Project exercise: Construction of groundwater model for your project location.

This exercise is intended to be the kick starter to the setup of the groundwater model that you will build during the projectwork. The exercise will lead you to through the first steps of building a GW model. I know from experiences that it is difficult to get started with the project groundwater model and I will encourage you to start during the course with this exercise. Make sure that all group members will work with the model – work two and two together with this exercise.

Problems:

1. **Modeldelineation**: Delineate the model area on the basis of a potential map and a stream theme.
   a. Download data
      i. Data for Hjørring: Download http://water.civil.aau.dk\gw\GIS\Hjorring_data_part1.zip and unzip locally.
         Contains:
         Hjorring25000-large.tif: 1:25,000 map of central Hjørring
         Hjorring200000.tif: 1:200,000 map of Hjørring
         Hjorring100000.tif: 1:100,000 map of Hjørring
         vandl25n_hjorring.shp: river and streams
         pot_map_point_hjorring.shp: points theme that forms the basis for the potential map.
         pot_map_cont_hjorring.shp: Potential map – 2.5 m contours (constructed from pot_map_point_hjorring.shp)
         locations.shp: location the Statoil and Shell express

         terrain_point_utm_hjorring.shp: Terrain point theme -25 m resolution

   Step b. and c. may be conducted in ArcGIS or in GMS.

   ArcGIS approach – start here:

   b. Import the background maps, the potential map and the stream theme into ArcGIS.
   c. Create a polygon theme in ArcGIS and draw a polygon covering your model area. Save the polygon theme as a shp file. NB. In GMS this shp file is used to define the model extend.
   d. Import the polygon theme into GMS (GIS module).

e. Construct a **Model area coverage** in the Map module (with nothing marked in the coverage setup)
f. Map the polygon theme to **Model area coverage**.

GMS approach – start here

g. Import the background maps, the potential map and the stream theme into GMS.
h. Construct a **Model area coverage** in the Map module (with nothing marked in the coverage setup)
i. Draw a polygon covering your model area in the **Model area coverage**.

and continue …

j. Create a **boundary coverage** by duplicating the **Model area coverage**. Mark layer range and specified head in the coverage setup. Specify the boundary type – specified head or no-flow – along the boundary. Specify the head on the boundary in case of "specified head" condition. Note that the head value is specified at nodes and not on the line segments.

2. **Streams:**

a. The stream can be implemented in different ways in GMS - either as rivers, where trace, water level and bottom elevation has to be known or as drain where only trace and water level (drain level) has to be known. The trace is given from the Stream theme (see above) and the bottom elevation and water level may be found in stream "regulation" documents. Alternatively the water level may be estimated from terrain data – e.g. 1-2 m below terrain. In this exercise we will define rivers and streams as "drains" and the drain level is given a 1.5 m below terrain level.
b. Import river and stream theme into GMS and construct a **Stream coverage** (as a duplicate of the **Model area coverage** with layer range and drain marked in the coverage setup).
c. Map the stream data from the GIS module to the Map module (stream coverage). Specify the Drain level (water level) as the terrain level minus 1.5 m. Before this can be done you will have to import terrain data.
d. Convert the GIS terrain theme to a point theme.

e. Generate a tin surface from the terrain point theme and subtract 1.5 m in data calculator (data menu). Assign the new tin surface to all nodal points in the stream coverage.

3. **Stop data collection and build the first model:** There are still a lot of data that has to be collected and treated, but before we go any further you should make some rough assumption regarding the missing data and produce the first model run for the model area:
   a. Create a **precipitation coverage** as a duplicate of the **model area coverage**. Mark *recharge rate* in the coverage setup and assign a recharge rate of 300 mm/year to the entire area.
   b. Create a **layer coverage** as a duplicate of the **model area coverage** with a layer range from 1 to 4. Mark *horizontal K* in the coverage setup and assign a homogeneous hydraulic conductivity of K=1e-4 m/s to all layers.
   c. Create a MODFLOW model as described in the tutorial and map the model to MODLFOW.
   d. Assign - in the 3D grid module - bottom levels to the four layers. (-100 m as lower boundary and 50 m as terrain level.)
   e. Enter initial head conditions in the 3D grid module – e.g. 40 m.

Run the model. (consult the tutorials - MODFLOW - Conceptual Model Approach exercise if you are having problems)

4. **Drains:** Large urban and rural areas are artificially drained by the use of ditches and/or drain pipes. It can be difficult to determine which areas that are drained without field inspections or access to detailed maps. It may however be assumed areas with surface near groundwater table are drained.
   Determine areas that may be drained by:
   a. Inspecting a map at the scale 1:25000 and locate any areas within the model area with ditches.
   b. Calculating the depth of the unsaturated zone (terrain minus groundwater potential). This task requires grid operations in ArcGIS or in GMS.
   c. Generate a polygon theme with drain areas on the basis of **a.** and **b.** assuming that all areas with an unsaturated zone depth less then 2 meters are drained.
   d. Import the drain theme in GMS and construct a drain coverage in the map module. Map the drain theme from the GIS module to the Map module (drain coverage)
   e. Specify drain level and drain conductance for the drain polygons.

5. **Net precipitation:** The net precipitation (precipitation – **actual** evapotranspiration) can be estimated from detailed calculations of the water balance on the canopy, on the ground surface and in the unsaturated zone or from long term catchment water balances.
   a. Select one or more river catchments near the project location and estimate the net precipitation (N-E). Water balance data may be found in the annual discharge report from the county of northern Jutland – see http://water.civil.aau.dk/gw/exercises/Afstromningsmaalinger2005.pdf
   b. Construct a recharge coverage in the map module a assign the net precipitation rate to a polygon that covers the model area.

Geological model: You will use an existing geological model in this exercise.

In http://water.civil.aau.dk\gw\data\Hjorring_data_part3.zip you will find the geological model in terms of digitized layer data:
L1.shp is the bottom of layer 1
L2.shp is the bottom of layer 2
L3.shp is the bottom of layer 3
L4.shp is the bottom of layer 4
L5.shp is the bottom of layer 5
Load these shape files into GMS, convert them to 2D scatter point data and interpolate to MODFLOW layers

6. **Abstractions:** Hjøring Waterworks has a well field and the Military facilities has three "pump-and-treat" wells south of Statoil and Shell Express. Shape files with location and pumping rates are found in http://water.civil.aau.dk\gw\GIS\Hjorring_data_part2.zip

   Indvinding_filtre_alle_HJVV_model_font_point.shp: Abstraction data – Hjørring Waterworks note that not all wells are present in the shape file. A complete list of all wells including abstraction data from 2001 to 2008 are found in **Indvindingsdata - Bagterp.xlsx:**

   Afvaergepumpninger_wgs84_point.shp: Abstraction data – Military facility

7. **Head observations.** For calibration purpose you will find a shape file with head observations in **pot_map_point_hjorring.shp** (from http://water.civil.aau.dk\gw\GIS\Hjorring_data_part1.zip) Load the

shape file into GMS, convert them to 2D scatter point data, construct an observations coverage and convert the 2D scatter point data to observation points.

8. **Go on with the modelling.**