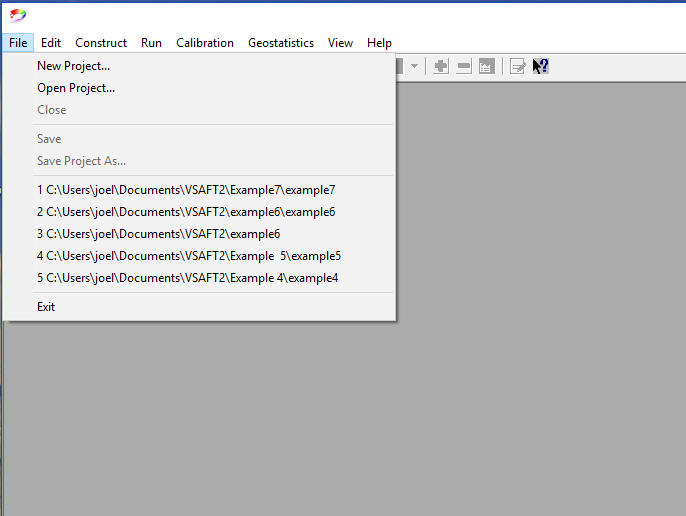
## Example 9: Ill-Posed one dimensional Horizontal Flow Problem

This example shows how to set up and solve an ill-posed 1-D inverse problem. It is similar with example 8 except less observation wells are used.

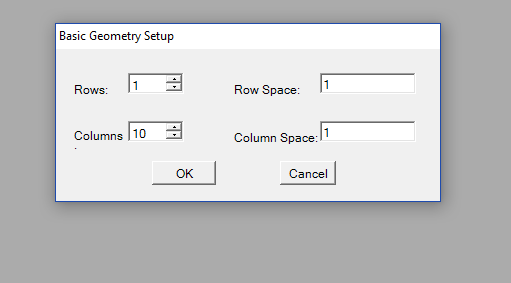
**Part 1: Generating observations well data:**

1. New Project

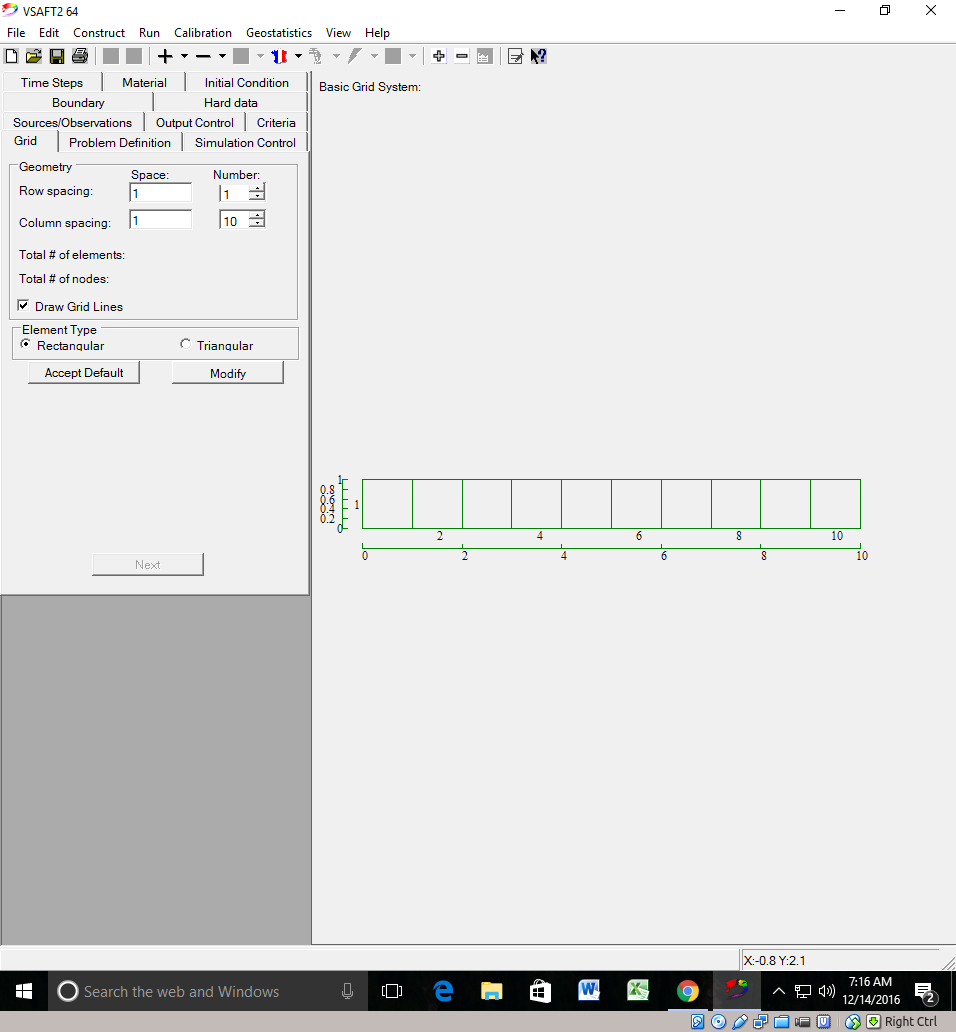
* Start a new project by selecting **File** then **New Project**.



Define the initial grid dimensions (you can edit this later).

* Change the value for the number of rows to **1**.
* Change the value for the number of columns to **10**.
* Change the row and column spacing to **1**.
* Select **OK**.

You should have been advanced to the main VSAFT2 window. Your screen should look like the one below.

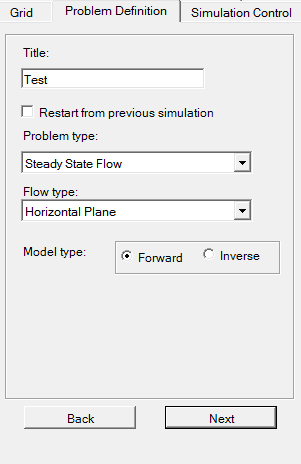


For this example we will accept the grid without editing the row or column spacing or adding additional rows or columns.

* Select **Accept Default**
* Select **Next** to advance to the problem definition tab.

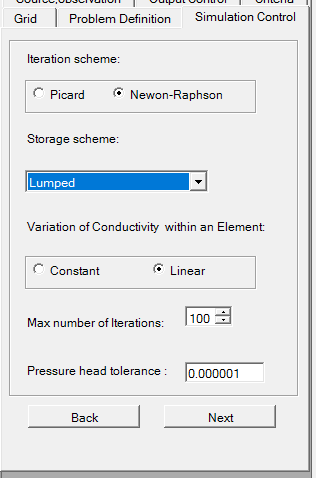
1. Problem Definition

* Enter a title in the TITLE box such as **Problem\_9\_Ill\_Posed**. This is for record keeping purposes and to assist in remembering the details of the model. Use a descriptive title.
* Use the Problem type drop down menu to select **Steady State Flow**
* Use the Flow type drop-down menu to select **Horizontal Plane**
* Choose model type as **Forward.**
* Select **Next** to continue to the simulation control tab.



1. Simulation Control

* Select the **Lumped** storage scheme.
* Select the **Linear** for the variation of conductivity within an Element.
* Set the **Pressure head tolerance** to **0.000001**
* Select **Next** to continue to the Material tab.



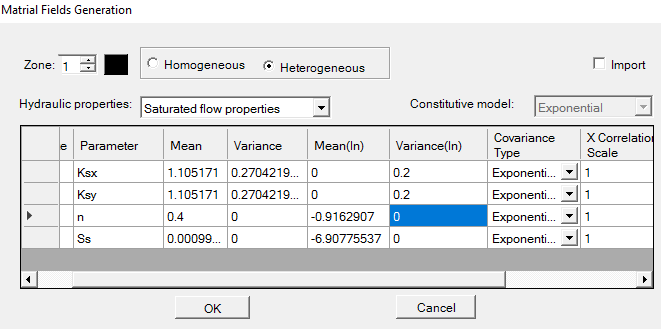
1. Materials

This example uses random material.

* Click **Define** to enter the material properties
* Choose **Heterogeneous** for representing random material.
* In the Hydraulic properties box select **Saturated Flow properties**.

Enter the X and Y correlation scale and the variance for Ksx, Ksy.

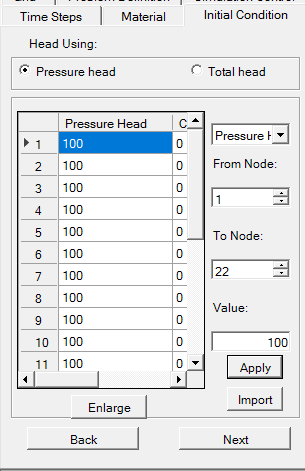
* X correlation scale = **1**
* Y correlation scale = **1**
* Variance (ln) = **0.2**
* Mean (ln) = **0**
* Select **OK**
* Select **Next** to continue to the Initial condition tab



1. Initial conditions

Set the initial hydraulic head

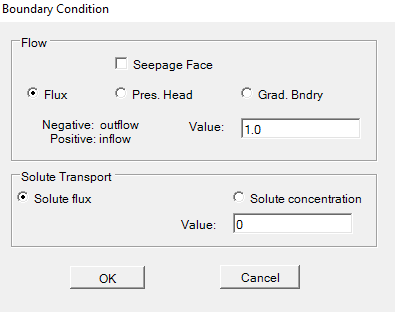
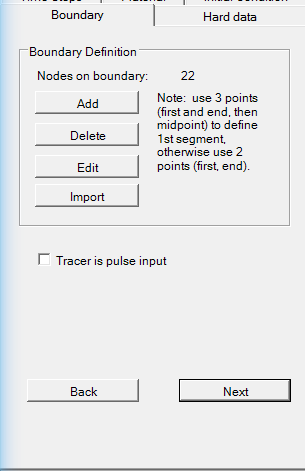
* Select **Pressure Head**
* Enter the initial hydraulic head of **100.0** in the value box.
* Select **Apply.**
* Select **Next** to continue to the initial condition tab.



1. Boundary

Here we will set the boundary conditions: the left side as a **prescribed flux** and the right side as a prescribed **pressure**.

* Click **Add** in the Boundary Definition area.
* With the mouse select the beginning and the end of the boundary on the left of the column. Also select the midpoint on the boundary so that VSAFT2 knows which direction along the boundary you wish to define. This step is only required for the first boundary.

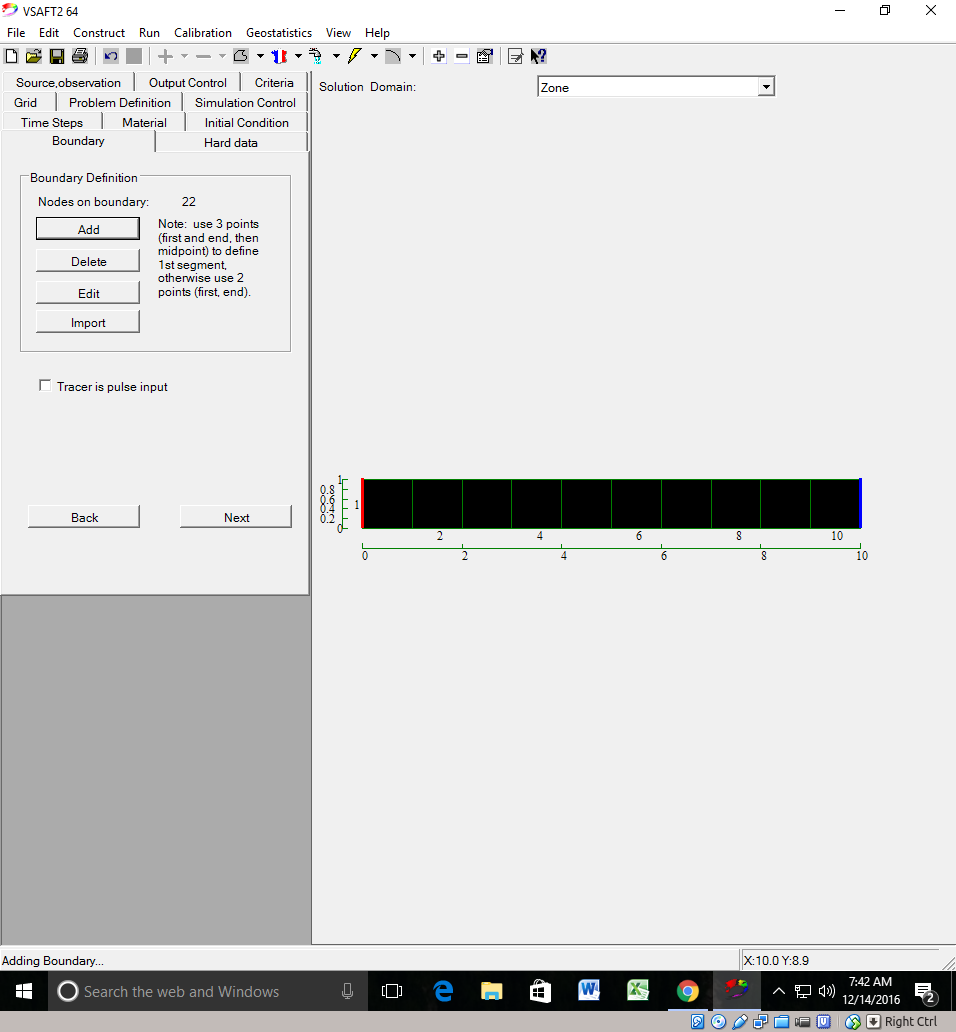


Once the boundary is defined a pop-up window will appear so the boundary values can be inputted.

* Select **flux** and enter the value of **1.0**.
* Select **OK**

Add another boundary condition to the right side of the domain.

* Select **Add** from the boundary definition window and define the right side as a prescribed head boundary.
* With the mouse, select the beginning and the end of the boundary on the right.
* Once the boundary is defined, a pop-up window will be displayed
* Select **Pres. Head** and enter the value of **100** in the pop-up window.
* Select **OK**
* Select **Next** to continue to the Source/Observation tab.

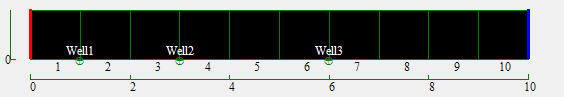


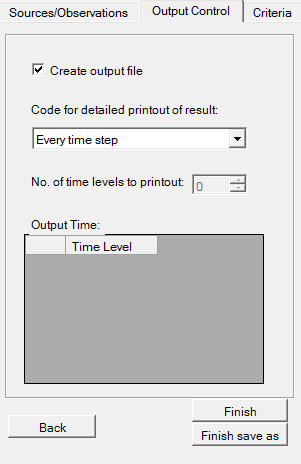
1. Source/observation

We will not need to add any sources because we are describing natural flow condition.

Add observation wells:

* Select **Add** under the stress definition section.
* Click the bottom part of the domain and create 3 observation wells at the nodes shown below.
* Name each well.
* Select **Next**.

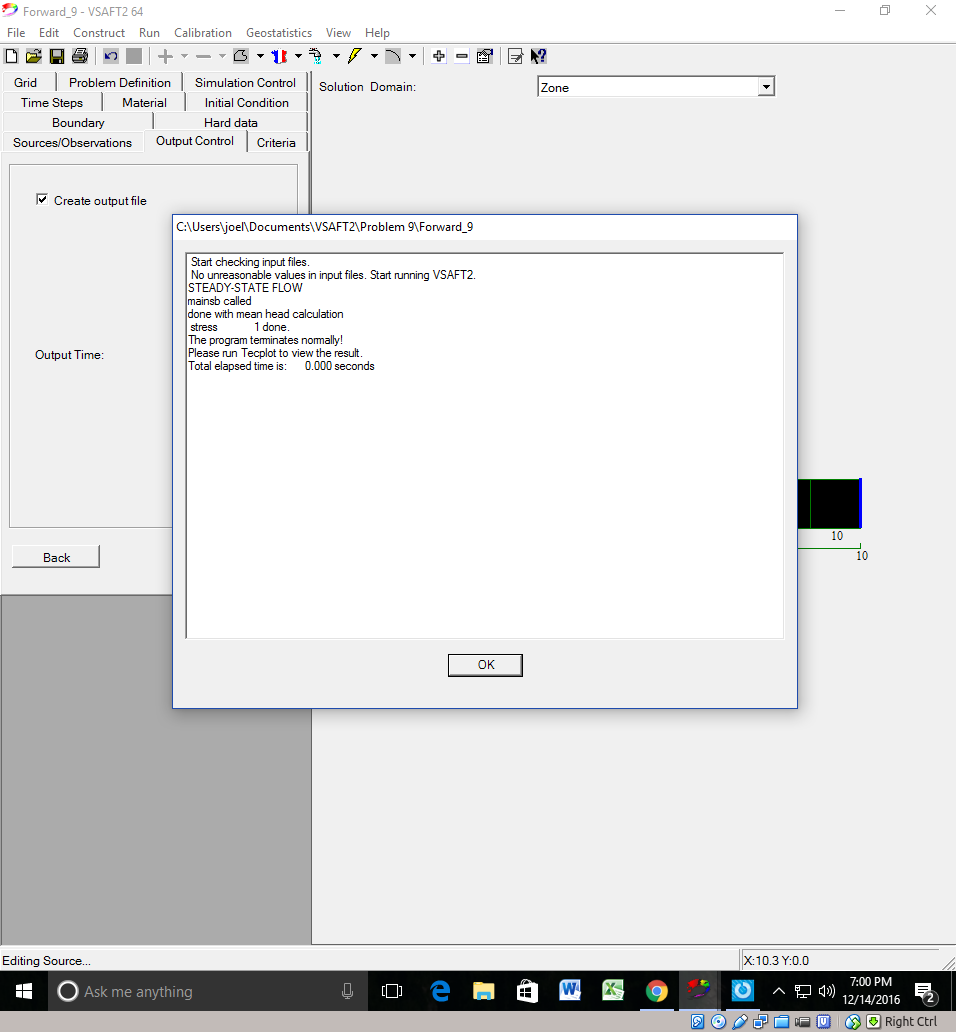


1. Output Control

* Make sure the **Create output file** box is checked.
* Leave the other defaults.
* Choose **finish save as** to save the project.
* Save the project as **Forward\_9**

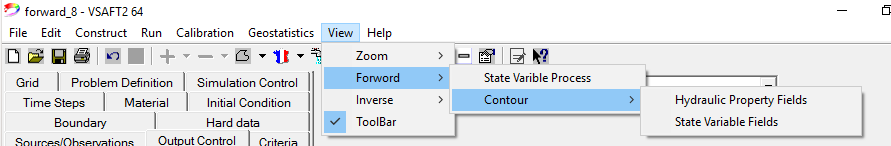
1. Running VASFT2

* Select **RUN** and then **VSAFT2**
* When finished the screen should look like the picture below.

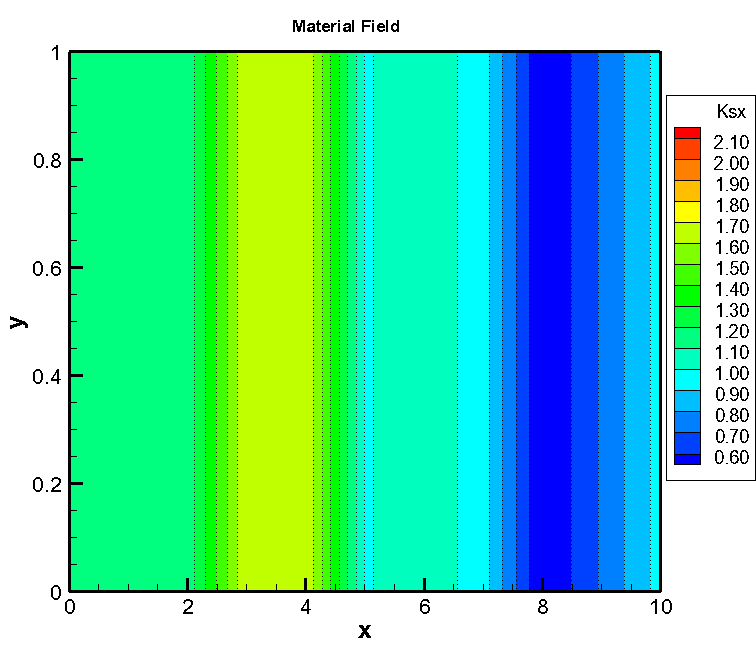


1. Plotting the hydraulic Conductivity

* They hydraulic conductivity can be plotted by selecting **View->Contour->Hydraulic Property Fields**.



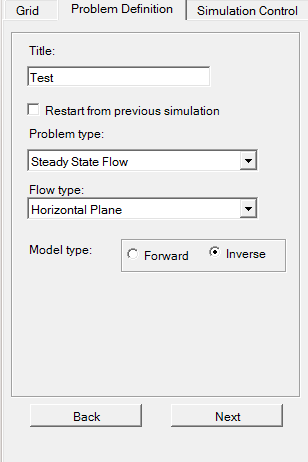
The generated field should be similar to the graph below.



**Part 2: Using well data generated from part one in an inverse model:**

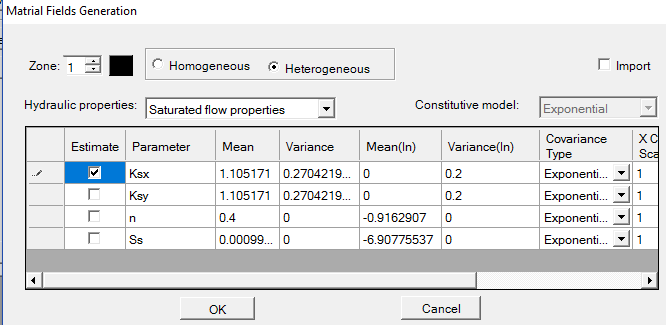
1. Problem Definition

* Select tab **Problem Definition**.
* Check **Inverse** in the model type.
* Then select the **Materials** tab.



1. Material

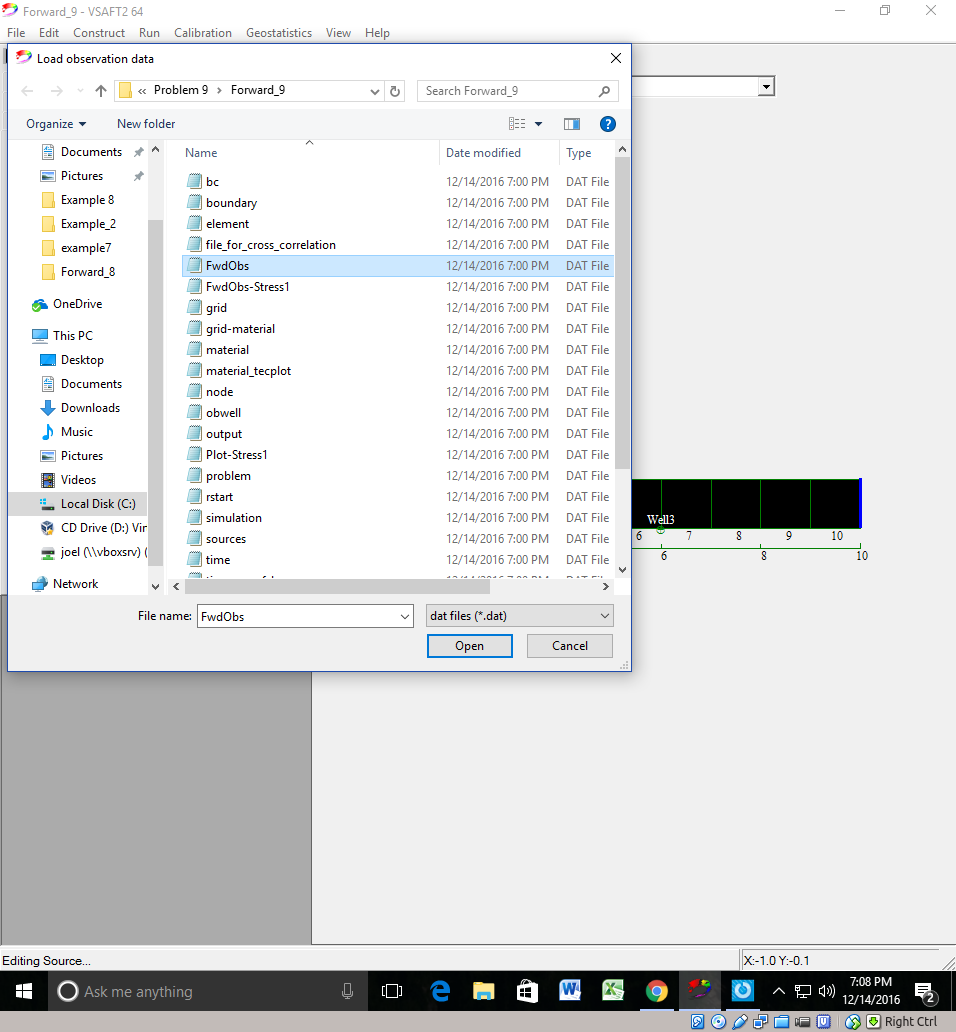
* Select the **Material** tab.
* Click **Define** in the “Zone Material Properties” section. A window, like the one shown on the right will open.
* Under the “Estimate” section select the checkbox next to Ksx. Since we are modeling a steady state saturated flow problem, we can only estimate Ksx.
* Make sure the parameters not being estimated from the part 1 are the same (they should be).
* Select **OK.**
* Now select the **Source.observation** tab.



1. Source.observation

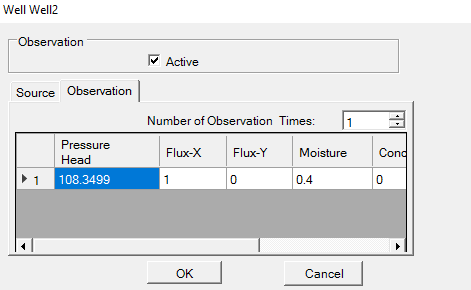
Now we can import the observed head generated by the synthetic test.

* Choose tab **Source.observation**.
* Click **Import** **Observations** in the “Stress Definition” area.
* Find the location of the file **FwdObs.dat** located in the Forward\_9 folder generated from part 1.
* Select **Open** to import the data.



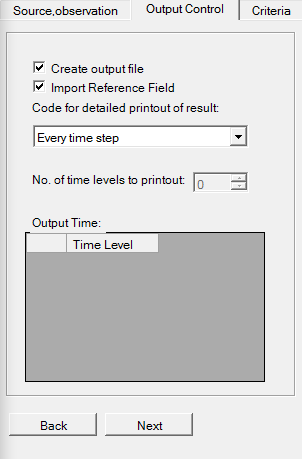
You can check whether the data is correct or not.

* Select **Edit Well** under the “Sources/Observation Definition” section and then click any of the observation well.
* A new window will open. Select the **Observation** tab and notice the fields are now populated with observational data from the forward model in Part 1.
* Select **Ok.**
* Select **Next** to continue to “Output Control” tab.



1. Output Control

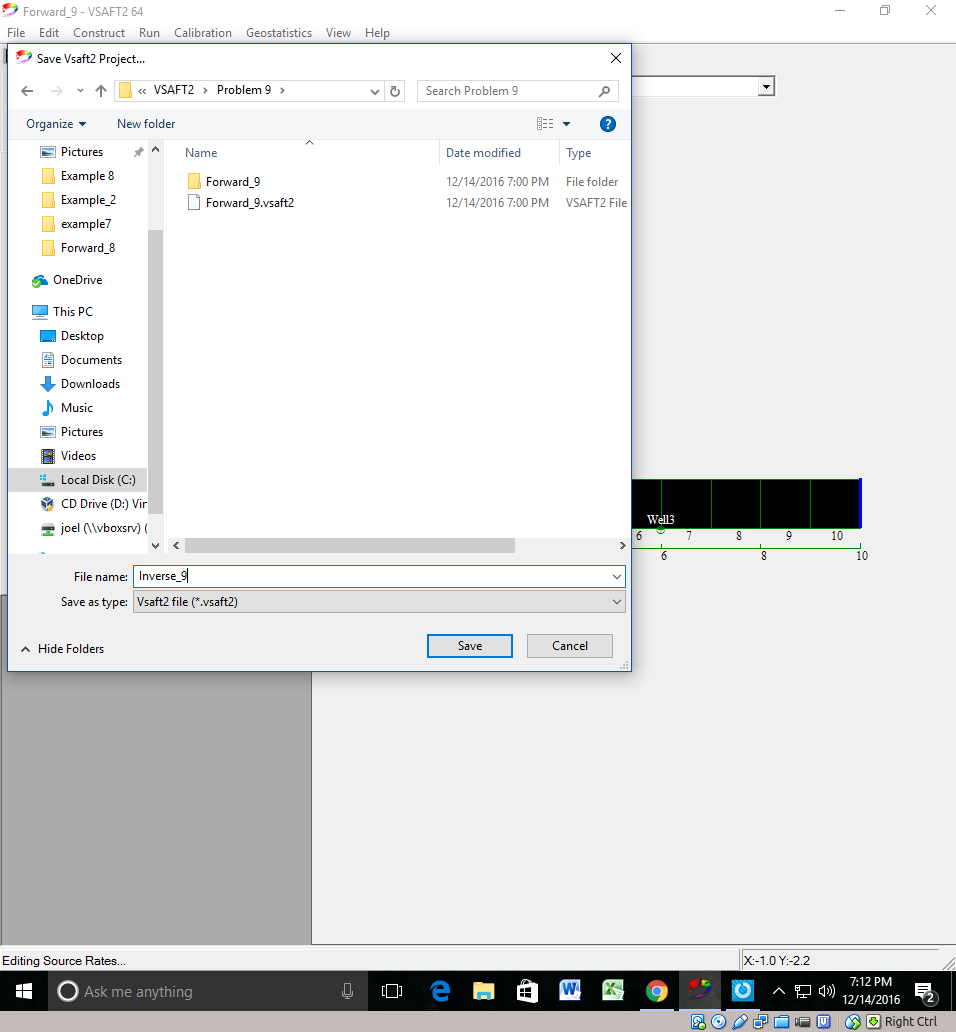
* Make sure the **Create output file** box is checked.
* Select **Import Reference Field** and a popup box will be displayed.
* Find the location of the file, **material.dat** located in the “Forward\_9” folder generated from part 1.
* Select **Open** to import the data. This will allow us to compare data from the forward problem to the results generated in the inverse problem.
* leave the other defaults
* Click **Next** to continue to the “Criteria” tab.



1. Criteria

The “Criteria” tab is used to define the parameters used for the parameter estimation.

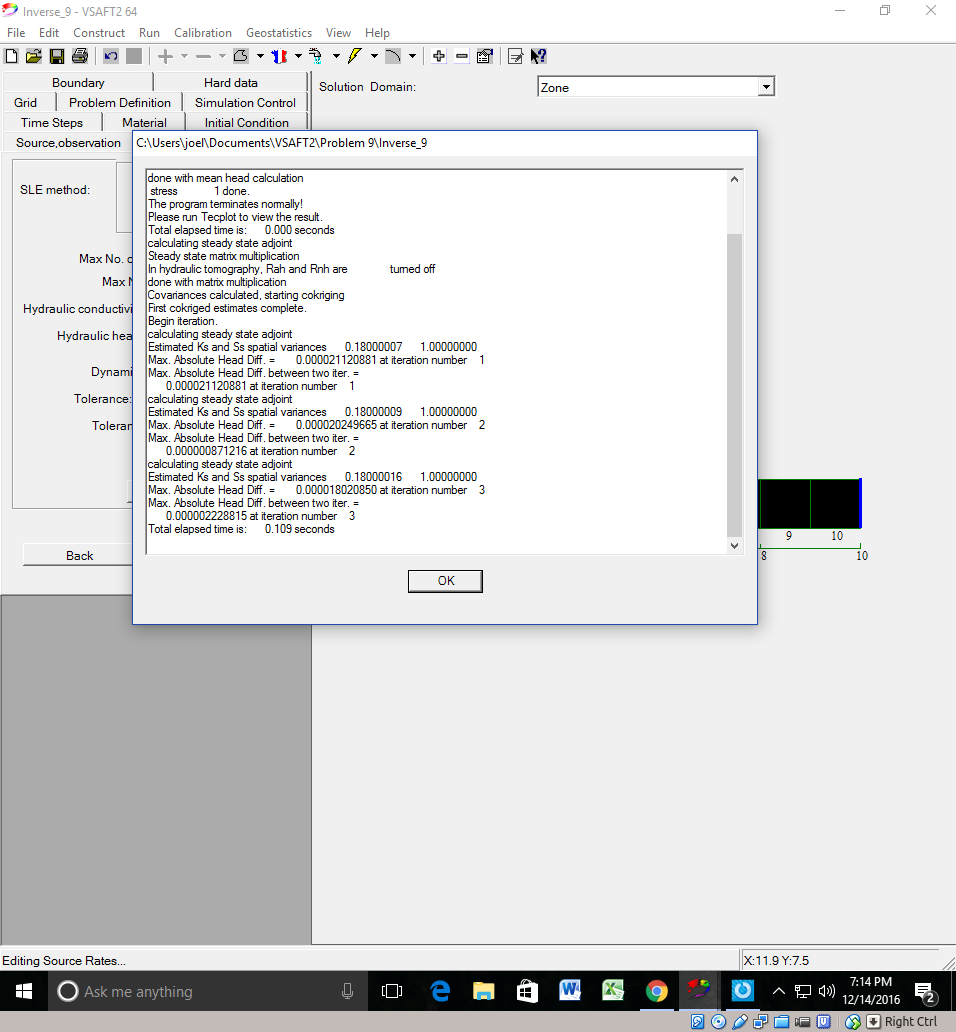
* For this example, we will keep all the parameters as default.
* Choose **Finish** **Save as**.
* Save the file as **Inverse\_9**



1. Running VASFT2

* Select **RUN** and then **VSAFT2**

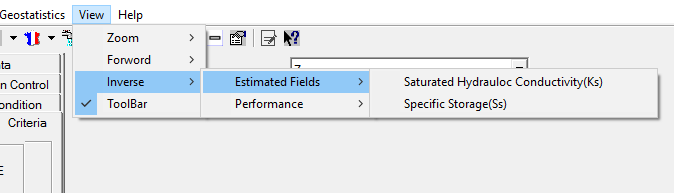
The program will run SSLE to estimate the unknown Ks values.



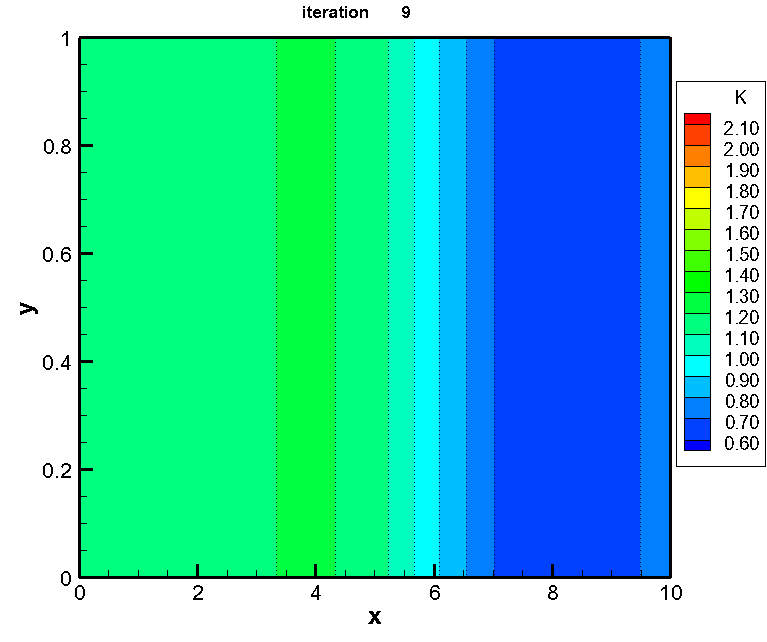
View results:

To view the property distribution derived from the inverse solution in TECPLOT

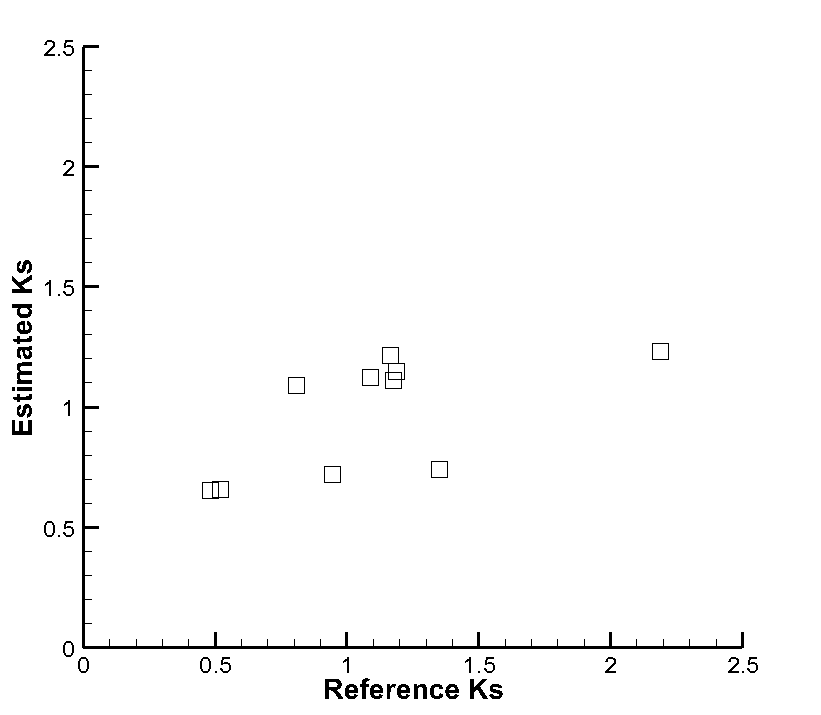
* Select **View->Inverse->Estimated Fields->Saturated Hydraulic Conductivity(Ks)**



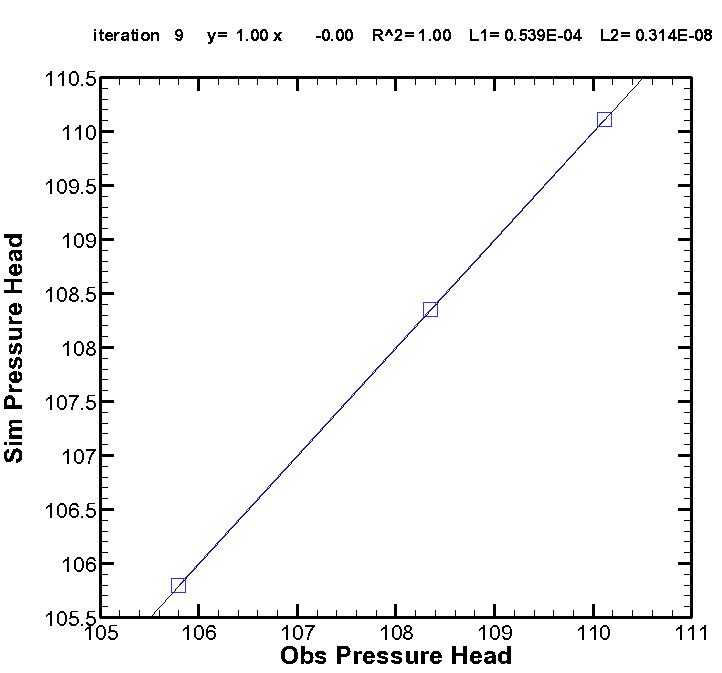
After adjusting the scale and iterations described in Example 8 the plot of the “Estimated Field” for hydraulic Conductivity will look like this:



Following the procedure described in “Example\_8”, we can produce an X-Y plot comparing the hydraulic conductivity at each observation well calculated by the inverse solver and the actual hydraulic conductivity generated by the forward problem.



Notice, like the two hydraulic conductivity field maps produced above; there is a large variation between the estimated hydraulic conductivity and the reference hydraulic conductivity do the lack of information used in the inverse estimation. Notice that this result is produced despite the solver converging on a solution that perfectly matches the pressure head data in our three wells as seen below.



An Ill-posed problem often has multiple solutions due to a lack of knowledge about the system. Some solutions may be substantially different from the actual system.