997094414	87.7303872959
1992.1	15.4740139836	1995.4	1.2323549547	83.1839594397

Ln 1, Col 1

FIGURE 16. Example of an output .txt file from the model "Affald-B single unit".

9. Affald-B multiple units

The model “Affald-B multiple units” (Figure 2) can be used to simulate concentration and mass discharge downstream a landfill made of several units that are partially submerged in the aquifer (the bottom of the landfill is below the top of the aquifer).

The interface of the model “Affald-B multiple units” is shown in the following figure. The user has different options (Back to the main menu; Save all the inputs; Load model inputs).

Affald_B_multiple

<< Back to the main menu Load model inputs

Source inputs

3 Select the number of different units of the landfill

2; 4; 2.5 [m] Source height. Lz1; Lz2; etc.

100; 160; 140 [m] Source width. Ly1; Ly2; etc.

100; 250; 200 [m] Point of compliance

Select the number of units first and then load the time series: Load the input time series

C:\xxxx\input_file.txt

Specify the units overlapping in the groundwater flow direction creating different aggregated plumes. Each unit must be entered at least once.

Plume 1 2

Plume 2 1

Plume 3 3

Plume 4

Plume 5

Plume 6

Horizontal transport parameters

10	[m] Thickness of the aquifer
100/365	[m/day] Groundwater velocity
1.0e-4	[1/day] First order degradation rate
0.25	[-] Porosity
1.0	[m] Longitudinal dispersivity
0.01	[m] Transversal dispersivity
0.005	[m] Vertical dispersivity
2.5	[-] Retardation factor

Save all the inputs (optional)

Choose the file name (The input time series is not saved). The file is saved in the same folder as the input time series file

Inputs_ CaseStudyXX_compoundXX Save

Outputs

Choose Output file name. The output is saved in the same folder as the input file

Out_ CaseStudyXX_compoundXX .txt RUN

FIGURE 17. Screenshot of the model “Affald-B multiple units”.

First of all the user must enter the right number of units to be simulated using the drop-down menu in the “Source inputs” window. Then the fields “Source height”, “Source width” and “Point of compliance” must be entered. Note that there must be the same number of entries as the number of units (i.e. if there are 4 units then there must be 4 numbers in the field “Source length” and in the other fields). The number of entries must be separated by a semicolon. For instance, the landfill of Faaborg (one of the examples included Miljøstyrelsen, 2018) has 2 different units and the following figure shows how to input the 2 unit geometries, distances to the PoC, etc.

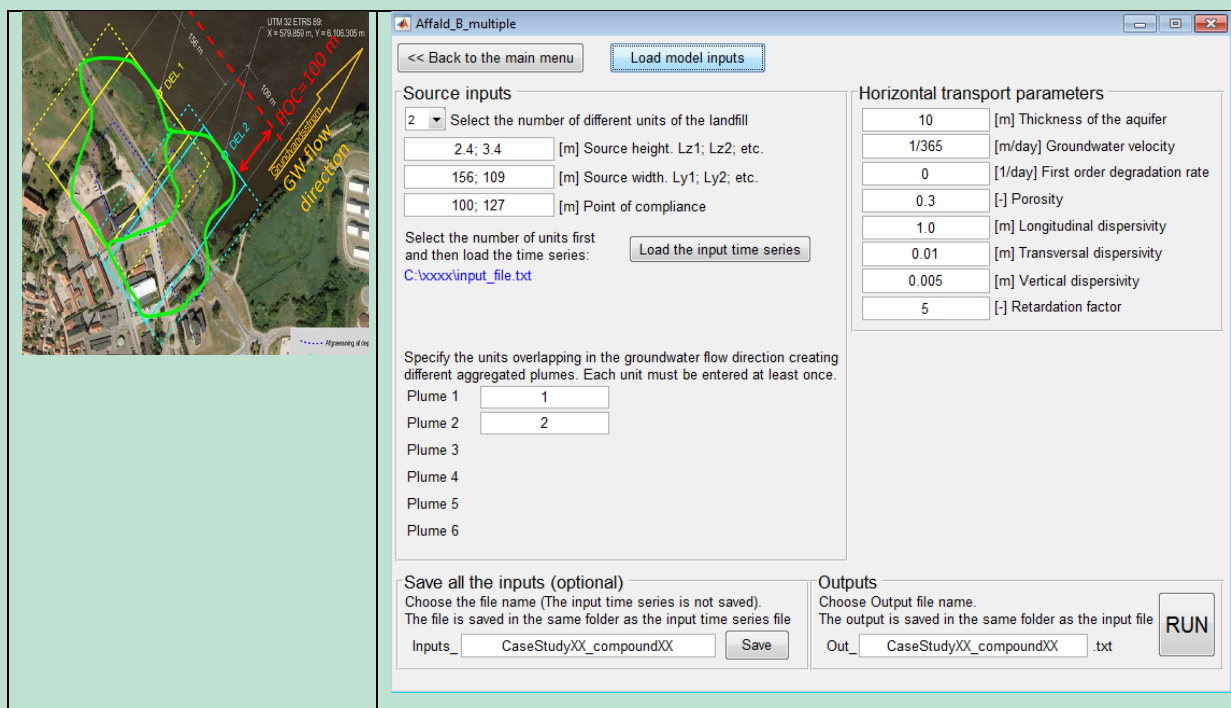


FIGURE 18. Example of how to enter the 2 units of the landfill of Faaborg. The input data are provided together with the model interface and are located in the folder “Input_files_examples_for_the_tutorials”

Now the user must enter the input time series by pressing the “Browse” button within the “Source inputs” box. A new window will open where the user needs to select the input .txt file. The input file must be created correctly according to the instructions given in the section “How to create the input .txt file”.

Afterwards the user needs to specify how the different source units overlap in the groundwater flow direction. A part of Section 7 shows how to do it.

Once the input time series is included then the user can save (this is optional) the input parameters. When all the input parameters are given the user can select the result file name and run the model by clicking on the “RUN” button. The model will run and automatically pop-up a result window and write the output .txt file in the same location as the selected .txt input file.

d. Affald-B multiple units. Step by step tutorial

In the following we show a step by step example of how to use the model:

- 11) Open the “Affald-B multiple unit” window.
- 12) Under the field “Select the number of different units of the landfill” choose “3”.
- 13) Click on “Load model inputs” and select the file “EX_2_inputs_AffaldB_MultipleUnits_3_Units”. This example contains 3 different units (several examples are provided and the user can choose among them).
- 14) Click on “Load the input time series” and load the provided input file “EX_2_Source_inputs_AffaldB_MultipleUnits_3_Units.txt”.
- 15) Let us call the case study “CASE_DDD” as shown in the following figure.

The screenshot shows the 'Affald_B_multiple' software window. It has a title bar with standard Windows controls. Below the title bar are two buttons: '<< Back to the main menu' and 'Load model inputs'. The main area is divided into several sections:

- Source inputs:**
 - A dropdown menu set to '3' with the text 'Select the number of different units of the landfill'.
 - Three input fields with labels: '2; 4; 2.5 [m] Source height. Lz1; Lz2; etc.', '100; 160; 140 [m] Source width. Ly1; Ly2; etc.', and '100; 250; 200 [m] Point of compliance'.
 - Text: 'Select the number of units first and then load the time series:' followed by a 'Load the input time series' button.
 - A blue hyperlink: 'C:\Users\lulo\Desktop\User_Interface_v1\input_files_examples_for_the_tutorials\Affald-B multiple units\EX_2_Source_inputs_AffaldA_MultipleUnits_3_Units.txt'.
 - Text: 'Specify the units overlapping in the groundwater flow direction creating different aggregated plumes. Each unit must be entered at least once.'
 - Plume selection fields:
 - Plume 1: '1;2'
 - Plume 2: '3'
 - Plume 3: 'None'
 - Plume 4: (empty)
 - Plume 5: (empty)
 - Plume 6: (empty)
- Horizontal transport parameters:**
 - A table of parameters:

10	[m] Thickness of the aquifer
100/365	[m/day] Groundwater velocity
1.0e-4	[1/day] First order degradation rate
0.25	[-] Porosity
1.0	[m] Longitudinal dispersivity
0.01	[m] Transversal dispersivity
0.005	[m] Vertical dispersivity
2.5	[-] Retardation factor
- Save all the inputs (optional):**
 - Text: 'Choose the file name (The input time series is not saved). The file is saved in the same folder as the input time series file'.
 - Input field: 'Inputs_ CASE_DDD' with a 'Save' button.
- Outputs:**
 - Text: 'Choose Output file name. The output is saved in the same folder as the input file'.
 - Input field: 'Out_ CASE_DDD .txt'.
 - A large blue 'RUN' button.

FIGURE 19. Screenshot for the step by step tutorial of model "Affald-B multiple units". The user has called the case study "CASE_DDD".

- 16) The user can save the inputs (this is optional) by pressing the "Save" button. Saved inputs can then be loaded with the "Load model inputs" button.
- 17) The user can change the input parameters (remember to use a dot as decimal separator and not a comma).
- 18) Run the model by pressing the button 'RUN' and wait until the results pop-up. The result window that pops up is shown in the following.

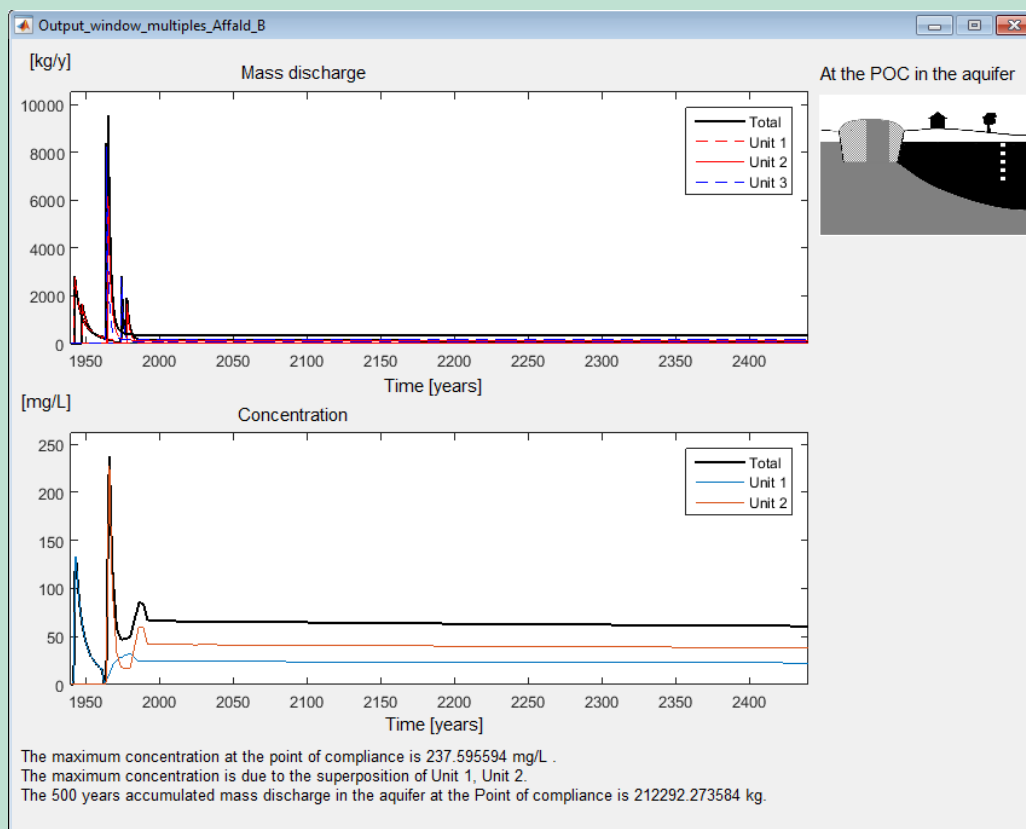


FIGURE 20. Example of a result window of “Affald-B multiple units”.

19) Reading the results from the pop-up window.

The top graph shows the mass discharge in the aquifer at an infinite plane located at the Point of compliance. Both the total mass discharge and the contribution from each unit are shown.

The bottom graph shows the highest concentration (over a 2 m long screen) in the aquifer. Both the total concentration and the contribution from each unit are shown. Nevertheless, in this case the maximum concentrations are given by the superposition of Unit 1 and Unit 2.

Note that the total mass discharge always results from all the units contributions, whereas the maximum concentrations can result from fewer units.

At the bottom of the result window there are 3 sentences reporting the maximum concentration at the point of compliance, the units that produce the maximum concentrations and the 500 year accumulated contaminant mass discharge.

20) A result file called “Out_CASE_DDD.txt” is automatically created in the same folder as the input time series file. The output file contains all the output time series and it is shown in the following (the file can also be opened in Excel). The output time series (mass discharge and concentration) for each unit are found by scrolling down in the same file.

```

Out_CASE_DDD - Notepad
File Edit Format View Help
Affald-B. Multiple units.
This .txt file is tab delimited and can be opened in Excel.
The values -999.0000 are to be ignored

Simulation time: 60.8192 seconds
Input file: C:\Users\tulo\Desktop\User_Interface\Examples\Affald-B
The maximum concentration at the point of compliance is 237.595594

LZ [m] 2; 4; 2.5
LY [m] 100; 160; 140
POC [m/y] 100; 250; 200
B [m] 10
u [1/day] 100/365
k [-] 1.0e-4
n [-] 0.25
alpha1 [m] 1.0
alpha2 [m] 0.01
alpha3 [m/y] 0.005
R [1/day] 2.5

time Total mass Total concentration
[y] [kg/y] [mg/L]
1940.0 0.0000000000 0.0000000000
1940.3 0.0000000000 0.0000000000
1940.5 0.0000000000 0.0000000000
1940.8 0.0000000000 0.0000000428
1941.0 0.0000000000 0.0000001064
1941.3 0.0000000000 0.0376486310
1941.5 0.0000000000 0.0937372180
1941.8 0.0000000000 5.9731683936
1942.0 0.0000000000 14.7048490003
1942.3 0.0000000000 43.5591487850
1942.5 2855.9709921712 82.2694253100
1942.8 2721.7118836083 108.3391405938
1943.0 2587.4527750454 128.2175605759

```

FIGURE 21. Example of an output .txt file from the model "Affald-B multiple units".

10. How to create the input .txt file

The models require the input time series of water discharge and contaminant concentration from the landfill that are obtained with the Kildestyrkemodel (2017). The models Affald-A and Affald-B require a .txt file with these time series. The .txt file must be created respecting the following requirements:

- There must be 2 heading lines and 3 columns for each contaminant unit
- The decimal separator must be a dot (not a comma)
- The 1st column is the time [years]
- The 2nd column is the water discharge [m^3/y]
- The 3rd column is the concentration [mg/L]
- The input time series must be 500-year long and with 1 year time step (501 lines in total)

The user can open with Excel the tab delimited input .txt files provided with the tutorials and see how the different time series are entered.

The following steps show an example of how to create the input file:

1) Copy the output time series of Kildestyrkemodel into a new Excel spreadsheets following the requirements stated above. The following figure shows 2 examples of how a spreadsheet should look like in the case of a single unit source and in the case of multiple units.

(a) Single unit source spreadsheet structure:

	A	B	C	D
1	Unit 1			
2	year	Q m ³ /y	mg/l	
3	1973	5000	2950	
4	1974	5000	2746.281	
5	1975	5000	2557.295	
6	1976	5000	2381.932	
7	1977	5000	2219.168	
8	1978	5000	2068.059	
9	1979	5000	1927.735	
10	1980	5000	1797.393	
11	1981	5000	1676.293	
12	1982	5000	1563.751	
13	1983	5000	1459.136	
14	1984	5000	1361.865	
15	1985	5000	1271.4	
16	1986	5000	1187.244	
17	1987	5000	1108.937	
18	1988	5000	1026.055	

(b) Multiple unit sources spreadsheet structure:

	A	B	C	D	E	F	G	H	I	J	K
1	Unit 1	Unit 1	Unit 1	Unit 2	Unit 2	Unit 2	Unit 3	Unit 3	Unit 3	Unit 4	Unit 4
2	year	Q m ³ /y	mg/l	year	Q m ³ /y	mg/l	year	Q m ³ /y	mg/l	year	Q m ³ /y
3	1973	19809	2950	1967	19809	8.099559	1967	11766	1490.613	2016	19809
4	1974	19809	2746.281	1968	19809	6.724223	1968	11766	1354.033	2017	19809
5	1975	19809	2557.295	1969	19809	5.586102	1969	11766	1230.4	2018	19809
6	1976	19809	2381.932	1970	19809	4.643666	1970	11766	1118.447	2019	19809
7	1977	19809	2219.168	1971	19809	3.862759	1971	11766	1017.036	2020	19809
8	1978	19809	2068.059	1972	19809	3.215274	1972	11766	925.143	2021	19809
9	1979	19809	1927.735	1973	19809	2.678068	1973	11766	841.8451	2022	19809
10	1980	19809	1797.393	1974	19809	2.232068	1974	11766	766.3127	2023	19809
11	1981	19809	1676.293	1975	19809	1.861551	1975	11766	697.7984	2024	19809
12	1982	19809	1563.751	1976	19809	1.553543	1976	11766	635.6289	2025	19809
13	1983	19809	1459.136	1977	19809	1.297334	1977	11766	579.1974	2026	19809
14	1984	19809	1361.865	1978	19809	1.084075	1978	11766	527.9569	2027	19809
15	1985	19809	1271.4	1979	19809	0.906455	1979	11766	481.4141	2028	19809
16	1986	19809	1187.244	1980	19809	0.758421	1980	11766	439.124	2029	19809

FIGURE 22. Examples of how to create the input time series for the models Affald-A and Affald-B in Excel. (a) The case of a single unit source. (b) The case of multiple unit sources.

- 1) Save the Excel file as "Text (Tab delimited)". See the following figure.

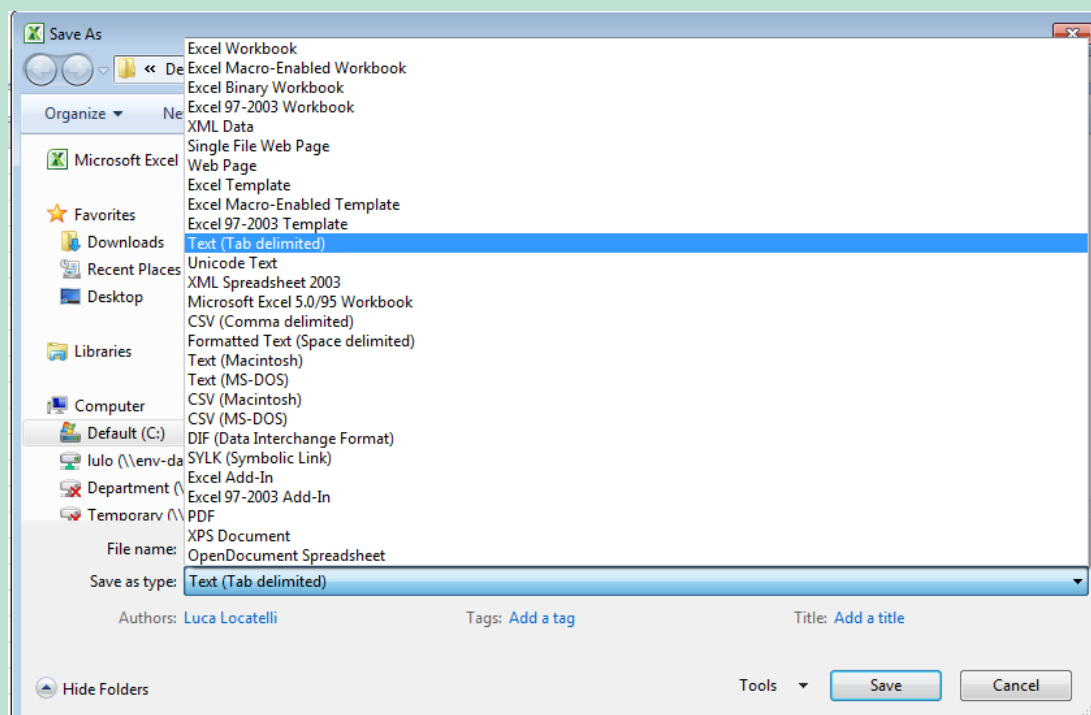


FIGURE 23. Example of how to save the Excel file as "Text (Tab delimited)".

- 2) Check that the .txt file looks like the one shown in the following figure.

(a)

EX_4_Source_inputs_AffaldA_Single

	File	Edit	Format	View	Help
Unit 1	Q m3/y	mg/l			
year					
1973	5000	2950			
1974	5000	2746.28114			
1975	5000	2557.29528			
1976	5000	2381.93199			
1977	5000	2219.16772			
1978	5000	2068.0588			
1979	5000	1927.73492			
1980	5000	1797.39331			
1981	5000	1676.29326			
1982	5000	1563.75115			
1983	5000	1459.13592			
1984	5000	1361.86488			
1985	5000	1271.39984			
1986	5000	1187.24362			
1987	5000	1108.93681			
1988	5000	1036.05478			
1989	5000	968.204959			
1990	5000	905.024327			
1991	5000	846.177113			
1992	5000	791.352668			
1993	5000	740.263518			

(b)

EX_2_Source_inputs_AffaldA_MultipleUnits_3_Units - Notepad

Unit 1	Unit 1	Unit 1	Unit 2	Unit 2	Unit 2	Unit 3	Unit 3	Unit 3	
Ar	Q m3/Ar	mg/l	Ar	Q m3/Ar	mg/l	Ar	Q m3/Ar	mg/l	
1940	17424.35133	170	1959	15060.22494	450	1959	15060.22494	590	
1941	17424.35133	138.0332209	1960	15060.22494	264.9932899	1960	15060.22494	160	272.859071
1942	17424.35133	113.4348869	1961	15060.22494	161.1136697	1961	15060.22494	101	134.029232
1943	17424.35133	94.30538331	1962	15060.22494	101.5380997	1962	15060.22494	71	71.32805043
1944	17424.35133	79.27868935	1963	15060.22494	66.66331418	1963	15060.22494	42	42.13926011
1945	17424.35133	67.36182923	1964	15060.22494	45.83861321	1964	15060.22494	28	28.14637714
1946	17424.35133	57.82555112	1965	15060.22494	33.16220227	1965	15060.22494	21	21.24435714
1947	17424.35133	50.12891477	1966	15060.22494	25.30082195	1966	15060.22494	17	17.74422993
1948	17424.35133	43.86685729	1967	15060.22494	20.33684766	1967	15060.22494	15	15.02058043
1949	17424.35133	38.73228793	1968	15060.22494	17.14721383	1968	15060.22494	14	14.94485811
1950	17424.35133	34.49488095	1969	15060.22494	15.06274745	1969	15060.22494	14	14.08883811
1951	17424.35133	30.9722865	1970	15060.22494	13.67801921	1970	15060.22494	14	14.06580714
1952	17424.35133	28.02653758	1971	15060.22494	12.74340081	1971	15060.22494	13	13.91390611
1953	17424.35133	25.54912996	1972	15060.22494	12.10277917	1972	15060.22494	13	13.82693061
1954	17424.35133	23.45472169	1973	15060.22494	11.65704289	1973	15060.22494	13	13.62700311
1955	17424.35133	21.67571695	1974	15060.22494	11.34234738	1974	15060.22494	13	13.72183931
1956	17424.35133	20.15821639	1975	15060.22494	11.1698404	1975	15060.22494	13	13.69483431
1957	17424.35133	18.85896656	1976	15060.22494	10.85896656	1976	15060.22494	13	13.69483431
1958	17424.35133	17.74304515	1977	15060.22494	10.6218765	1977	15060.22494	13	13.69483431
1959	17424.35133	16.7820925	1978	15060.22494	10.396118	1978	15060.22494	13	13.69483431
1960	17424.35133	15.95295118	1979	15060.22494	10.170618	1979	15060.22494	13	13.69483431
1961	17424.35133	15.23661282	1980	15060.22494	9.94439198	1980	15060.22494	13	13.69483431
1962	1105.589598	39.70681547	1981	15060.22494	9.7198107	1981	15060.22494	13	13.69483431
1963	1105.589598	39.69057485	1982	15060.22494	9.494924	1982	15060.22494	13	13.69483431
1964	1105.589598	39.67439198	1983	15060.22494	9.269849	1983	15060.22494	13	13.69483431
1965	1105.589598	39.65826664	1984	15060.22494	9.0448107	1984	15060.22494	13	13.69483431
1966	1105.589598	39.6421986	1985	15060.22494	8.8198107	1985	15060.22494	13	13.69483431
1967	1105.589598	39.62618765	1986	15060.22494	8.5948107	1986	15060.22494	13	13.69483431
1968	1105.589598	39.61023356	1987	15060.22494	8.3698107	1987	15060.22494	13	13.69483431
1969	1105.589598	39.59433611	1988	15060.22494	8.1448107	1988	15060.22494	13	13.69483431
1970	1105.589598	39.57849509	1989	15060.22494	7.9198107	1989	15060.22494	13	13.69483431
1971	1105.589598	39.56271026	1990	15060.22494	7.6948107	1990	15060.22494	13	13.69483431
1972	1105.589598	39.54698143	1991	15060.22494	7.4698107	1991	15060.22494	13	13.69483431
1973	1105.589598	39.53130837	1992	15060.22494	7.2548107	1992	15060.22494	13	13.69483431

FIGURE 24. Examples of how the .txt input file should look like. (a) The case of a single unit source. (b) The case of multiple unit sources.

11. Frequently asked questions.

Here is a list of questions/issues/discussions that the users might find useful.

- 1) QUESTION. The output concentration is not smooth. Instead, it is made of several small steps like the one shown below.

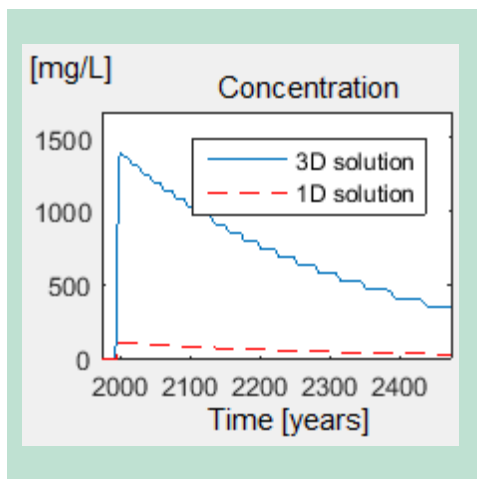


FIGURE 25. Examples of an output concentration that is not smooth.

ANSWER. The program in order to run fast discretizes the input source functions. It can happen in some cases that the input function discretization is somewhat rough and the output looks like the one in the figure. The error introduced by the rough discretization is generally insignificant.

- 2) QUESTION. The output concentration from the 3D model has a flat peak like the one shown in the figure below.

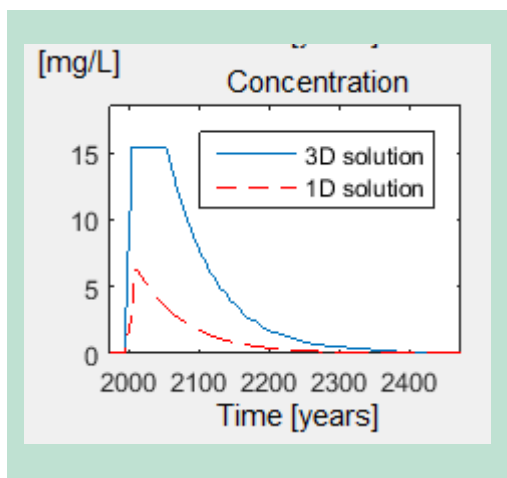


FIGURE 26. Examples of an output concentration from the 3D model that shows a flat peak.

ANSWER. The 3D model assumes that the input water from the landfill do not affect the water balance of the aquifer (Nevertheless, landfills are generally large and can affect the water balance of an aquifer). Therefore, the model computes the concentrations in the aquifer excluding the dilution given by the additional water coming from the landfill. In some cases the model gives concentrations that are higher than the input concentrations and this is physically unacceptable. Concentrations in the aquifer that are higher than the input concentrations are excluded. The contaminant mass discharge in the aquifer is correct since it is computed using a different model. See the main report (DEPONIER RAPPORT 2017) for further details and discussion about the models.

- 3) QUESTION. How is it possible that the 1D model results in much lower concentrations compared to the 3D model?

ANSWER. The 1D model is based on different assumptions compared to the 3D model, i.e. it assumes that the contaminant is uniformly distributed over the depth of the aquifer. This assumption is valid only in the case of "thin" aquifers. Therefore if the aquifer is "thick" the 1D model can give much smaller concentrations compared to the 3D model. See the main report (Miljøstyrelsen, 2018) for further details and discussion about the models.

- 4) QUESTION. Why is the output concentration from the model constant as a function of the distance downstream the landfill?

ANSWER. The user might experience that the output concentration of the 1D model does not change even if different PoC distances are entered (i.e. the concentration is the same at PoC=100m and PoC= 600m). This happens in the case of thin aquifers (1D model) and when there is no degradation. This is because the 1D model does not include dispersion. Conceptually, this is reasonable for landfills discharging in thin aquifers, in fact it will require very large distances before dispersion will have an effect and in most of the cases the PoC distances are relatively small.

References

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