Drains

1 Introduction

This steady state SEEP/W example illustrates different ways to model drains. Should the hole be incorporated into the mesh and what is the most appropriate boundary condition to apply at the drain? An important point to remember is that a drain modeled in two-dimensions extends horizontally into the page and therefore represents a drainage trench.

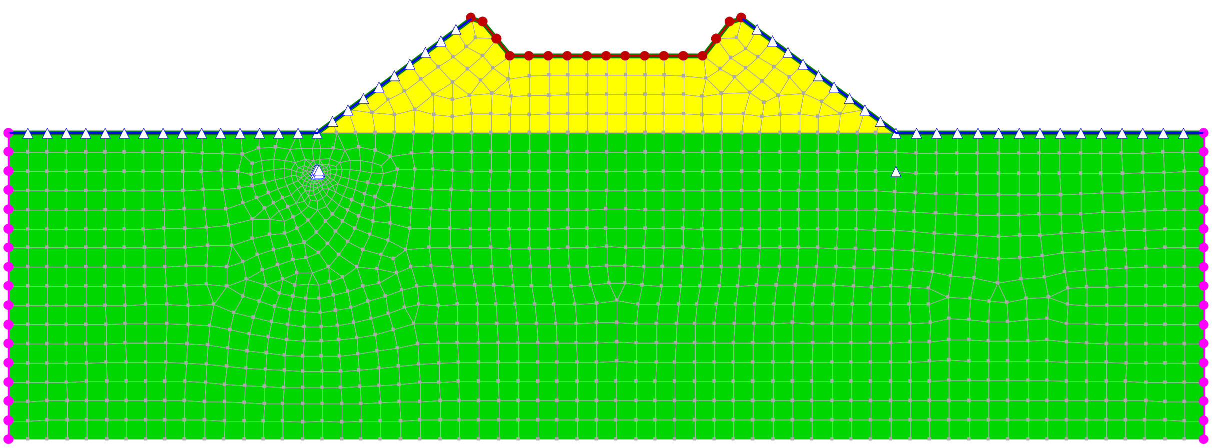
2 Feature highlights

GeoStudio feature highlights include:

- Steady state flow
- Seepage face and P=0 boundary conditions
- Multiple files in a single analysis
- Flux sections and results information for drain flow

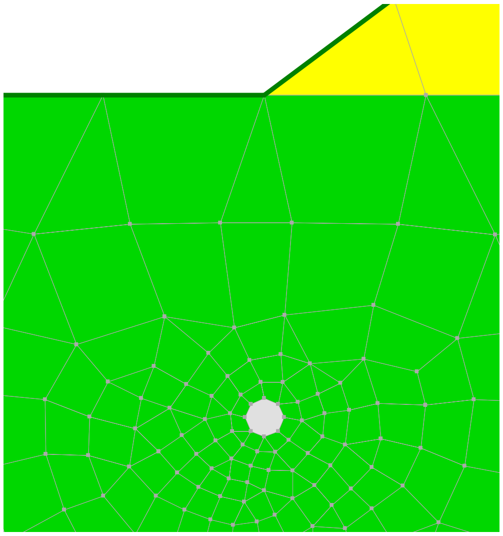
3 Geometry and boundary conditions

The image below shows an elevated canal with potential seepage faces that can develop on either side of the levees. The objective of this example is to see if a drain can be used to draw down the watertable to prevent a possible seepage face on the slopes. If so, how should the drains be modeled?



The left and right sides of the model show a total head boundary condition with a value equal to the elevation that corresponds to a watertable 1m below the ground surface. The slopes of the levee and ground surface are a potential seepage face boundary condition. The inside of the canal is a total head boundary condition with a value of 10.5, which will result in a 0.5 m depth of water.

There are two drains constructed in the model. On the left side is a drain set up by using a circular region with diameter of 12cm, as shown below. The right side is a drain at a single added free point. The boundary condition on the circumference of the hole drain is Q=0, potential seepage faces. This BC will let water out of the system if the pressures reach zero, but will not let water enter the system if the soil is unsaturated.

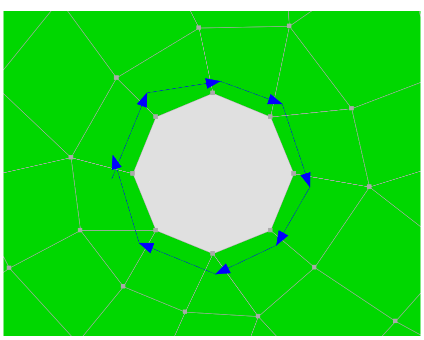


There are three analyses in this project. The first considers the case where there are no boundary conditions at the drain locations. This means there is no flow out of the model at those points. The second analysis has the hole drain active with the seepage review BC and the free point drain with a P=0 boundary condition. The P=0 boundary condition is OK to use as long as there is no chance the pressures around the drain location will go negative. If this happens, then the drain will become a source for water.

In the third analysis, the free point drain BC is a Q=0, potential seepage face. This BC will also let water out if the pressures are positive or zero at the point, but will not let water back in if the soil has negative pressures.

All boundary conditions are applied by creating the boundary condition objects and then assigning them to the appropriate geometry item. In this case, the regions edges, the circular region perimeter, or the free point at the drain location. No boundary conditions are applied directly on the mesh. If you re-mesh the model, the boundary conditions are automatically applied on the new mesh during the solving.

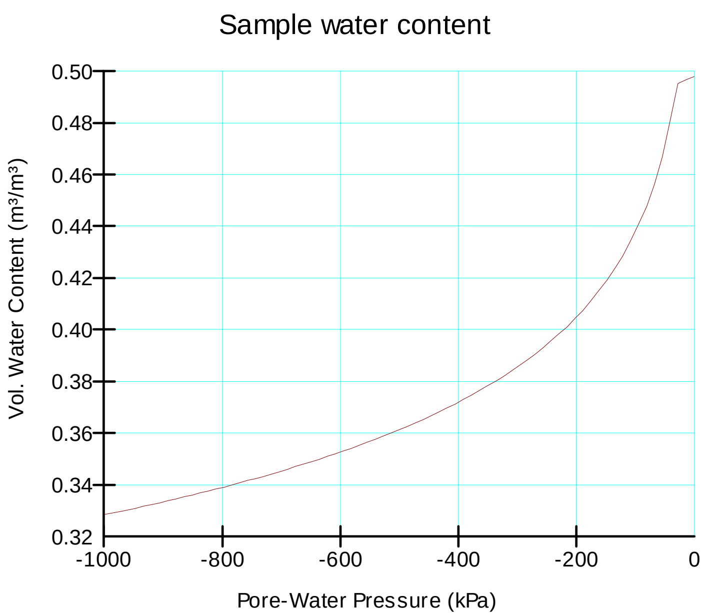
A flux section has been drawn around the circular drain as shown below. This will provide the total flow crossing the section which in this case is flow leaving the drain. Notice how the segments of the flux section cross tip and tail at the starting point of the sequence and that at this point the entire adjacent elements are covered. In other words, do not leave part of a flux section not crossing the entire element, or some portion of flow will be missed.

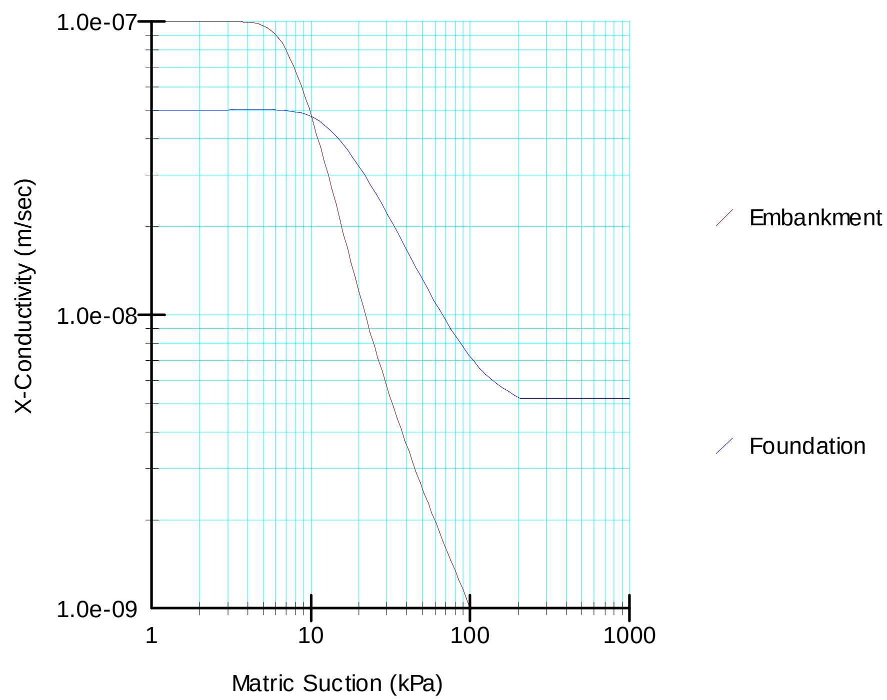


4 Material properties

The material models are set up to simulate a slightly higher permeability levee embankment over a lower permeable foundation soil. The model is steady state, so a water content function is not mandatory, but one is entered for each soil so that the conductivity functions could be estimated using the built in routines. The water content and conductivity functions for the two soils are shown below.

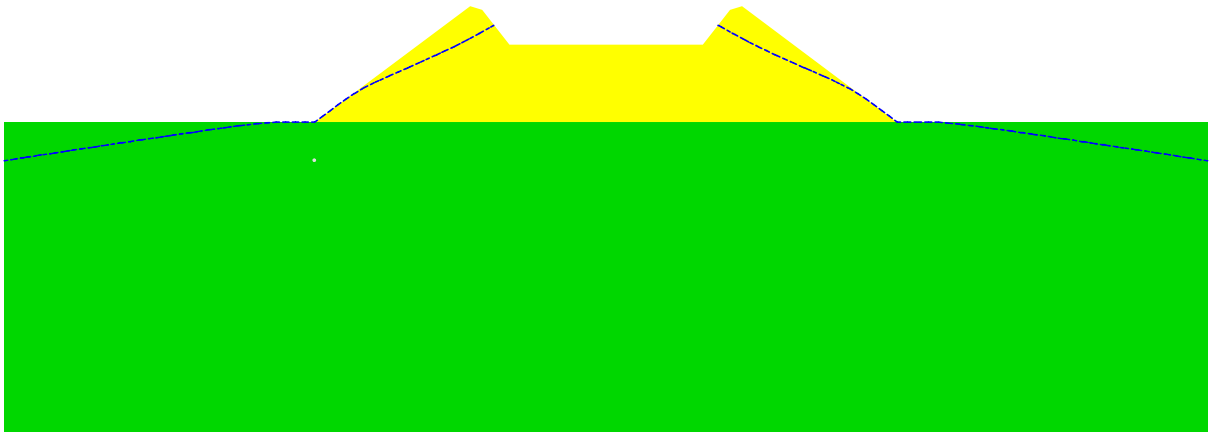
For these functions it is not necessary to develop them over a very large pressure or suction range. Since there is no evaporation applied in the model, the largest negative pressure that could develop at any point is the hydrostatic equivalent of the overall model height.





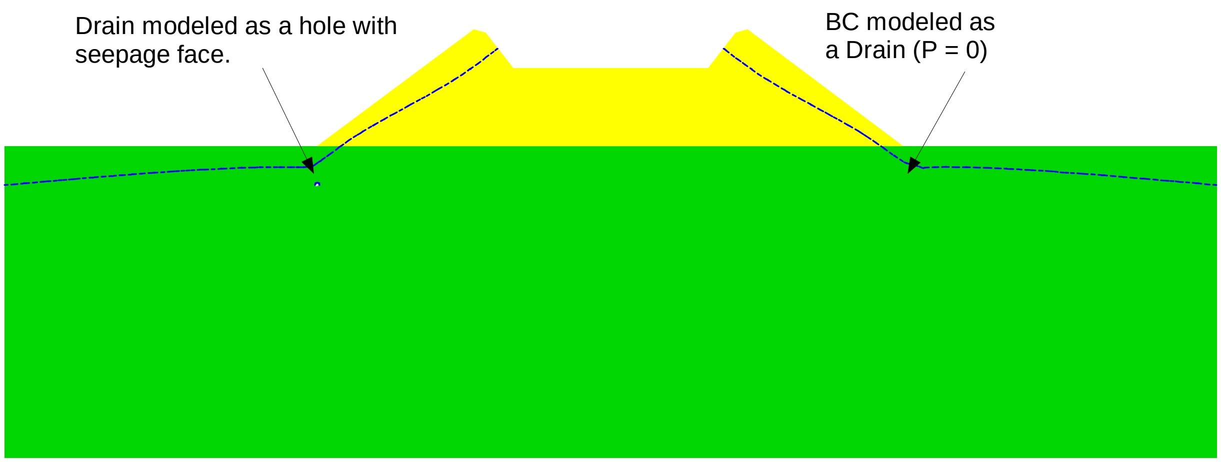
5 Discussion of results

The steady state solution showing the phreatic surface with no drainage is shown below.



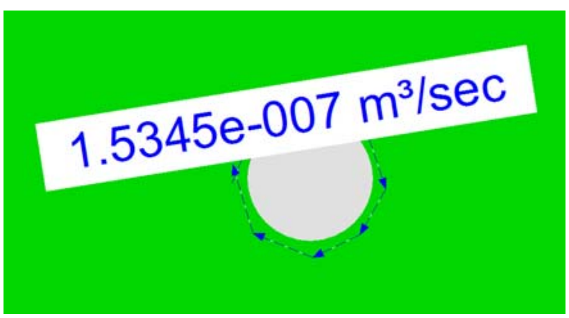
You can see that there is a seepage face developing on either slope, which is not desired.

The image below is for the same model, but with the circle drain and P=0 free point drain applied.

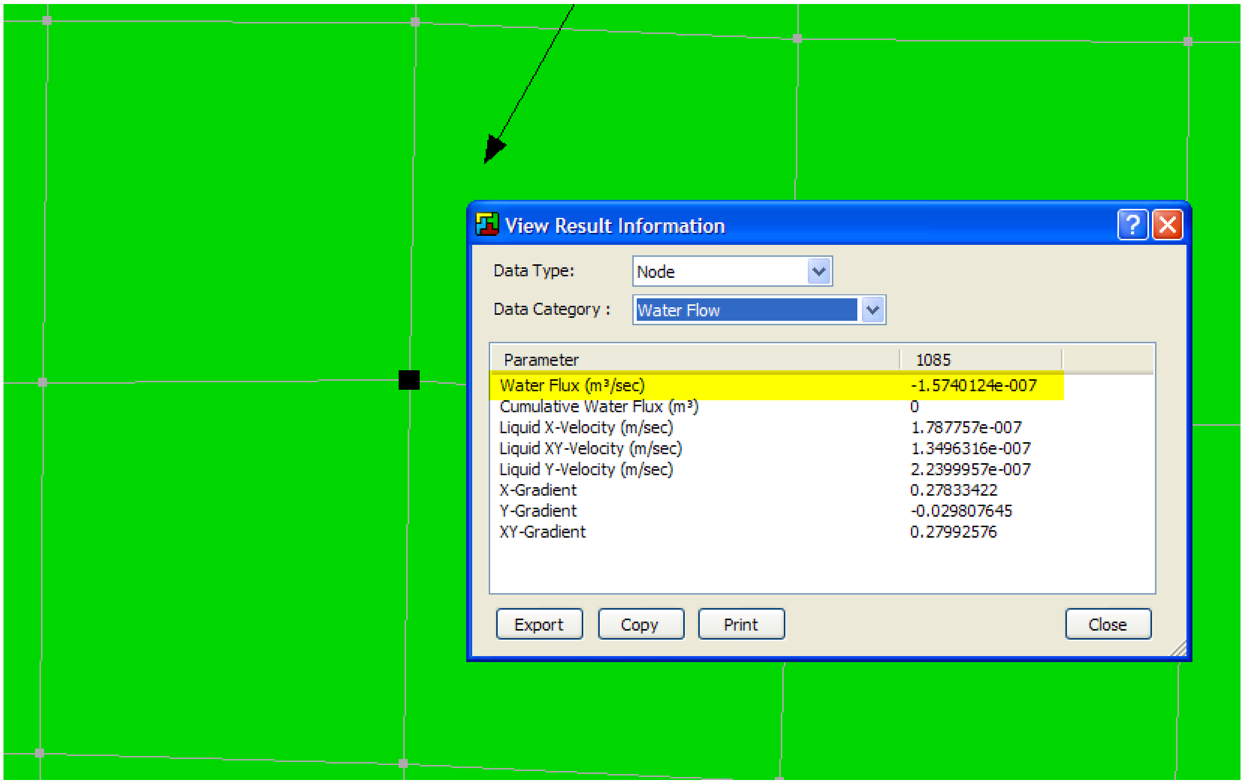


You can see that there is almost the same phreatic surface, and that the drains have served to remove the seepage face from the slopes. We can zoom in to the drains and look at total flow out of each drain.

For the circle drain the flux section value shows…

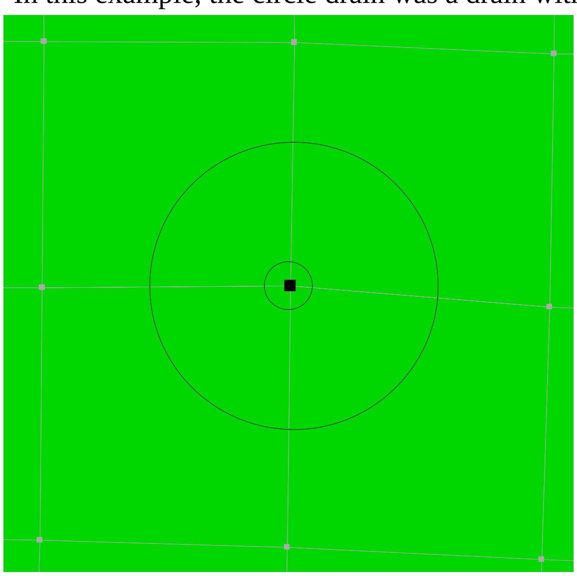


The free point drain value is obtained using the View Results Information command and selecting the free point as shown below.



The nodal flow is computed as -1.57 e-7 m3/sec, which agrees very well with the flux section total flow for the circle drain case. The result for the free point drain with P=0 case is the same as the Q=0 seepage face review case, as was expected.

It should be noted now that the circle drain case will not always be the same as the free point drain case. In this example, the circle drain was a drain with a 12 cm diameter and the free point was located at the intersection of elements with edge lengths of 0.5 m. A comparison of the actual drain size and the free point element size is shown below. While they look quite different in size, we can see from the results above that the computed flows are very similar. If the actual element size adjacent to the free points were much much larger, it is not likely that the free point flow would yield similar results as the circle drain.



A free point drain is the recommended starting point for the model, compared with adding complexity of a circle drain and mesh, as long as the element sizes are kept fairly close in scale to the drain size. In this case, the element edges are about 5x the drain hole diameter and the results are reasonable.