Final Project: Due May 15th at midnight

For the final project, you will be responsible for finalizing your group's Wiki page. This includes uploading the following deliverables from Milestones 1 and 2, as well as including a brief (2-4 paragraph) discussion of each bullet point:

- 6 geologic cross-sections with a map that clearly shows the transect of each. Include a discussion about any differences between your cross-sections and previous conceptualizations, if relevant. Also discuss how closely you were able to replicate your cross-sections in MODFLOW. Show one example cross-section from MODFLOW for comparison.
    - *Note that your cross-sections do not have to be developed in Python.*
- Discuss the hydraulic conductivity and storage obtained from your aquifer tests. How do these compare with your calibrated values? If they differ, why do you think this is?
- Show total pumpage through time for the five facilities in your region with the greatest demands (for the Green River Lowlands, this can be limited to IWIP data only). These plots should include the original data and "model-ready" data with gaps filled and outliers removed.
- Include a map of the point demands with scaled points to denote larger pumpers. For the Green River Lowlands group, include your estimated irrigated withdrawals in this map.
    - *To my knowledge, only one group was officially made this type of map. This took the group a while to develop, so make sure at least one group member is giving attention to this.*
- **Show a transmissivity map (note that you can calculate the transmissivity in each layer and sum each layer). For purposes of this class, you may assume full saturation of each layer when calculating transmissivity.**
    - *To my knowledge, nobody has done this yet because we officially eliminated the last task of Milestone 1 earlier. However, this is such a fundamental map that it should always be shown when developing a groundwater flow model.*
- Show a map of high and low recharge zones. Be sure to clearly label your final calibrated recharge when showing this map.
- Show a map of the boundary conditions (wells, rivers, and drains)
- Show a map of the calibrated potentiometric surface and a map of drawdown from pre-development conditions (in other words, the head difference between the model with and without pumping)
- Calculate reductions in natural groundwater discharge (the difference between discharge to rivers between pre-development and current conditions)
    - *Note that current means the year that you are simulating pumpage, so 1995 for American Bottoms, 2002 for Will County, and 2019 for Green River Lowlands*
    - *Hint: Use the List File*

You will also be responsible for the following tasks regarding calibration of the model:

- Plot observed against simulated heads. Calculate *mean error* and *mean absolute error*.
- Calibrate to the best of your ability by reducing the mean absolute error. This will involve changing multiple aquifer parameters, including hydraulic conductivity, recharge, and river/drain conductance.
- Plot points where the error is relatively large (what this means will differ for different models). If observed head is greater than simulated head, then color red (your model results are too low). If observed head is less than simulated head, then color blue (your model results are too high).
- You should not expect to have a perfectly calibrated groundwater flow model by the end of this project. However, you should make some recommendations as to the type of data that you would recommend collecting that could help you understand the real-world system and improve your model calibration.

Finally, each group should develop a plan for the next stage in model development to address three specific questions. Daniel recommends the following but is open to other questions of interest.

1) **American Bottoms:** How would you model the migration of a contaminant under changing Mississippi River elevations? Things to consider include:
    a. How do you simulate a transient river boundary condition?
    b. What assumptions would you make regarding the IDOT dewatering wells which are designed to prevent groundwater flooding under high stage conditions?
    c. How would you assign a source contaminant concentration related to an old industrial site in MT3DMS?
    d. Is there previous work that has attempted to simulate solute transport under changing river conditions?

2) **Will County:** How does chloride enter and move through the aquifer, and will it approach the EPA secondary standard (250 ppm) or pose a threat to the sensitive habitat of the region? Things to consider include:
    a. How do you assign chloride concentrations in recharge, both spatially and temporally?
    b. How would you determine the total average chloride concentration discharging to streams or wells?
    c. What data do you need to calibrate this model, and what appears to be available?
    d. Is there previous work that has attempted to simulate chloride migration through an aquifer?

    Since Will County has an additional person in their group, also consider the following question: "How can you use the model to determine the reduction in natural groundwater discharge and change in chloride concentration discharging to an individual surface water feature, in particular the Lockport Nature Preserve?"

3) **Green River Lowlands:** How does nitrate enter and move through the aquifer, and will it approach the EPA primary drinking water standard (10 ppm) and pose a threat to domestic or community supply wells?
    a. How do you assign nitrate concentrations in recharge, both spatially and temporally? How would you propose handling denitrification?
    b. How does the aquitard influence migration of nitrate from the Tampico to the Sankoty?
    c. What data do you need to calibrate this model, and what appears to be available?
    d. Is there previous work that has attempted to simulate nitrate migration through an aquifer?

When considering the relevant questions above, your response should include data that you need for the model, setup of appropriate modeling packages, and a workflow to create the desired results. *To be clear, you are not responsible for setting any of these items up in the model, just creating a plan to proceed with the next phase of modeling.*

Note that you are responsible for presenting a well-thought out Wiki with minimal spelling and grammatical errors. You are also responsible for having well-commented code.

In addition to your Wiki, make sure your Github Projects tab is updated to reflect completed tasks and add "to-do" items for the next stage of model development.