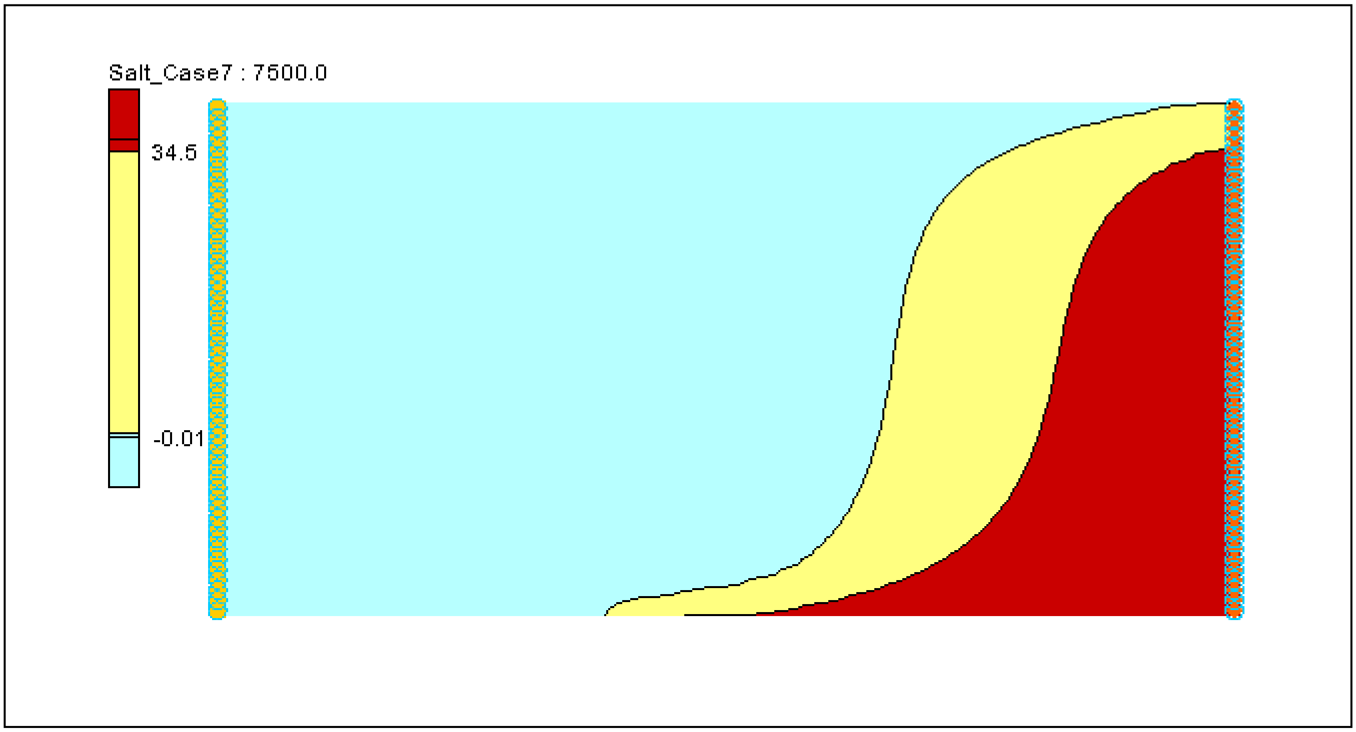
v. 10.0

GMS 10.0 Tutorial

SEAWAT – Viscosity and Pressure Effects

Examine the Effects of Pressure on Fluid Density with SEAWAT



Objectives

Learn how to simulate the effects of viscosity and how pressure impacts the fluid density in SEAWAT.

Prerequisite Tutorials

- SEAWAT – Thermal Effects

Required Components

- Grid Module
- MODFLOW
- MT3D
- SEAWAT

Time

- 15-30 minutes

1 Introduction

This tutorial describes how to simulate the impact of concentration and/or temperature on fluid viscosity using SEAWAT. Then it examines the effects of pressure on fluid density.

1.1 Outline

Here are the steps of the tutorial:

1. Importing an existing SEAWAT simulation
2. Run SEAWAT with different scenarios.
3. Examine the results.

2 Description of Problem

The problem is shown in Figure 1; this is a confined aquifer with an initial temperature of 5°C. Warm freshwater is injected from the west side of the model at a 1 m^3/day. The initial concentration of salt in the model is 35 kg/m^3.

The tutorial will look at the effects of salinity and temperature on viscosity and the effects of pressure on fluid density in this example. This example problem is very similar to the problem described in the SEAWAT documentation.[1]

---

1. Langevin, C.D., Thorne, D.T., Jr., Dausman, A.M., Sukop, M.C., and Guo, W. (2007). SEAWAT Version 4: A Computer Program for Simulation of Multi-Species Solute and Heat Transport: U.S. Geological Survey Techniques and Methods Book 6, Chapter A22, 39 p.

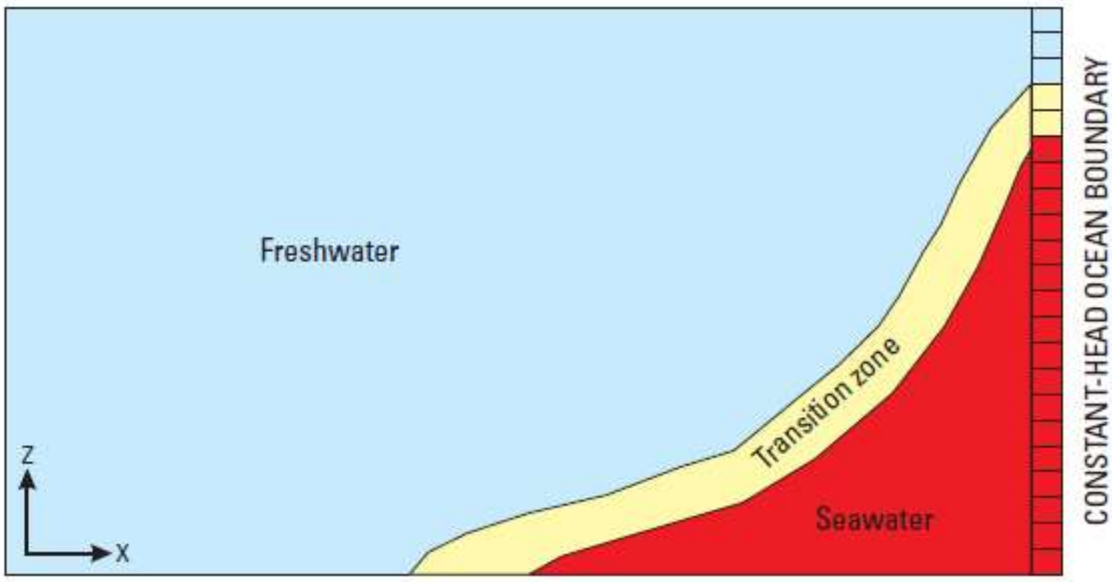


Figure 1 Site to be modeled with SEAWAT

3 Getting Started

Do the following to get started:

1. If GMS is not running, launch GMS.
2. If GMS is already running, select the *File* | **New** command to ensure the program settings are restored to the default state.

4 Importing the Existing Model

The user will start with a model that has already been created.

1. Select the **Open** button (or the *File* | **Open** menu command).
2. Browse to the *\Tutorials\SEAWAT\Case_Studies\Sample\Case5* folder.
3. Select the "case5.gpr" file.
4. Click **Open**.

This imports the model.

5 Adding the Effects on Fluid Viscosity

This tutorial will use the VSC package to simulate changes to the fluid viscosity.

1. Select the *SEAWAT* | **Global Options** command to open the *Global Options* dialog.
2. Turn on *Viscosity (VSC)*.

3. Select the **OK** button to exit the dialog.

5.1 Modifying the VSC Package

For the first scenario, the user will simulate the effect of salinity on fluid viscosity in the simulation.

1. Select the *SEAWAT* | **VSC Package** command to open the *SEAWAT VSC Package* dialog.
2. Enter a value of "-1" for *Fluid viscosity calc. (MT3DMUFLG).*

This value means that the fluid viscosity will be calculated using one or more MT3DMS species. In this case, they are "Salt" and "Temperature."

3. Enter "0.0008904" for *Reference viscosity (VISCREF).*

The reference viscosity (*VISCREF*) is viscosity of the reference fluid (warm freshwater).

4. Select "eq. 18" for *Temp. affect on visc. (MUTEMPOPT).*

MUTEMPOPT indicates which method/equation is used to solve the fluid viscosity.

5. Enter "2" for *Temp. species id (MTMUTEMPSPEC).*

MTMUTEMPSPEC indicates the temperature species. In this project, the temperature species ID is 2.

6. Turn on *Use default values for A1-A5*.

The default coefficients for this equation are specified according to SUTRA (Voss, 1984).[2] These default values are only valid for temperature in Celsius. Notice that GMS automatically fills in the values.

7. Click on  to insert a species in the spreadsheet.
8. In Species ID column, enter "1."

Notice that the species name has changed to *Salt*.

9. Enter "1.923e-6" for *DMUDC.*
10. Ensure that *CMUREF* is "0."

DMUDC indicates the slope of the linear equation, which relates fluid viscosity to solute concentration. *CMUREF* indicates the reference concentration for species. The entries should match those in the following figure.

2. Voss, C.I. (1984). SUTRA – A finite-element simulation model for saturated-unsaturated, fluiddensity-dependent ground-water flow with energy transport or chemically-reactive single-species solute transport: U.S. Geological Survey Water-Resources Investigations Report 84-4369, 409 p.

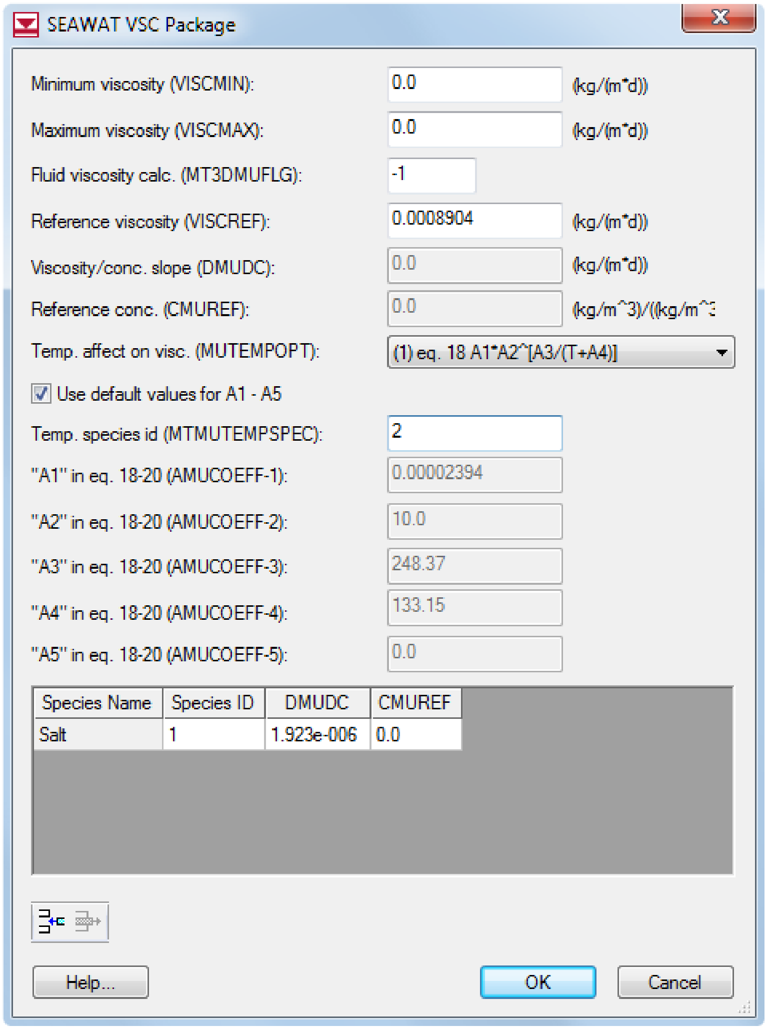


Figure 2 VSC Inputs.

11. Select **OK** to exit the dialog.

6 Saving the Model with a New Name and Running SEAWAT

The user is now ready to save changes and run SEAWAT.

1. Select the *File* | **Save As** menu command.
2. Browse to the *\Tutorials\SEAWAT\Case_Studies* folder.
3. Change the project name to “case6.”
4. Save the project by clicking the **Save** button.
5. Select the *SEAWAT* | **Run SEAWAT** command.
6. When SEAWAT finishes, select the **Close** button.

7 Viewing the Solution

The user will now view the results of the SEAWAT model run.

1. Expand the "3D Grid Data" folder and the "grid" item.
2. Select the "Salt" dataset below the "case6 (MT3DMS)" solution in the Project Explorer.
3. Select a different time step in the time step window.

The results from "case6" and "case5" are very similar. This suggests that viscosity variation has minimal effect on the simulated salinity and temperature in this case. The figure below shows Salt concentration at 5000.0 days for "case5" and "case6."

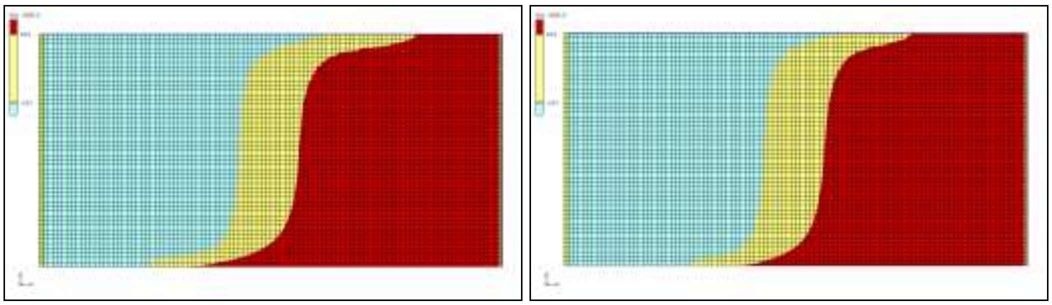


Figure 2 Comparison of Salt Species for "case5" (left) and "case6" (right)

8 Saving the model with a new name

Now it is possible to start making changes for another scenario. First, save the model with a new name.

1. Select the *File* | **Save As** menu command.
2. Change the project name to "case7."
3. Save the project by clicking the **Save** button.

9 Adding the Effects of Pressure on Fluid Density

For the next scenario, the user will look at how pressure affects the fluid density.

9.1 Modifying the VDF Package

The pressure effects can be activated using the *DRHODPRHD* parameter.

1. Select the *SEAWAT* | **VDF Package** command to open the *SEAWAT VDF Package* dialog.
2. Enter a value of "0.00446" for *Density/press. slope* (*DRHODPRHD*).
3. The *reference press. head* (*PRHDREF*) should be "0."
4. The VDF inputs should be the same as those in the following figure:

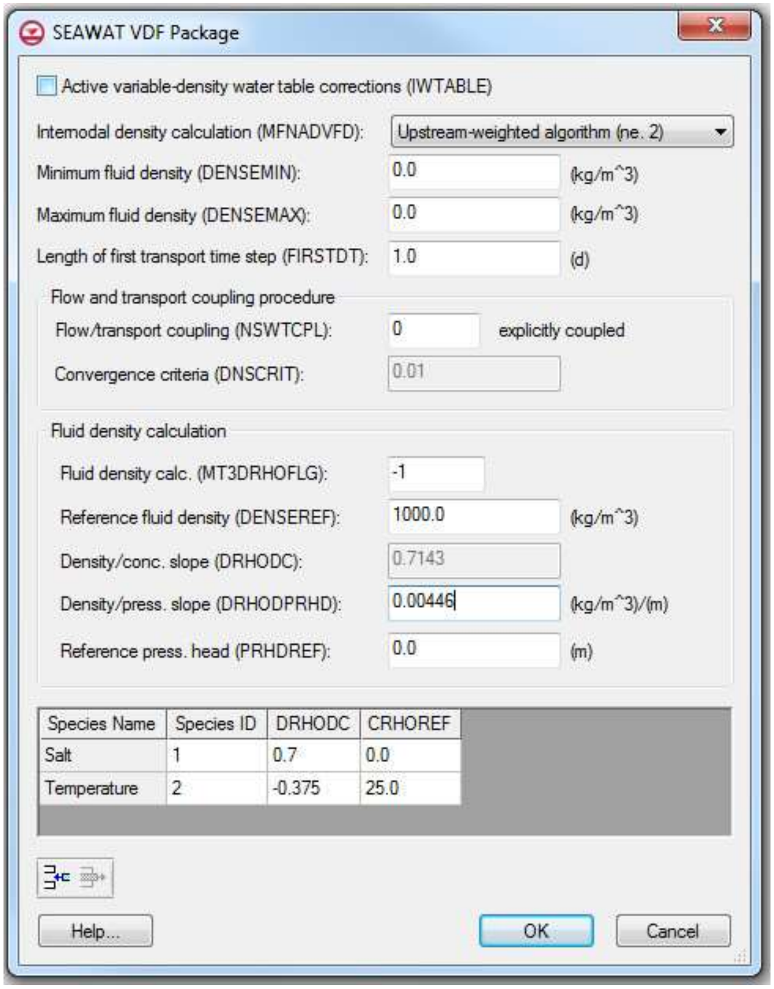


Figure 3 VDF Inputs simulating pressure effect on density

5. Select **OK** to exit the dialog.

10 Saving and running SEAWAT

Now save the changes and run SEAWAT.

1. Select the **Save** button to save the project
2. Select the *SEAWAT* | **Run SEAWAT** command.
3. When SEAWAT finishes, select the **Close** button.

11 Viewing the Solution

The user will now view the results of the SEAWAT model run.

1. Select the "Salt" dataset below the "case7 (MT3DMS)" solution in the Project Explorer.
2. Select a different time step in the time step window.

The compressibility of water due to pressure almost has no effect on the salinity and temperature. This minor effect is due to the shallow depth (500m) of the aquifer in this example. The effect of pressure on fluid density is negligible for shallow aquifers.

12 Conclusion

This concludes the tutorial. Here are the key concepts in this tutorial:

- SEAWAT combines MODFLOW and MT3DMS to solve variable density groundwater flow and solute transport problems.
- SEAWAT can simulate the effect of concentration and temperature on fluid viscosity.
- SEAWAT can simulate the effect of pressure on fluid density.