

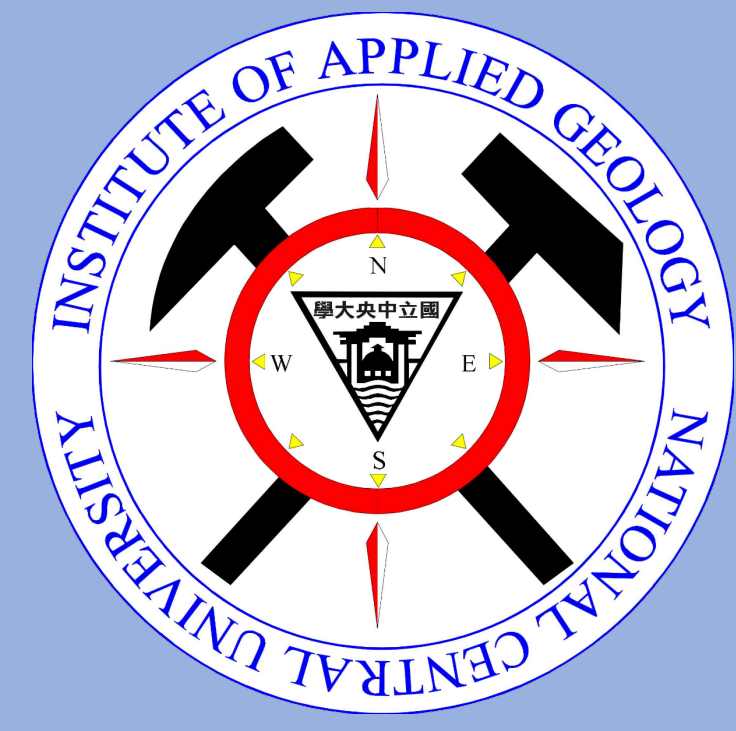
Integration of GemPy and FloPy packages for modeling seawater and freshwater interactions in coastal aquifers

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Abstract

Coastal groundwater resource is a potential alternative water resource to bridge the gap of increasing water demands. An accurate hydrogeological model could reduce the uncertainty of the flow and transport estimations in coastal aquifers. The study aims to develop a framework that integrates the open-source GemPy and FloPy for modeling seawater and freshwater interactions in the coastal aquifer in Taoyuan, Taiwan. In the study, a series of field works were conducted to acquire site-specific information, including core drilling and identification of geological materials, groundwater level observation, and hydraulic tests. The geological model uses data obtained from the core samples to map the stratigraphic distribution of the coastal aquifer. The results show that the strata in this area are mainly stacked horizontally within 100m underground, the upper part is dominated by gravel layers, and the middle and lower parts are stacked by sand and mud layers. Next, the data obtained from the test and the material distribution in the geological model will be used to establish a flow field model in this area.

Study Area

The TaiCOAST workstation is located in the coastal area of Taoyuan in northern Taiwan. The surface is covered with alluvial layers, with an average upper layer thickness of about 20 meters composed of gravel. The lower layer is mainly composed of interbedded sand and silt.

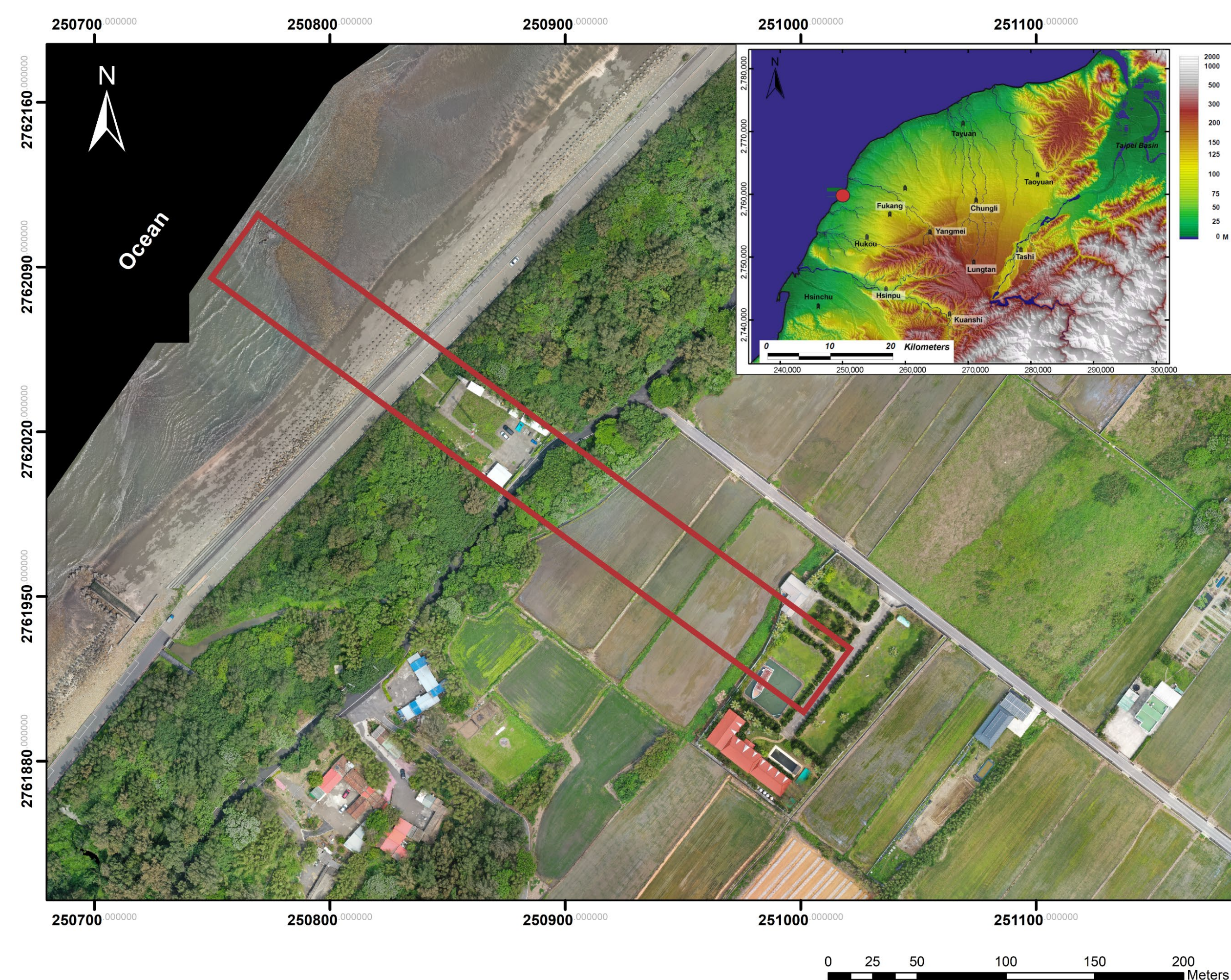


Figure 1. The UAV figure of the study area in the red rectangle, the map in the upper right corner is a topographic map of the Taoyuan area (Wang Yu, 2003).

Methodology & Results

A geological model was established based on the borehole data from the site, and the GemPy and FloPy were combined using Python code, allowing for the efficient input of the geological simulation model into the groundwater flow conceptual model.

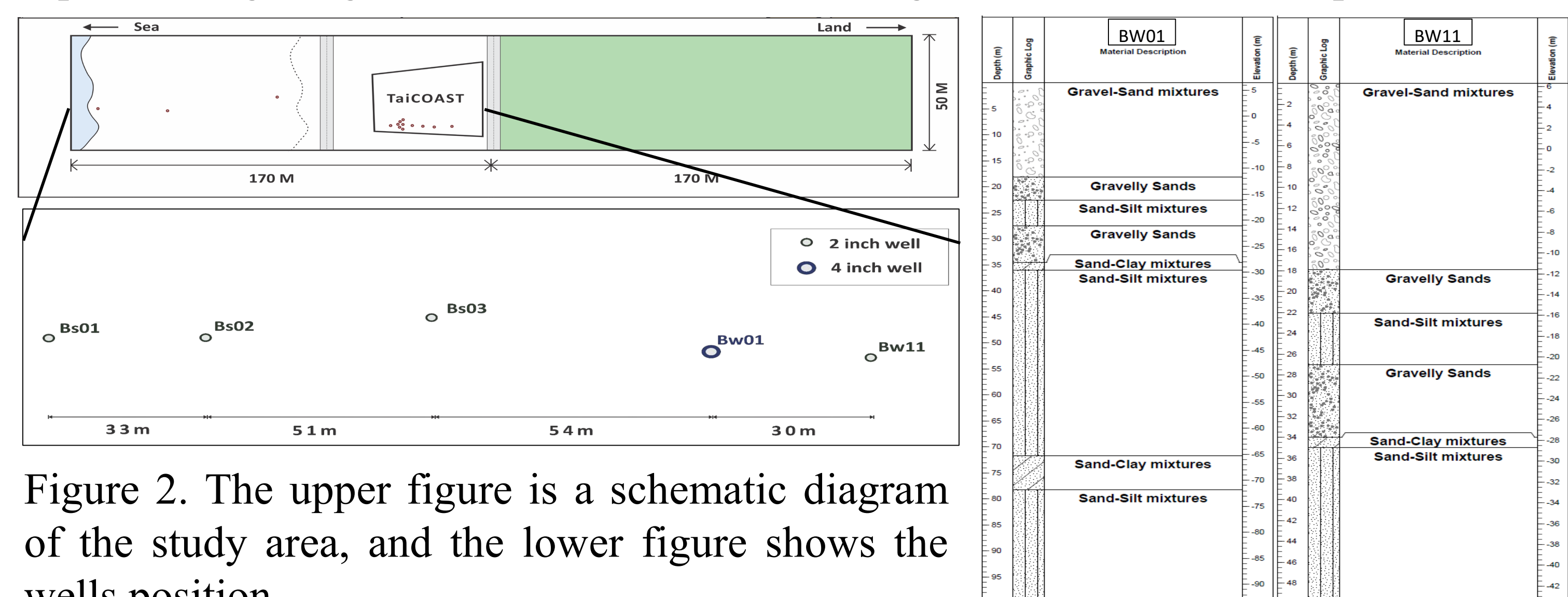


Figure 2. The upper figure is a schematic diagram of the study area, and the lower figure shows the wells position.

Figure 3. Borehole data of BW01 and BW11.

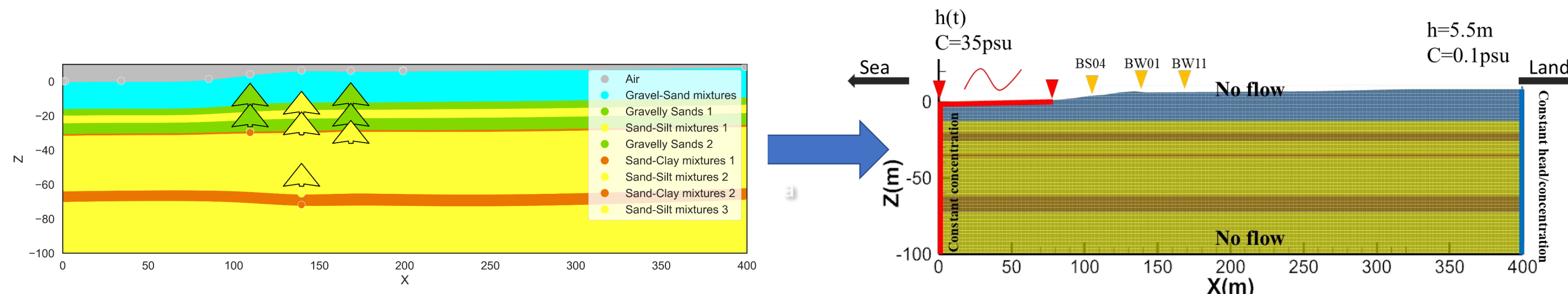


Figure 4. The left figure shows Using GemPy to generation the 2D geological model. All the cells in the geological model are assigned an ID, which represents the material, so that the location of the material can be defined in the groundwater flow model using the cells location and ID. The right figure shows the conceptual model of groundwater flow model with 400*110 grids (Grid size: Δx : 1m; Δz : 1m). The hydraulic conductivity are set according to different materials.

Flow Chart

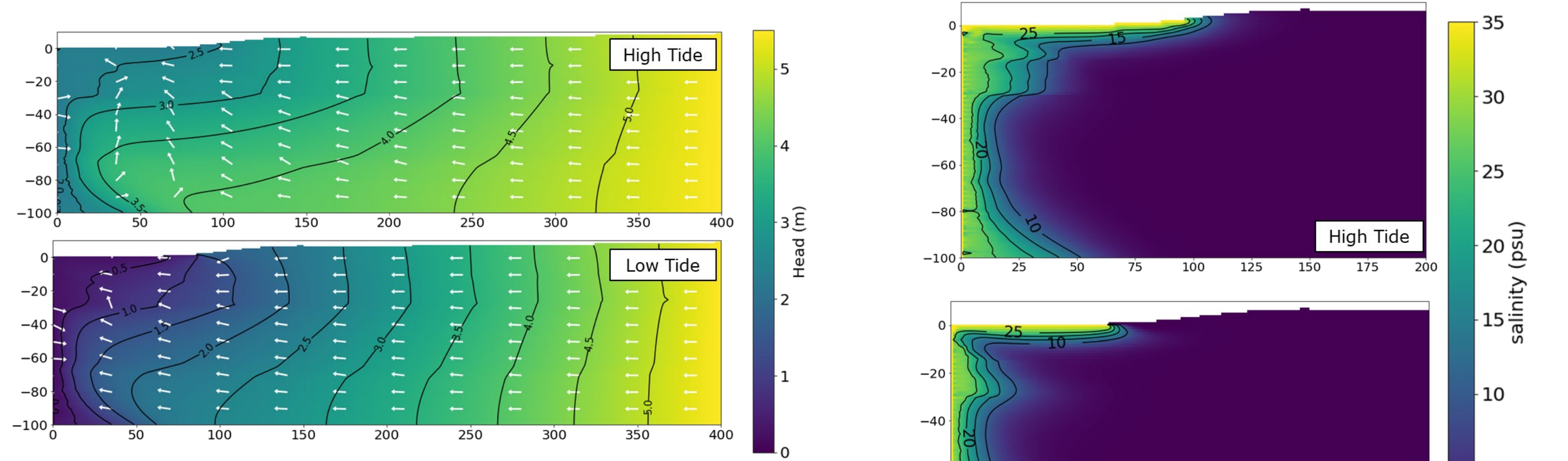
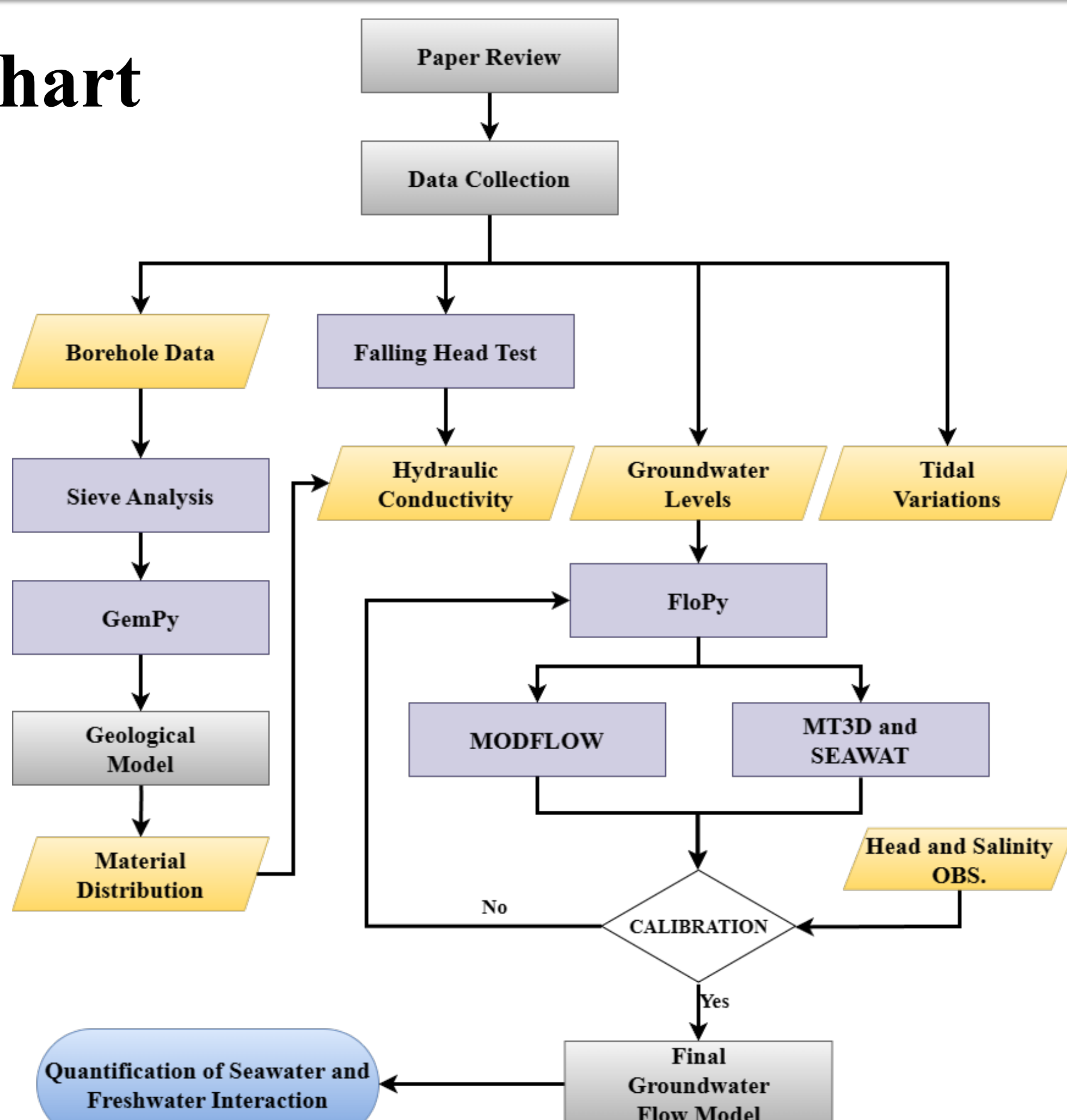


Figure 5-1. Using FloPy to simulate head of groundwater field in high tide and low tide.

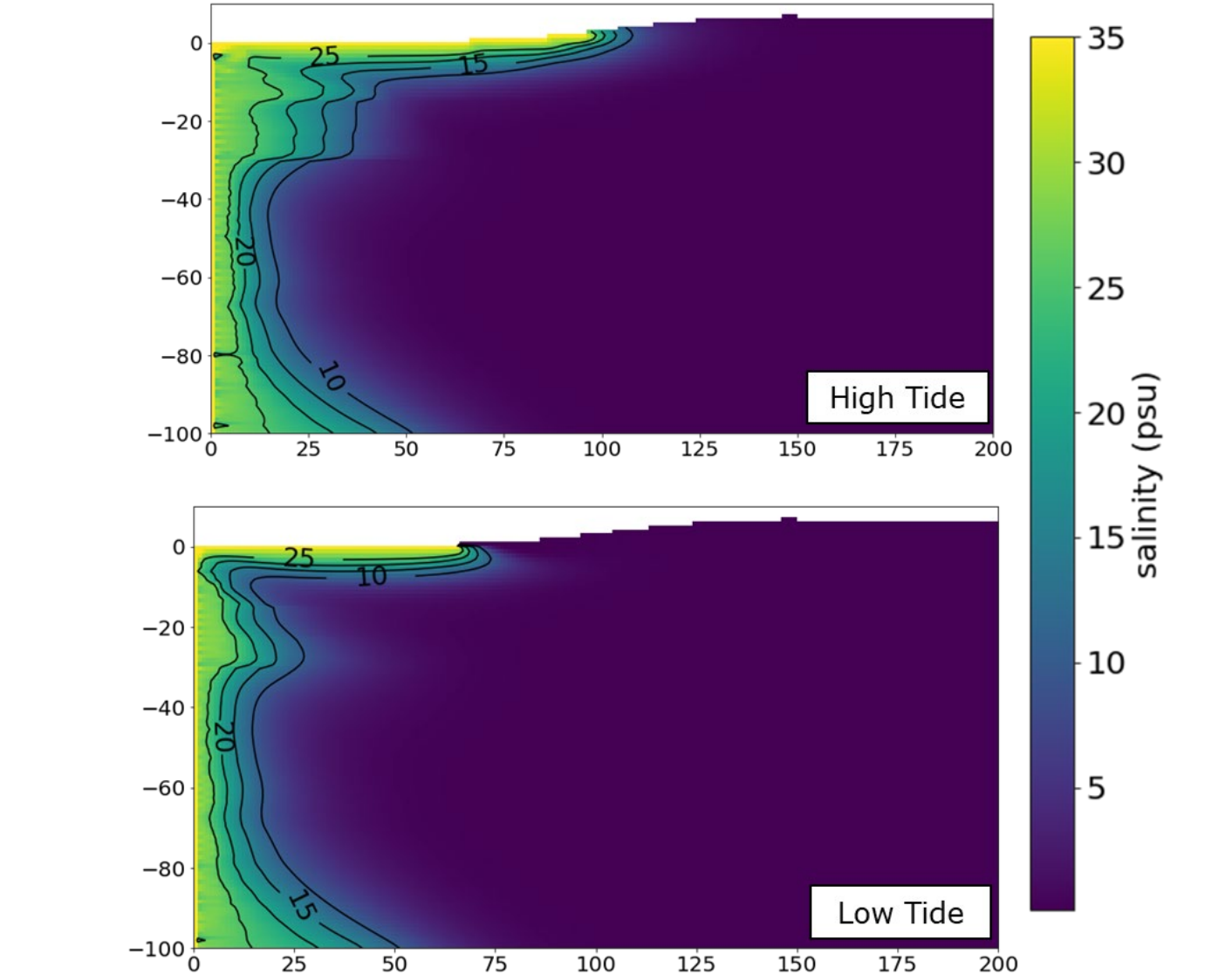


Figure 5-2. Using FloPy to simulate salinity of groundwater field in high tide and low tide.

Conclusion

1. This study use the Python code in conjunction with open-source software GemPy and FloPy, that enhancing the efficiency of model development.
2. The GemPy model results reveal the distribution of geological materials within the site, with a horizontal layering.
3. Above an elevation of -30m, the distribution of groundwater salinity is more noticeably influenced by tidal periodicity.

Reference

1. Wang Yu, Taiwan. (2003). Morphotectonics in Taoyuan – Hsinchu Area, Northwestern Taiwan.