GEO-SLOPE | Direct Contact
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Modeling Soil-Climate Interaction
2006 Workshop Dates

Advantages of using "surface regions" when modeling soil-climate interaction

It is very common when doing certain types of seepage and thermal modeling to include the interaction between the soil and the atmosphere. This is the case when designing soil cover systems over landfills, when predicting surface runoff, and when considering climate-induced ground freezing. A difficulty associated with these types of models is that the climate often changes quickly, which can induce large thermal or hydraulic gradients over small distances near the soil surface. These gradients may lead to numerical instability in some cases.

> **2006 Workshop Dates**
> GEO-SLOPE will be holding two modeling workshops again this year, one in the UK and one in Canada. The UK Workshop will be in Birmingham, England, on May 22-24. The Canadian workshop will be in Calgary on October 16-18. Seats fill up quickly, so register early. Details about these and other training opportunities are online.

The GeoStudio suite of modeling products requires that all soils be defined using regions which can be any geometrical shape. The regions are then automatically meshed with a variety of structured or unstructured grid patterns. Usually deciding which pattern to choose is not always critical to obtaining a good solution. However, the selected grid pattern can be important when dealing with ground-climate interactions. There is a strong numerical advantage to having appropriate finite element shapes near the ground surface. For this reason, and others, there is an additional special surface region option in GeoStudio that will automatically apply single or multi-layered soil regions across any portion of an existing soil geometry.

The surface regions have special properties within GeoStudio depending on whether they are applied within SEEP/W, VADOSE/W or TEMP/W. Some properties of surface regions are that:

- They are constructed to ensure all elements are quadrilateral and form a well-structured mesh.
- The constructed layers can have different thicknesses across the model profile and can even pinch out to zero thickness. This is beneficial with multi-layered engineered cover systems over landfill waste.
- The finite element nodes within the surface region are all aligned vertically which allows you to specify vegetation rooting patterns that can vary with both depth and time.

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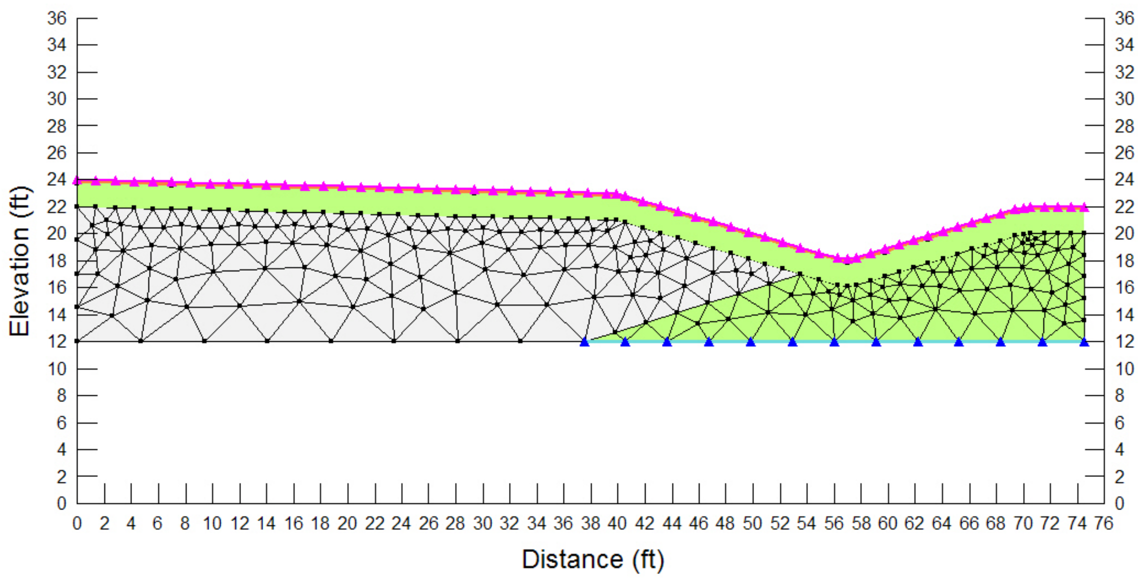
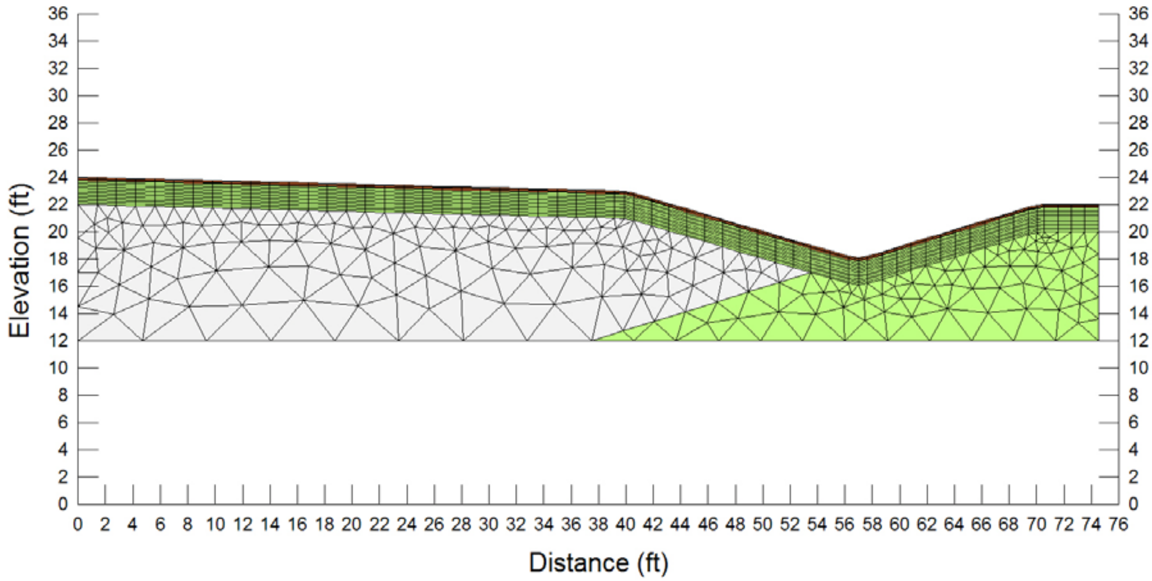
- The interfaces between the various soil layers in a surface region can be used to automatically track instantaneous and cumulative flows, and so, are in effect built-in flux sections.
- The automatic surface region construction process allows you to develop a very fine mesh near the ground surface where it is needed most.
- Within the SEEP/W and VADOSE/W programs, assigning a unit flux boundary condition along a surface region allows for the automatic generation of seepage faces and the accumulation of surface water runoff, which may collect at any low points along the surface. The water will remain in these low points over time until it either infiltrates or evaporates, depending on the degree of complexity within the model.

The following image shows a soil cover system over a lined landfill. It is assumed there is no flow across the impermeable landfill liner, so the objective in the analysis is to determine the performance of the lateral drainage system that surrounds the landfill cell. Only a portion of the landfill cell surface is modeled but data from this reduced cross section can be used to understand runoff over the entire field scale.

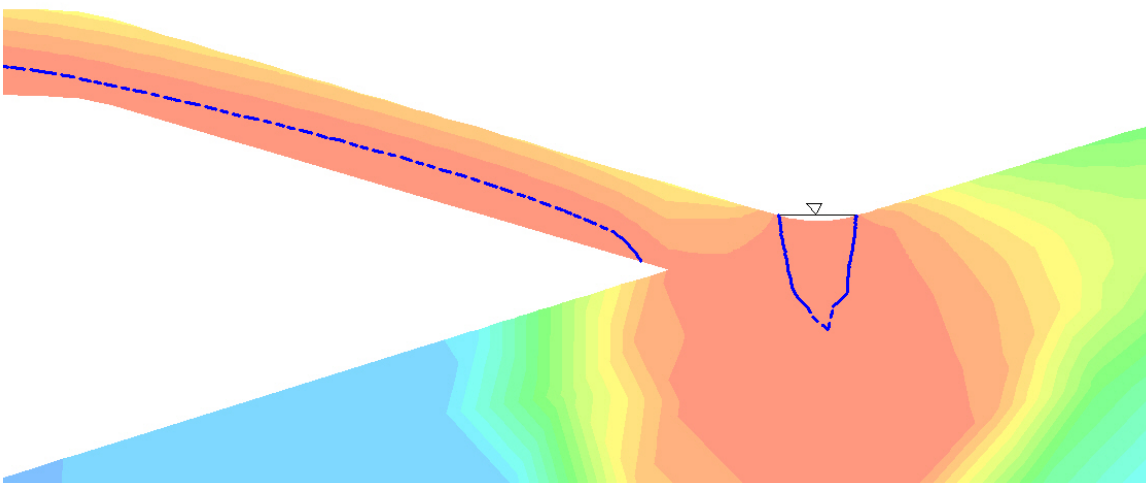
The cover system in this case serves to act as a growth medium for vegetation and is constructed out of the same natural soils that exist outside the landfill cell. A unit flux rainfall boundary condition is applied to the top of the model and a unit downward gradient boundary condition is applied to the bottom of the trench.

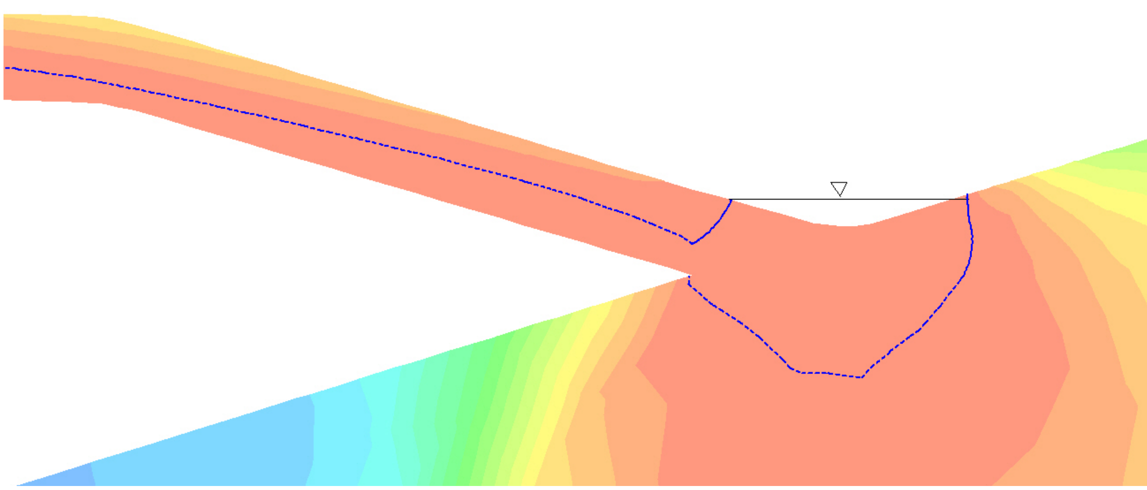


In the figure above it appears that there is no finite element mesh within the surface region. The mesh has been hidden from view but can be optionally displayed as shown below.

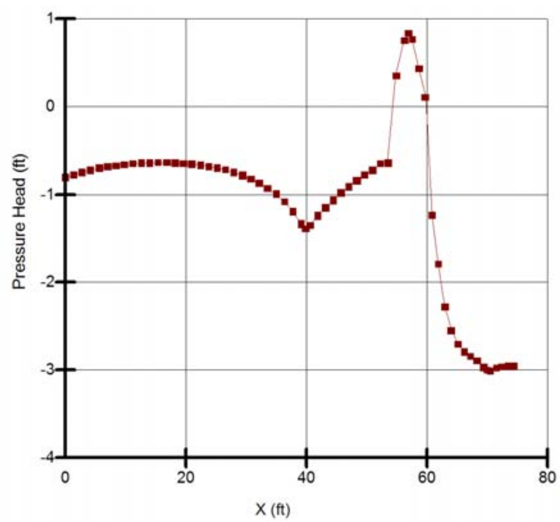


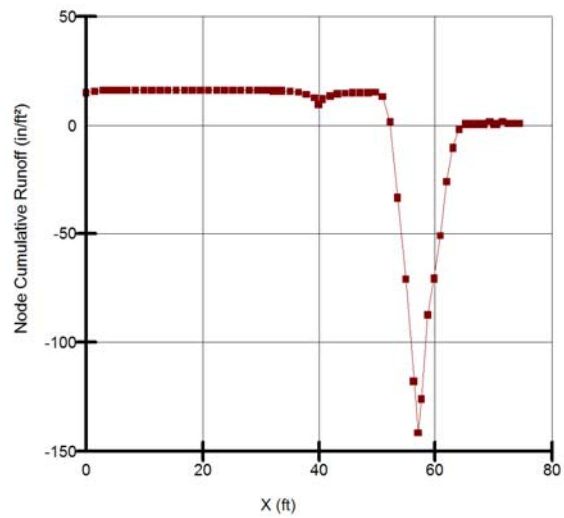
The next two images below show volumetric water content contours in the cross section as well as the computed position of the phreatic surface at two points in time during a rainfall event. The phreatic surface line intersects the trench system at an elevation that corresponds to the depth of water in the trench at that time.





The following two graphs refer to the second point in time shown above. The graph on the left shows the computed pore-water pressure versus x-coordinate for all ground surface nodes. The graph on the right shows the generated runoff or seepage face water fluxes as a function of the x-coordinate for that point in time. It is clear that there is runoff water up slope and seepage water within the drain trench walls. The exact depth of ponding at its deepest point is given by the maximum pressure head value. It was mentioned before that the cross section is not the entire landfill cell width. However, the cumulative runoff graph shows that on the long, sloping part of the surface there is a relatively constant runoff rate. This rate could be used to manually estimate entire runoff volumes for the three dimensional cell surface. The total cell runoff could then be compared to the storage volume in the trench drains to ensure they are designed to handle the largest flow capacity cases.





GeoStudio surface regions allow for simple generation of special finite element meshes along any shaped ground surface. They have special properties and meaning within the solution process and should be used whenever climate-ground interaction is an important component of the overall heat or mass balance in your thermal or seepage analysis.

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