Filling Pond Head verses Volume Functions

1 Introduction

The objective of this illustration is show how to model the filling or draining of a pond where the water is seeping into the pond from the soil or from the pond back into the soil, respectively. The head in the pond is not known, and depends on the volume of water seeping out of or into the soil. A special head boundary function can be used in this case.

Feature Highlights

Transient boundary conditions

Transient water level in a river

Seepage reporting to a collection area and then draining back into a river channel

Head vs Volume boundary function

2 Geometry and boundary conditions

The geometry of this example is over-simplified so that the key points are clearly illustrated. Figure 1 comprises a square river channel and a geometrically well-defined collection area referred to as the pond. The pond can both collect water while the river is rising but also supply water back to the river as the water level in the river declines.

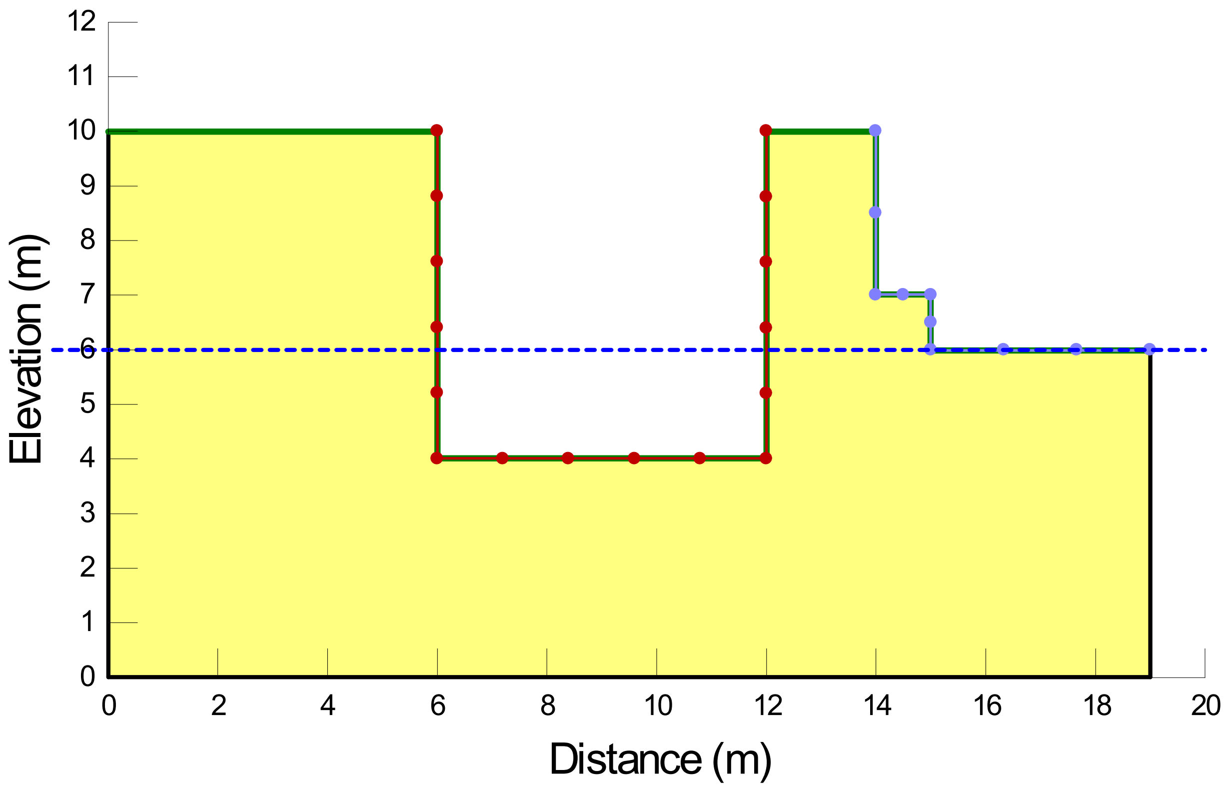

Figure 1 Geometry

There are two analyses in this file. In the first analysis, the river level rises over 10 a day period and is then held constant for the remainder of the analysis so that the pond can fill. Figure 2 shows the head versus time boundary function applied to the river. Figure 3 shows the head versus volume function applied to the pond. The later function relates the cumulative flow volume out of the domain (and into the pond) to the head in the pond. The head is 6 m when no water has flowed into the pond, 7 m when 4 m^3 of water has collected in the bottom portion of the pond (4 m x 1 m x 1 m), and 10 m when the entire 19 m^3 of the pond has been filled. The cumulative volumes are specified as negative values because the simulated volume rates are negative when water leaves the domain (and flows into the pond). The analysis duration of 150 days ensures that the pond fills entirely.

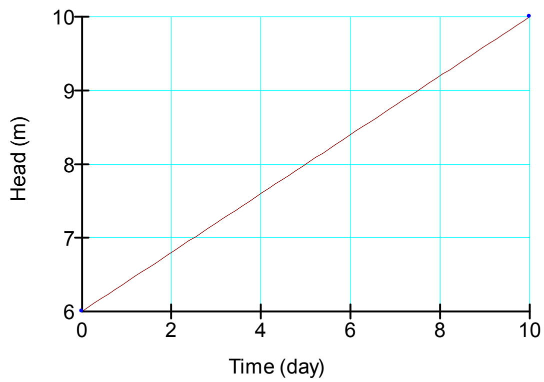

Figure 2 Increase in water level over time

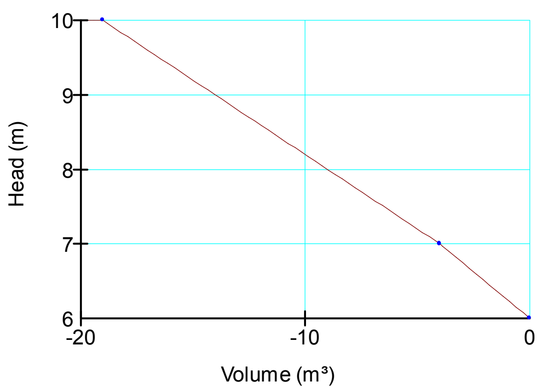

Figure 3 Head vs Volume function: Analysis 1

The second analysis reverses the effects of the rising river. The river level now drops over 10 a day period and is then held constant for the remainder of the analysis so that the pond can drain. Figure 4shows the head versus time boundary function applied to the river. Note that the boundary condition must be defined as a potential seepage face to allow water to exit the channel face above the water level. Figure 6 shows the head versus volume function applied to the pond. The later function relates the cumulative flow volume into the domain (and out of the pond) to the head in the pond. The head is now 10 m when no water has flowed into the pond (i.e. it is full), 7 m when 15 m^3 of water has drained out of the upper portion of the pond (5 m x 3 m x 1 m), and 6 m when the entire 19 m^3 of the pond has drained. The cumulative volumes are now specified as positive values because the simulated volume rates are positive when water enters the domain (and flows out of the pond).

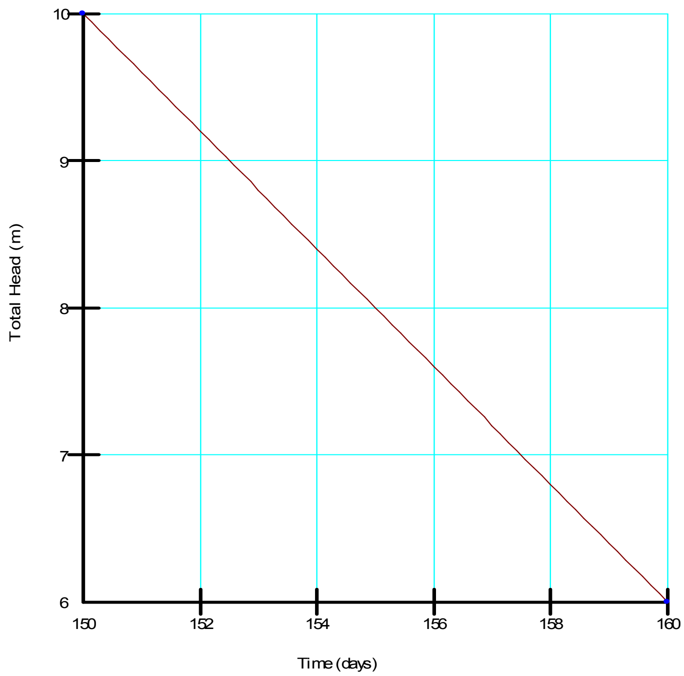

Figure 4 Decrease in water level over time

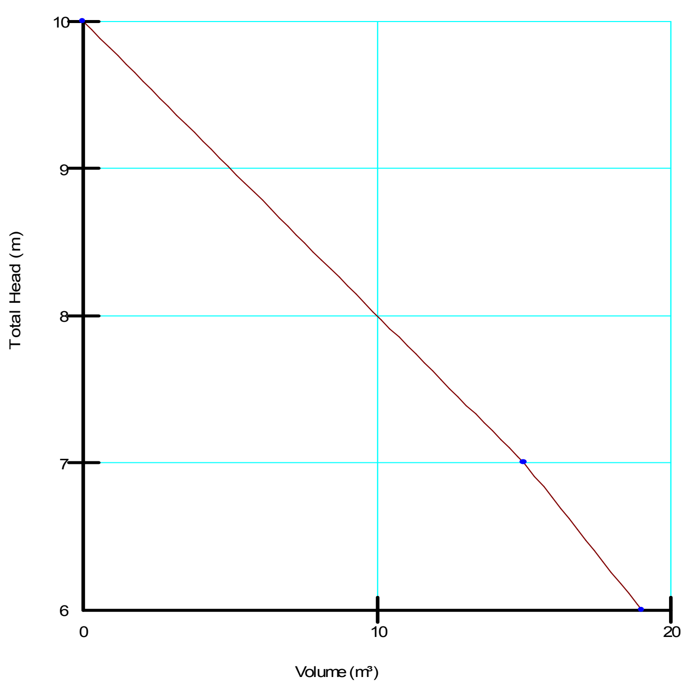

Figure 5 Head vs Volume function: Analysis 2

3 Material properties

Figure 6 shows the hydraulic conductivity and volumetric water content functions that are required to complete a transient analysis involving unsaturated soil. The functions were selected for demonstrative purposes only.

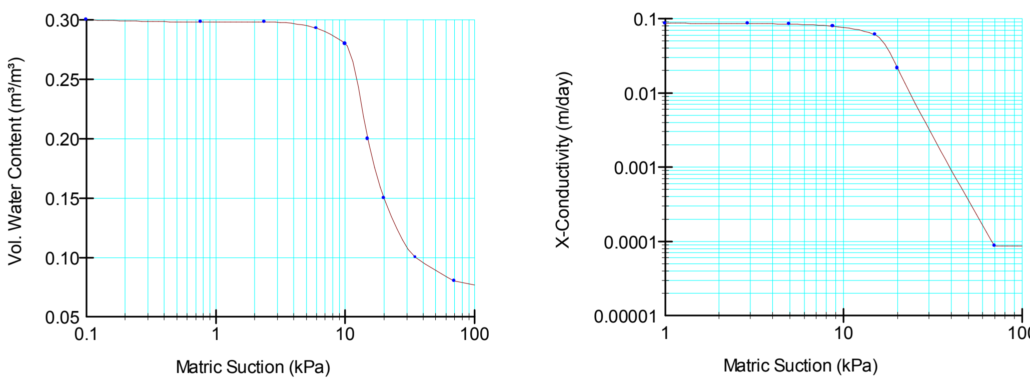

Figure 6 Hydraulic conductivity function and a volumetric water content function

4 Discussion of results

Figure 7 and Figure 8 are screen captures from analysis 1 and 2, respectively, showing water seeping from the river into the pond and then water draining out of the pond and back into the river.

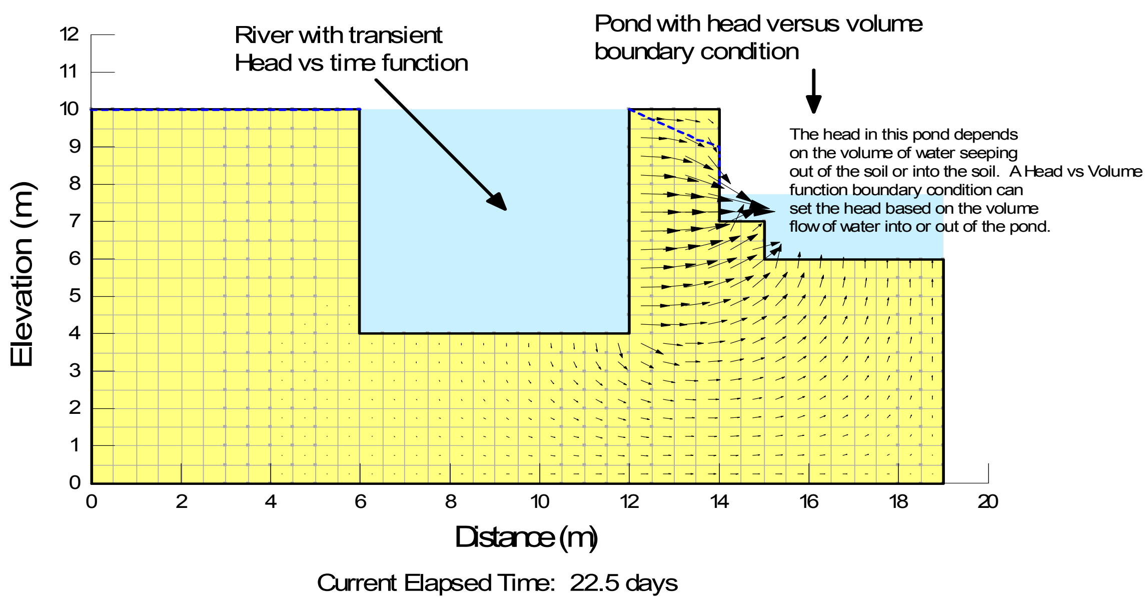

Figure 7 Screen capture from analysis 1

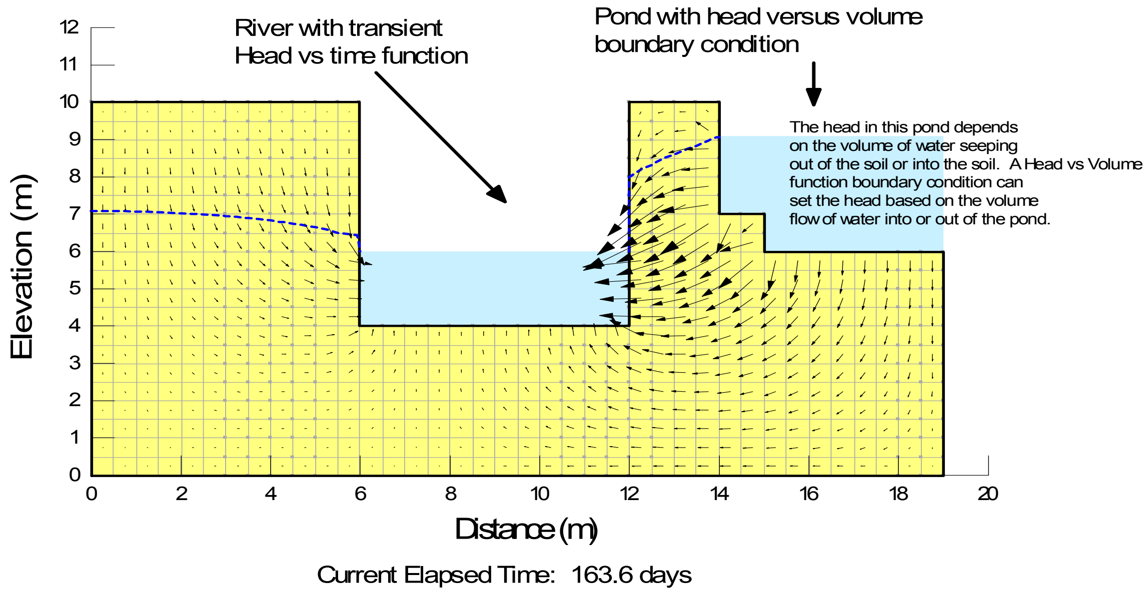

Figure 8 Screen capture from analysis 2

Figure 9 compare the head versus time histories at the base of the river and pond (Draw | Graph). The head in the river appropriately reaches full height within 10 days. There is naturally a delay in the filling of the pond as the water seeps through the soil. The pond is full by 150 days.

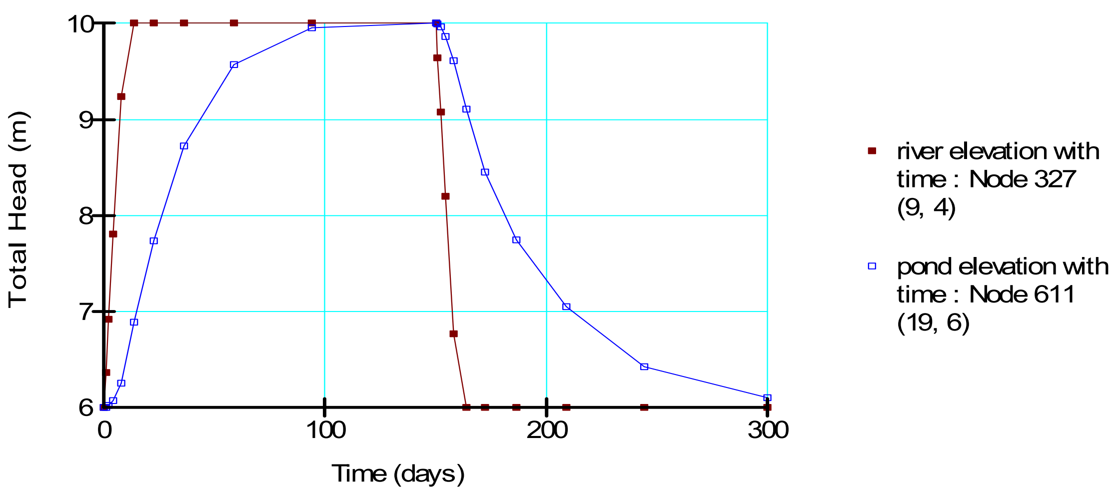

Figure 9 Head versus time in the river and pond

Figure 10 shows the cumulative water volumes that flowed out of the domain (into the pond) during analysis 1 and into the domain (out of the pond) during analysis 2. The graph was generated by selecting all nodes that comprise the pond, plotting cumulative volume versus time, and choosing the graph option to 'sum y versus average x'; that is, sum the cumulative volume for all nodes and plot this value versus time at each saved step. The cumulative volume out of the domain (into the pond) reaches -19 m^3 when the pond is full at 150 days (compare with Figure 9). The second analysis excludes the results from the first analysis (KeyIn | Analysis); consequently, the graph resets to 0 at the initiation of the second analysis. The cumulative volume then varies between 0 and +19 m^3 as the water flows into the domain (out of the pond) and back into the river. The head declines accordingly (compare with Figure 9).

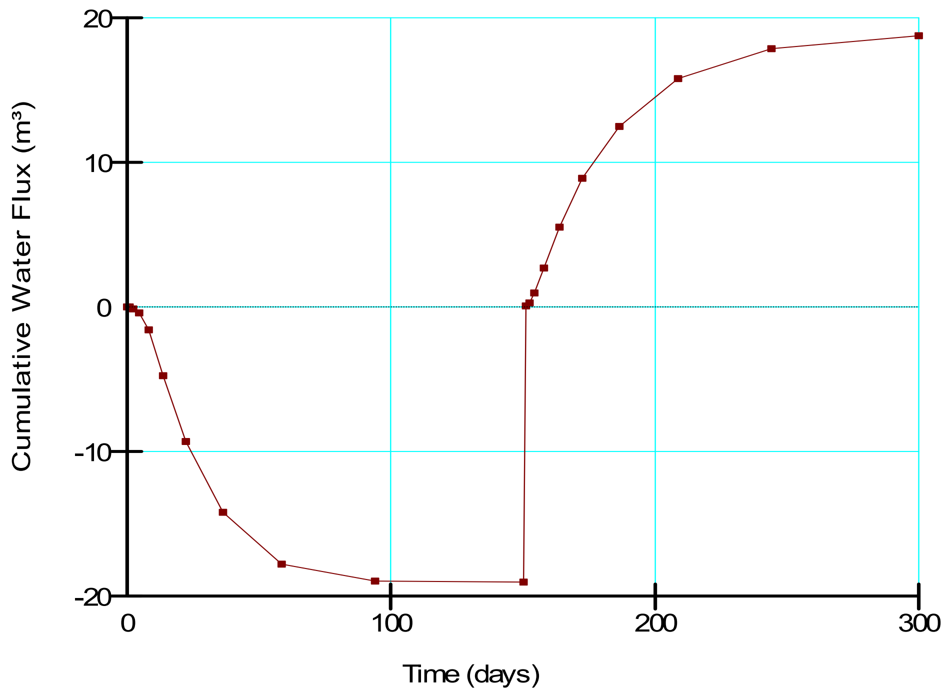

Figure 10 Cumulative water volumes out of and then into the domain.