IHE module 3

Dec 2017 and January 2018

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Transient Groundwater Flow, Analytical Solutions

# Syllabus

The syllabus is a document that you may refer to at later stages in your career. We will not cover the entire syllabus. A list of covered subjects follows below.

# Exam

The exam will last one hour and consists of solving several tasks and providing answers to questions concerning the text. Required formulas will be given.

# Grading

Grading will be 70% exam, 30% assignments

Exam: Answers must show the motivation, i.e. rationale of your answer. I want to see what steps you make and why. **So motivate each step with some clarifying words**. Just numbers or incomprehensible formula derivations do not count!

# Assignment

An assignment will be provided. It can be partially made in class during the exercises during the afternoons. **But I must have the results latest when I judge your written exams. I can't give marks without it**. Any assignments handed in thereafter will not be graded implying that the entire mark will be defined by the results of the written exam.

It is clear that I expect everyone to do his/her own assignments. It is generally easy for me to see who copied his or her work from someone else.

# What to learn/understand

Chapters 1 through 4.2. Check yourself by answering the questions on pages 37-39.

Chapter 4.3: Skip

Chapters 5.1 through 5.3, to the extent that you understand and can answer the questions on page 47-48.

Chapter 5.4.1-5.5.2. Understand how the *erfc* function works, understand that that the differential equation is a water balance, and understand what the parameters in the solution mean. Answer the questions on page 51-53

Chapter 5.4.3. Skip. It may be useful as a future reference.

Chapter 5.4.5. Understand how superposition in time works, and how to apply it when the analytic solution is provided.

Chapter 5.5.1-5.5.5 Understand how superposition in space works. Answer the questions on page 62.

Chapter 5.6. Understand what the formula means and how we cracked it down to a characteristic time for groundwater systems and to their halftime. Check if you can answer the questions at page 66-67.

**Flow to wells**

Chapter 6.1, 6.2 Introduction to wells

Chapter 6.3. Theis: Relation between the transient and steady-state well solutions. The Theis solution and its approximation.

It’s always good if you exercise to derive the basic differential equations (i.e. the physics). Realize that these partial differential equations are always water balances for an arbitrary, infinitesimally small portion of the aquifer.

Chapter 6.3.1 Skip.

Chapter 6.3.2. Theis Type curve.

Chapter 6.3.3. Understand classic pumping test analysis. See also example in chapter 6.3.9 with the associated figures on pages 88, 90 and 91.

Chapter 6.3.4-6.3.7 Standard behavior obtained from simplified Theis well function. **This chapter is specifically important.**

Chapter 6.3.11 Superposition in time.

Answer the questions on page 95-96.

Chapter 6.4.1-6.4.2: Skip, use as reference.

Chapter 6.5 Hantush: transient flow to a well in a semi-confined aquifer.

It's always a good exercise to derive the partial differential equation yourself. This is, in fact, a basic engineering skil as it specifies the physics of the problem.

The analytical solutions in chapter 6.5.1 and 6.5.2 do not have to be remembered. They serve as a references so you can implement them in Excel or Python when needed.

Chapter 6.5.4: Answer the questions on page 109-110

Chapter 6.5.5: Skip, we will do the test in the exercises.

Chapter 6.6: Only understand the mechanism, as you are likely to encounter it in practice.

Chapter 6.7: Skip

Chapter 7: Skip

Chapter 8. Skip.

Chapter 7.1 Wells

Chapter 9. Introduction. Relate the mathematical power series to express the Theis well function to the simplification worked out in chapter 9.2.

Chapter 9.3. Radius of influence. How did we derive it from the simplified log formula of the Theis well function?

Chapter 9.4. Skip

Chapter 9.5. Analysis of pumping test. How can we do that on half log paper and on double log paper ?

Chapter 10. The general form of the Hantush well function compared the Theis well function, both mathematically as with respect to the shape of the curves in the figure of page 73.