ModelMuse with Support for PEST – Beta 5

This version adds more flexible methods for adding (or deleting) pilot points. It also resolves some of the known issues from Beta 4.

# How Pilot Points are Used

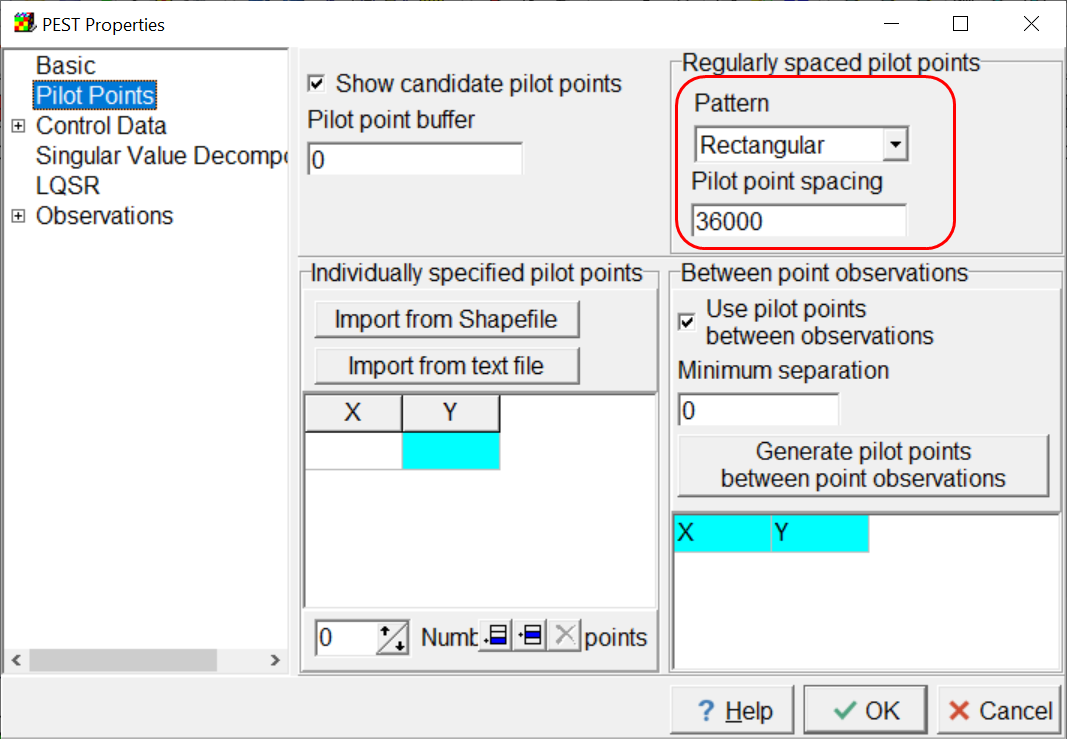
Pilot points are recorded on the

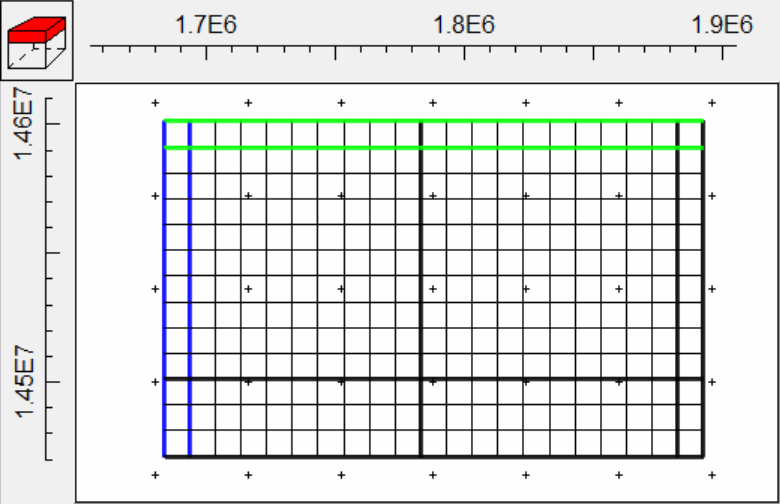
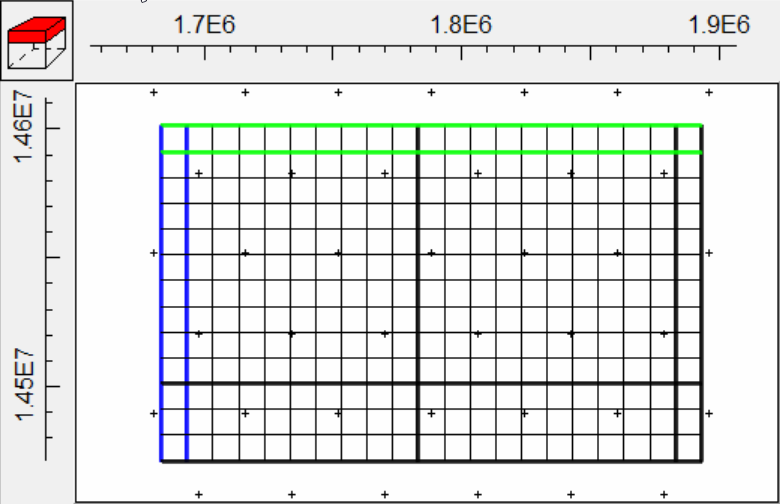
# Defining Pilot Point Locations

Model Muse provides several ways to define pilot point locations. These methods can each be used separately or together with other methods.

## Regularly Spaced

Regularly spaced pilot points arranged either in squares or equilateral triangles can be defined by specifying the desired pattern and pilot point spacing in the **Model|Pest Properties** dialog box. By design, some pilot points will typically lie outside the model grid or mesh. Pilot points defined in this way will be displayed as small plus symbols. The only control the user has over their position is through the pattern and spacing. It is not possible to delete such pilot points individually. If the spacing is set to zero or the pattern is set to none, pilot points will not be defined by this method. The spacing is typically at least several times larger than the cell size.



Regularly space pilot points are often used where there is little information available about the distribution of the properties to be estimated by pilot point interpolation.

## Individually Specified Pilot Point Locations.

Another way to specify pilot points is to specify them individually This can be done in several ways. One way is to import them from a text file or a Shapefile. Buttons on the **Model|Pest Properties** dialog box can be used for that purpose. For text files, each line must define a pilot point location. The line must start with two numbers separated by a comma and/or one or more spaces. Additional text may be present on the line but it will be ignored. For Shapefiles, each unique point in the Shapefile will define a pilot point location. The pilot point locations will be displayed in a table in the **Model|Pest Properties** dialog box. The user can also type pilot point locations in that table or copy locations from a spreadsheet program and paste them in that table. Finally, on the ModelMuse main form, the user can select **Edit|Add Pilot Point** or click the **Add pilot point** button and then click on the top view of the model to add a pilot point at the location where the mouse button was released.

Individually specified pilot points are displayed with a small x symbol instead of a small plus symbol. They can be deleted by the user.

Individually specified pilot points can be useful in helping to express the users expert knowledge about a property. For instance, suppose we believe that hydraulic conductivity of a unit is higher near rivers than along ridges. In such a case we might place the pilot points along the river and on the ridge lines.

## Generate Pilot Points Locations Between Observation Locations

Pairs of point observations can give information about the properties of the material between them. For example, a large head difference between them might mean that the material between them has a low transmissivity whereas a small head difference might mean that the material between them has a low transmissivity. ModelMuse provides a way of automatically generating pilot point locations between point observations. To do this, the user clicks the **Generate pilot points** button on the **Model|Pest Properties** dialog box. ModelMuse will identify all the point objects that define calibration observations and create a triangulation of them. It will then create pilot points at the midpoint of the edges of each triangle.

If the point observations are closely spaced together, especially if there are several in the same cell, the pilot points may be too tightly clustered together. In such cases, it can be desirable to delete some of the closely spaced pilot points. To do this, the user can specify a **minimum point separation** when generating the pilot points between observations. ModelMuse will use this separation to delete some of the pilot points that are too close together.

Pilot points between point observations are displayed with a small x symbol instead of a small plus symbol. They can be deleted by the user.

# Deleting Pilot Points

Pilot points can be deleted in several ways. First, for individually specified pilot points, the user can delete the row in the table containing them in the **Model|Pest Properties** dialog box. The user can also select **Edit|Delete Pilot point(s)** or click on a **Delete pilot point(s)** button and then click on a pilot point to delete it. This only applies to individually specified pilot points or pilot points between point observations. It does not apply to the regularly spaced pilot points. To distinguish between these two types of pilot points, the regularly spaced pilot points are drawn using a plus symbol and the others are drawn with a x symbol. To delete multiple pilot points at once, select **Edit|Delete Pilot point(s)** or click on a **Delete pilot point(s)** button and then click down on a location on the top view of the model. Then drag the mouse while holding the mouse button down. When the mouse button is released, all the pilot points that are allowed to be deleted in the rectangle defined by the locations where the mouse button was depressed and where it was released will be deleted.

# Known Issues

There are several issues that are yet to be resolved. Here are the most prominent ones of which you should be aware.

## No Prior Information for Pilot Points

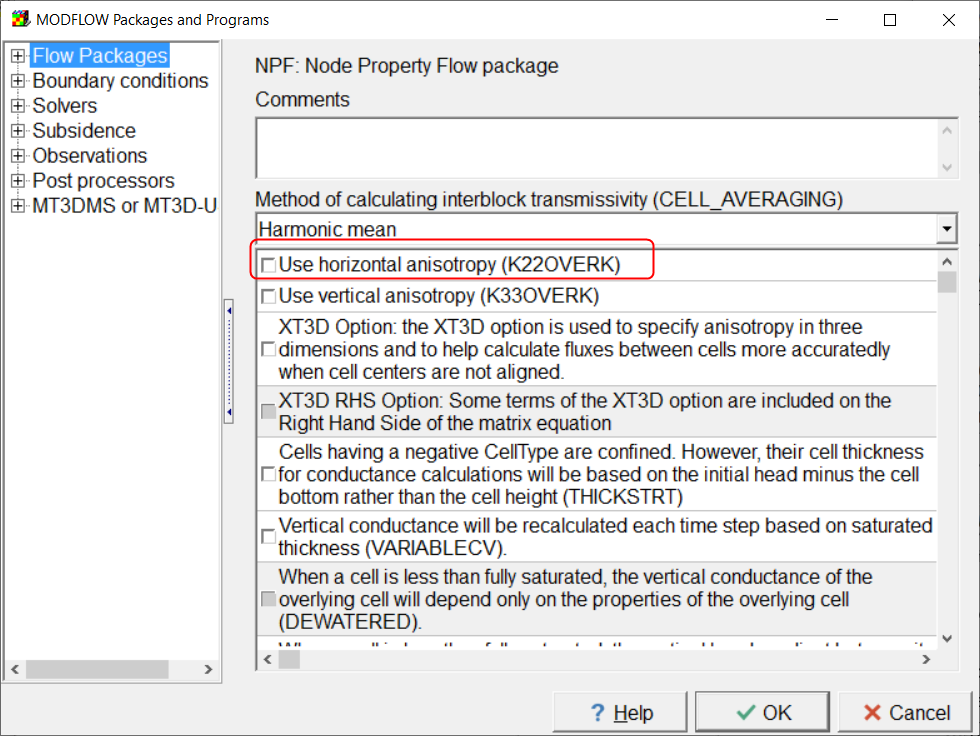
ModelMuse does not include any prior information for Pilot Points as would typically be required. You may wish to use GENREG in the PEST groundwater utilities. To add such information. There are other utilities in the PEST Utility Support Software that you might also consider.

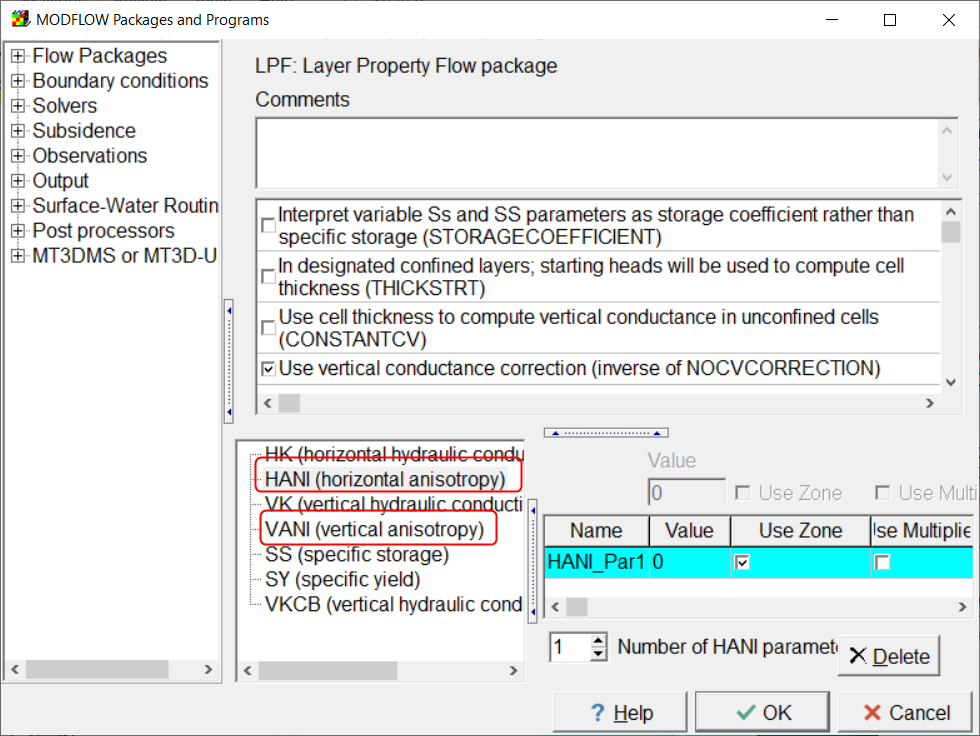
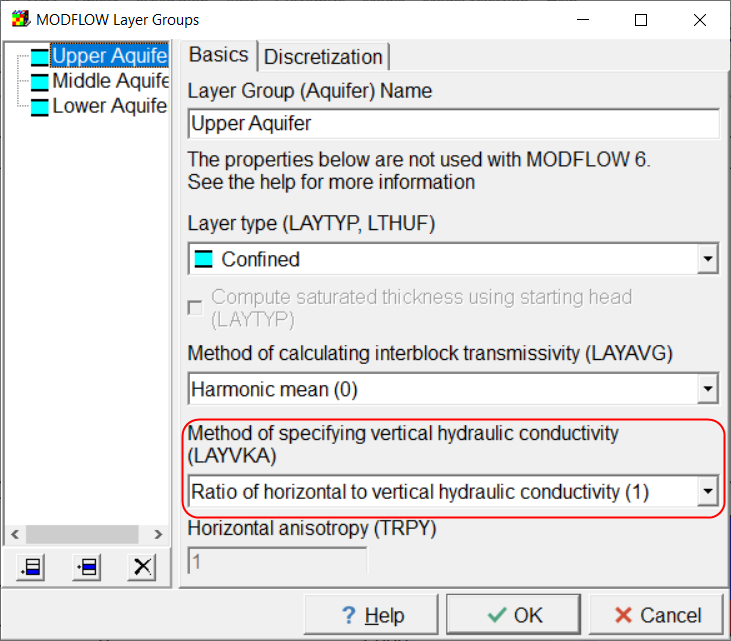
## Linked Data Sets and Anisotropy.

In ModelMuse, there are a number of data sets whose default formulas link them with other data sets. The most prominent of these are Kx, Ky, and Kz. The default formulas for Ky is Kx and the default formula for Kz is Kx/10. Now consider the case where you want Ky to have the same value as Kx but you also want to calibrate Kx. One option would be to define one or more parameters for Kx but do nothing with Ky. PEST will then modify Kx but the value of Ky was set by ModelMuse and doesn’t instruct PEST to modify it so nothing happens to Ky so you don’t achieve your goal of having Ky be the same as Kx. Another option would be to have both Kx and Ky be estimated and to use the same parameters for both and in the same locations. This doesn’t work either so long as the formula for Ky is set to Kx. Suppose the parameter value was 1E-4 m/s. Kx then gets a value of 1E-4 times whatever value was assigned to Kx by the default formula or objects. Let’s assume that the default formula for Kx is 1 so the final value for Kx is 1E-4. The value of Ky set by the default formula is 1E-4. This is multiplied by the parameter value to get a final value of 1E-8. That is very different from your goal of having Kx equal to Ky.

The best way to handle this to meet the goal is to specify horizontal anisotropy as the model input rather than specifying Ky directly. In MODFLOW 6, this is done using an option in the NPF package. There is a similar option for vertical anisotropy. In MODFLOW-2005, horizontal anisotropy is part of the model input by default and you can also have vertical anisotropy be part of the model input. You can also have horizontal anisotropy and vertical anisotropy parameters. The parameters are specified in the “Model|MODFLOW Packages and Programs” dialog box. The vertical anisotropy option is specified in the “Model|MODFLOW Layers” dialog box.

There are no similar options for SUTRA. Your best option is probably to use tied parameters for Ky and Kz. However, this isn’t supported right now if pilot points are used.



## Tied Parameters and Pilot Points.

At present, if Pilot Points is selected for a parameter in the “Model|Manage Parameters” dialog box, the parameter is replaced by a series of pilot points. Therefore you can not have such a parameter involved in tied parameters either by being tied to another parameter or by having another parameter being tied to it. However, ModelMuse doesn’t prevent you from tying such parameters in either direction. There might be some way of handling this at least in some cases but, at present, ModelMuse will just create a defective PEST control file.

## SUTRA Boundary Condition Parameters

There isn’t yet a way a specifying boundary condition parameters for SUTRA.

## Pilot Points for Boundary Conditions

ModelMuse does not yet provide a way to utilize pilot points for boundary conditions.

## Bugs in SUTRA

There are some bugs in the released version of SUTRA that inhibit it from being used with PEST. Alden Provost has provided a fixed version of SUTRA but we are still awaiting the official release of a fixed version.

## Pilot Points are not displayed in the Export Image dialog box.