Rapid fill and drain

1 Introduction

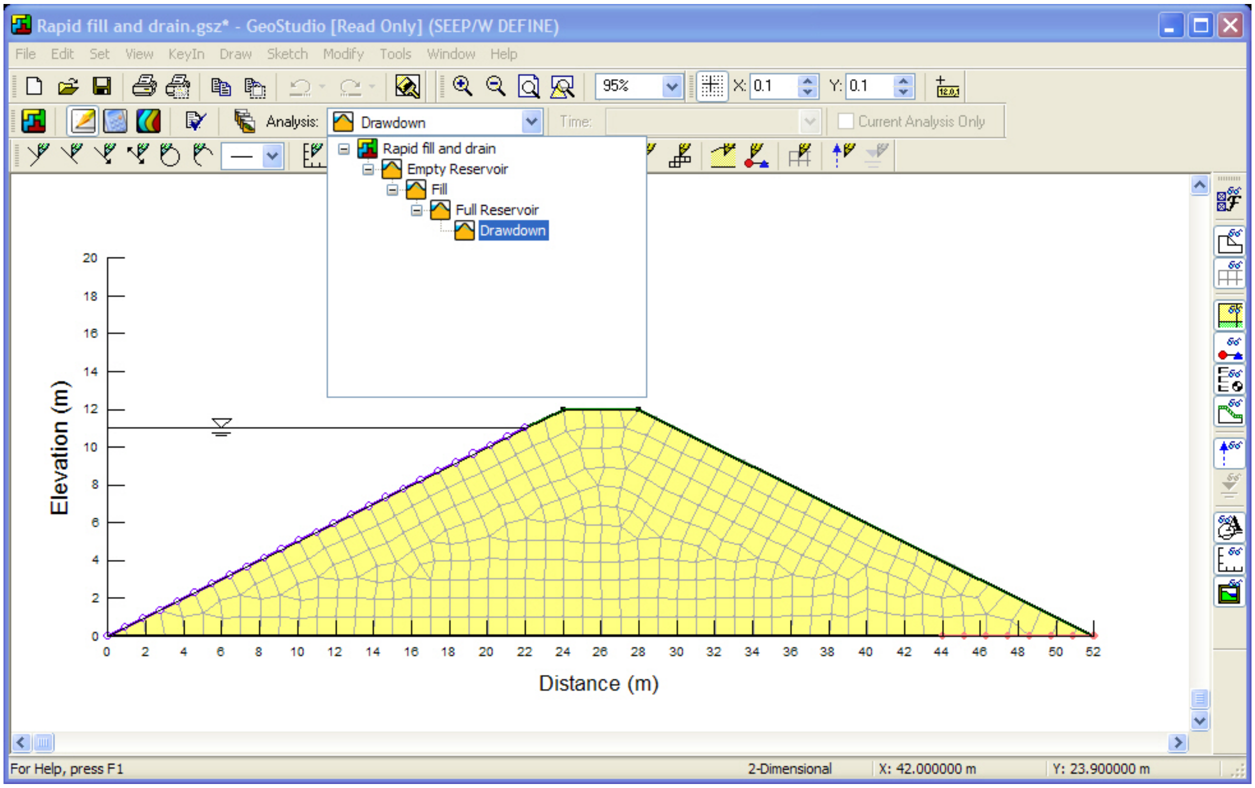
The objective of this illustration is to show how to model the rapid filling and drawdown of a reservoir. The boundary conditions are transient for both the filling and drawdown processes.

Feature Highlights

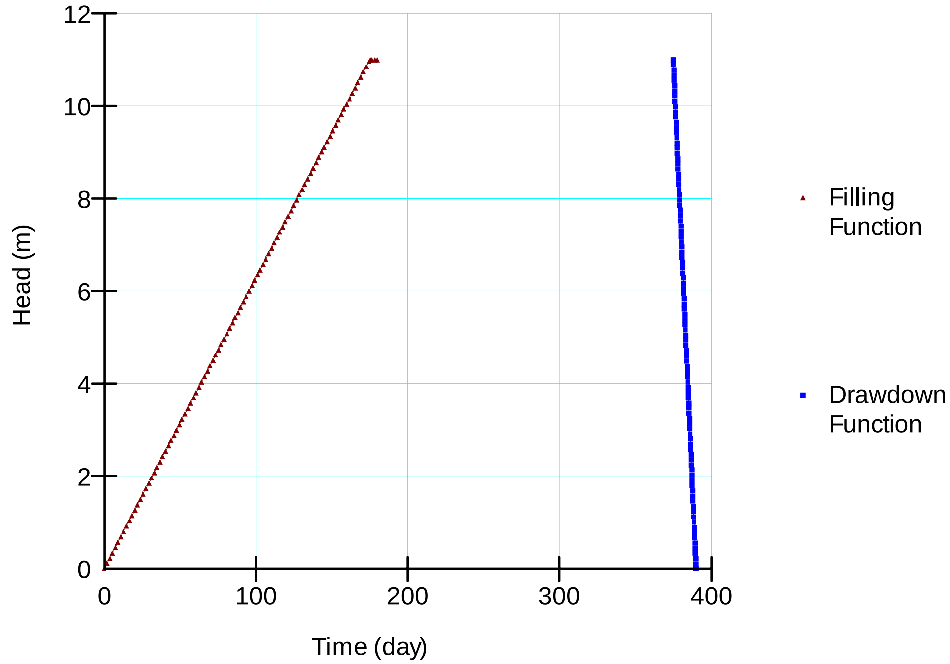
- Transient boundary conditions
- Animation of processes (making a movie)
- Flow across the phreatic surface
- Seepage face toe drain

2 Geometry and boundary conditions

A screen capture of Geo-Studio gives a clear picture of this example file. There are four analyses in the file: steady state empty reservoir, a filling stage, a transient period of a full reservoir, and a drawdown stage. The dam cross section has a toe under-drain system represented by pressure= 0 boundary conditions. This would be the case if there were a coarse gravel drain at a continually saturated exit location. The difference between the four examples is primarily the boundary conditions over time on the upstream face.



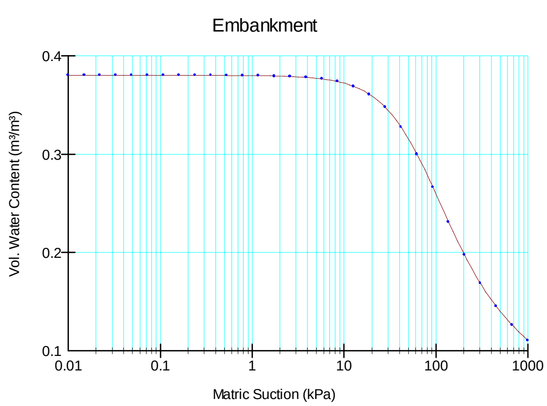
The filling and drawdown functions can be shown on a single plot, as follows. The first function is the Heat versus time function that shows it will take about 190 days to fill the reservoir. The second function shows the drawdown as it beings about day 380 and ends about day 390. While each function is unique, it is now possible to plot more than one function on the same graph – a nice feature when it comes to needing to compare functions, or in this case, show how they connect over time.

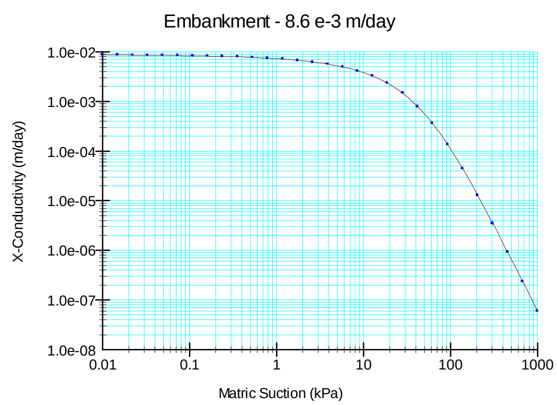


Between days 190 and 380, a constant head of 11m was applied to the upstream slope.

3 Material properties

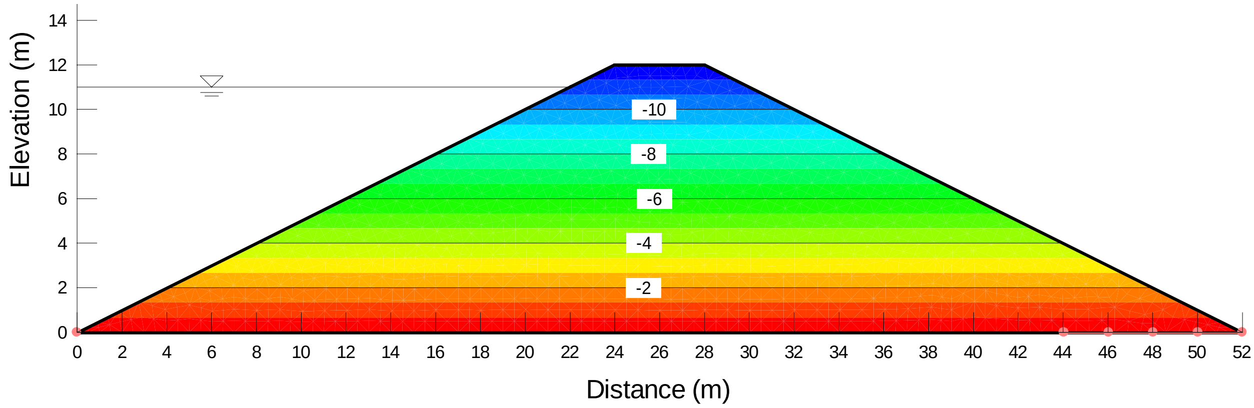
As this is a transient saturated / unsaturated flow example, it was necessary to choose the Saturated / Unsaturated material model. This model requires a water content function and a hydraulic conductivity function. These are shown below.



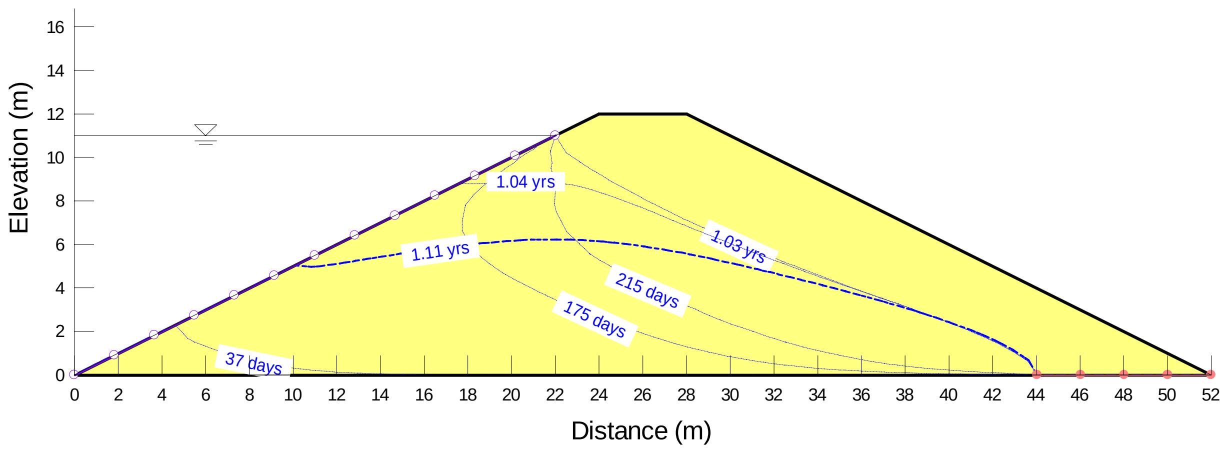


4 Discussion of results

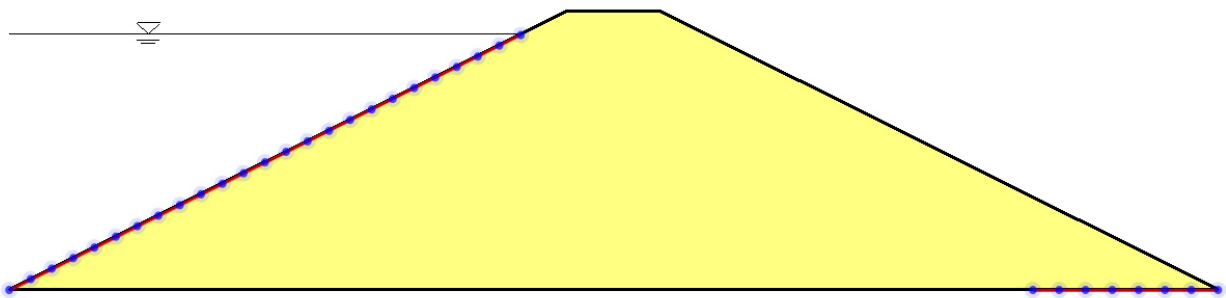
The initial stage steady state pressure head profile is shown below. The initial conditions analysis was set up with the drain boundary conditions applied and a single P=0 condition at the bottom left node. The solved steady state pressure profile shows negative hydrostatic pressures above the watertable location (in this case, the base of the model), which would be the case for an exposed soil with no surface infiltration.

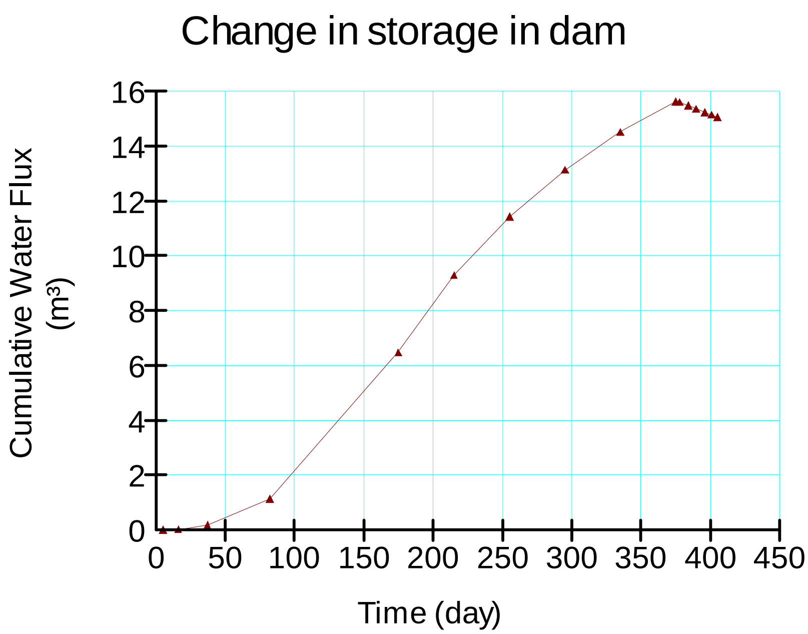


The following image shows the location of the P=0 isoline at different times during the staged analyses. The earlier times are shown in "day" units and then as the time passes over one year, the units change to "years". You can see there is a combination of filling and drawdown isolines, and that by the end of the analysis there are still some significant excess pore-water pressures in the dam. A movie of this process can be viewed by clicking: [rapid fill and drain.avi]. This link will be active as long as this .pdf file is in the same folder as the movie file.



The next image is a water balance accounting of the filling and draining. The graph was assembled by choosing the boundary nodes on both the upstream and downstream boundary node locations, and then summing the cumulative flows over time. The chosen nodes are shown first, followed by the chart.





This type of graph, which sums up a series of different plots, can be made directly in GeoStudio by choosing the Sum(Y) vs Average(X) check box option. This will add up all individual nodal flow (Y) values and plot them versus the average (X) value, which in this case is time, and since the time is the same at each data save interval, the average of time is equal to time for all series being summed.