Characterization of flow in coastal aquifers based on multi-scale hydraulic testing methods

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Abstract： This study combines different approaches, including field and laboratory hydrogeological experiments and inverted models, to estimate the spatial distribution of hydrogeological parameters and assess the temporal and spatial dynamic characteristics of the groundwater system. There are six observation wells installed in the study area, which were used to conduct cross-holes pumping tests and multi-layered water level observations to analyze the hydraulic conductivity of the site. The inverted model, VSAFT2, was used to estimate the spatial distribution of hydraulic conductivities. The numerical model will be used to integrate the long-term observation data of coastal groundwater levels and the spatial distribution of aquifer characteristic parameters obtained from hydraulic tests to carry out the numerical simulation of the time-series dynamic flow field of groundwater. This model will be used to analyze the characteristics of the interaction between groundwater and seawater at this site, and discuss the benefits of developing groundwater in coastal areas and the usability of this model in actual situations. To sum up, this study not only have avoid the tidal effect to let the result to be more in line with the real situation, but also well depicted the synthetic spatial distributions of the K value and the aquifer heterogeneity of this site.

Research Process

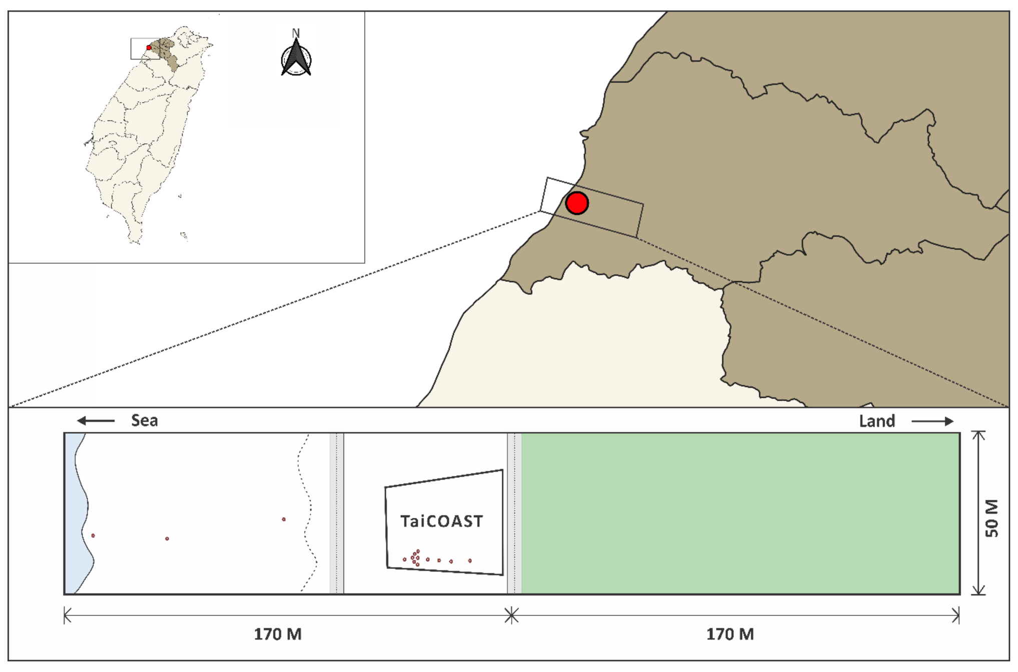

Fig 1. Study Area

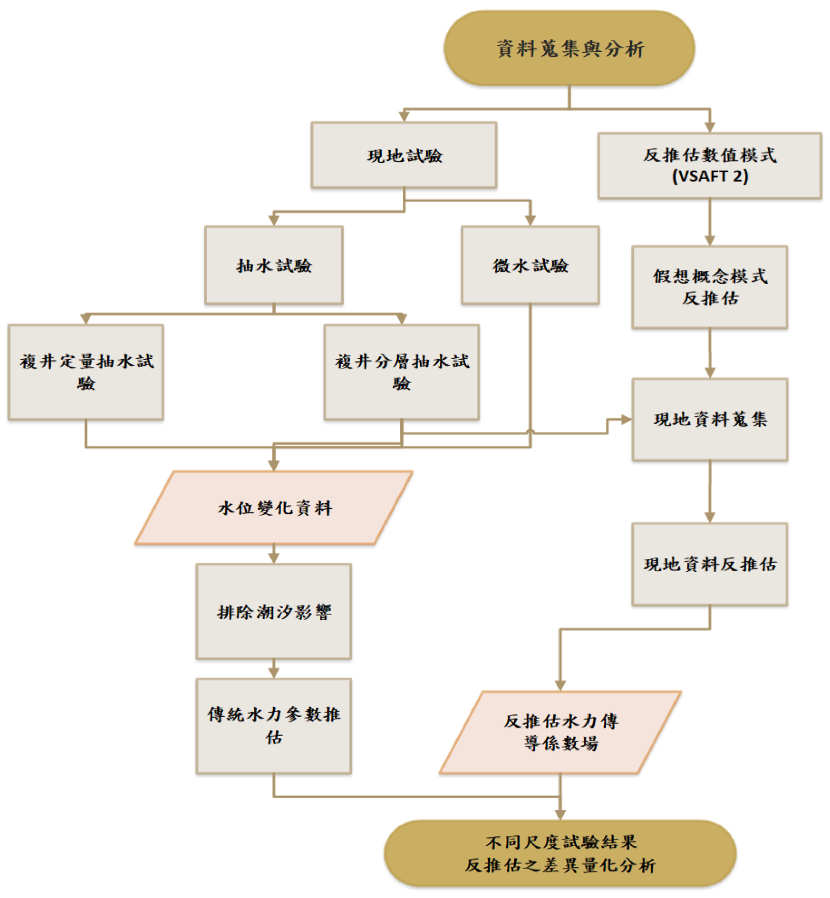

Fig 2. Work Flow

Table 1. Study Area Well Information

	BW01	BW02	BW03	BW09	BW10	BW11
DIAMETER	4inch	4inch	4inch	4inch	4inch	2inch
DEPTH	100m	50m	50m	50m	50m	50m
PENETRATION	Full	Full	Full	Partial	Partial	Full

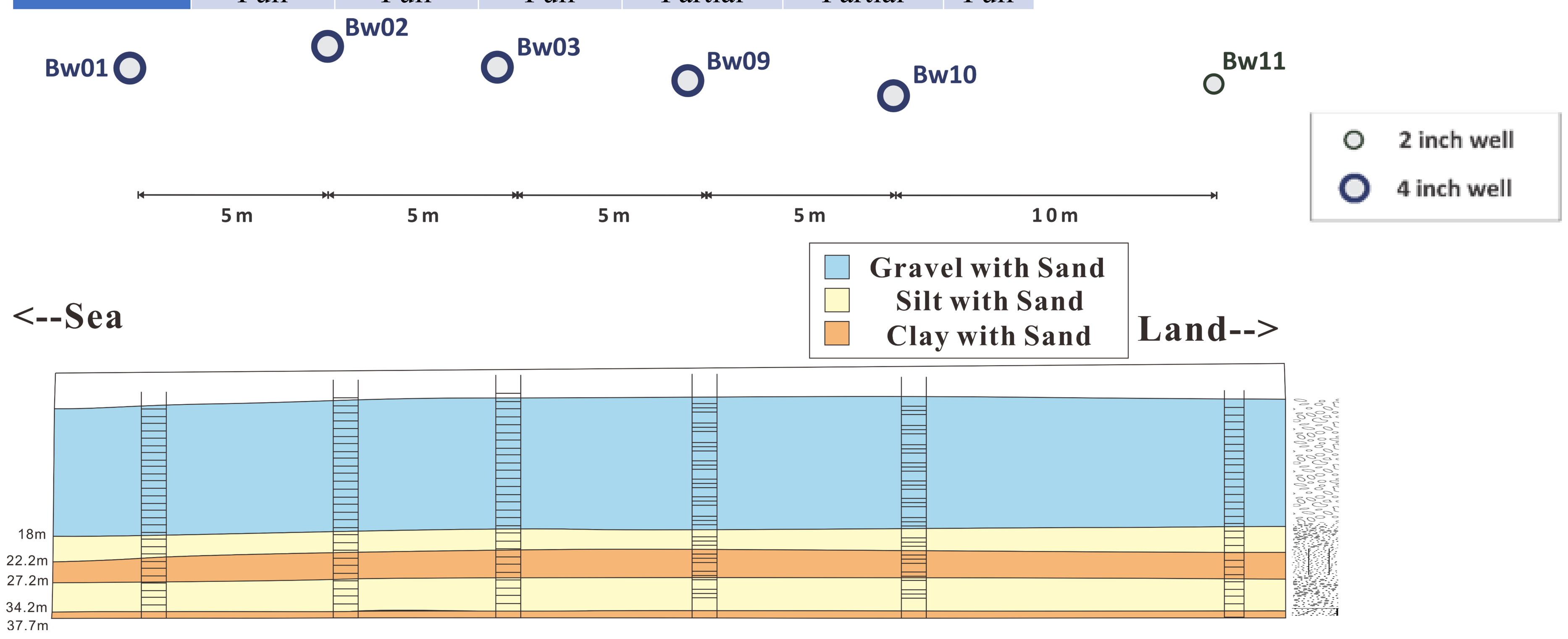

Fig 3. Schematic diagram of the site with borehole data

Aquifer Test design

By utilizing cross-hole pumping tests combined with layered observations, specific hydraulic parameters of the formation can be obtained, which enhances the accuracy of data during parameter estimation. The design methodology is illustrated in the following schematic diagrams (Figures 4-6).

Fig 4. Packers

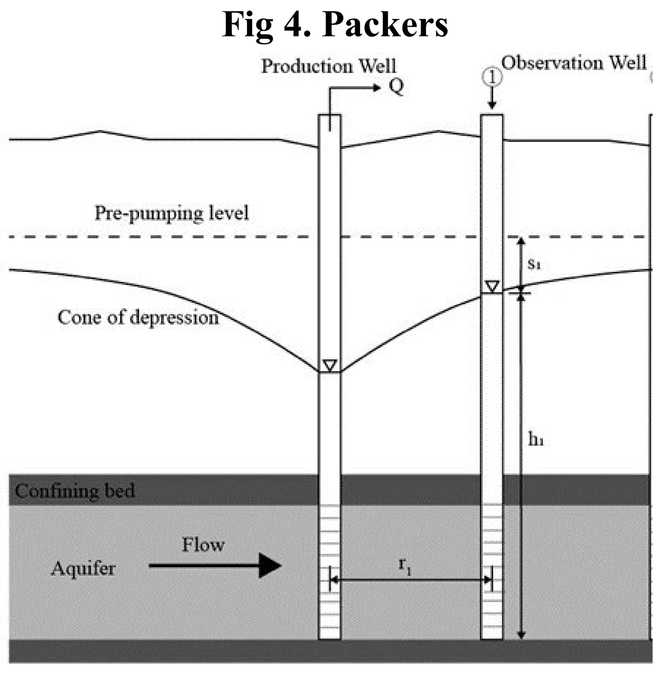

Fig 5. Multi-Well Pumping Test Diagram

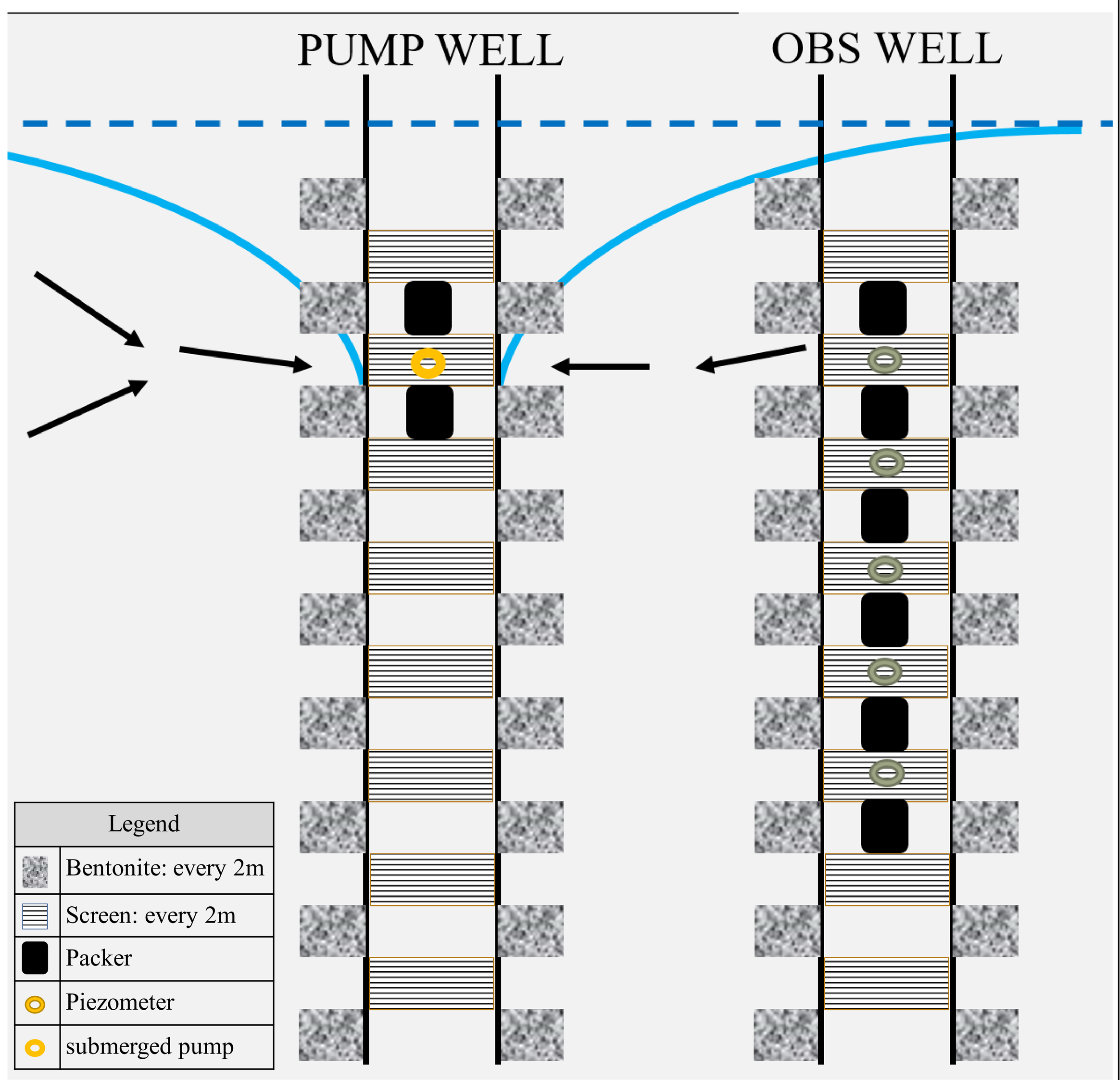

Fig 6. Layered Pumping Test Diagram

Result & Discussion

From the results shown in Figures 7 to 10, can see that tidal has a significant impact on hydraulic testing. After calibrate the MWPT data with tidal effects, hydraulic conductivity (K) exhibits a significant increase.

Table 2. MWPT_K Result

Pumping Well	OBS Well	Distance r (m)	With tidal_K(m/d)	With out tidal _K(m/d)
BW10	BW09	5	0.968	3.228
	BW10	0	0.180	0.188
	BW11	10	0.838	4.219
BW09	BW03	5	0.223	1.786
	BW09	0	0.226	0.904
	BW10	10	0.317	4.23

Table 3. MLST_K Result

BW02		BW10	
K(m/day)	depth (m)	K(m/day)	depth (m)
0.316	6~8	0.612	6~8
0.47	10~12	0.108	10~12
0.556	14~16	2.012	14~16
2.064	18~20	0.225	18~20
1.197	22~24	0.275	22~24
0.443	26~28	1.479	26~28
0.906	30~32	1.385	30~32

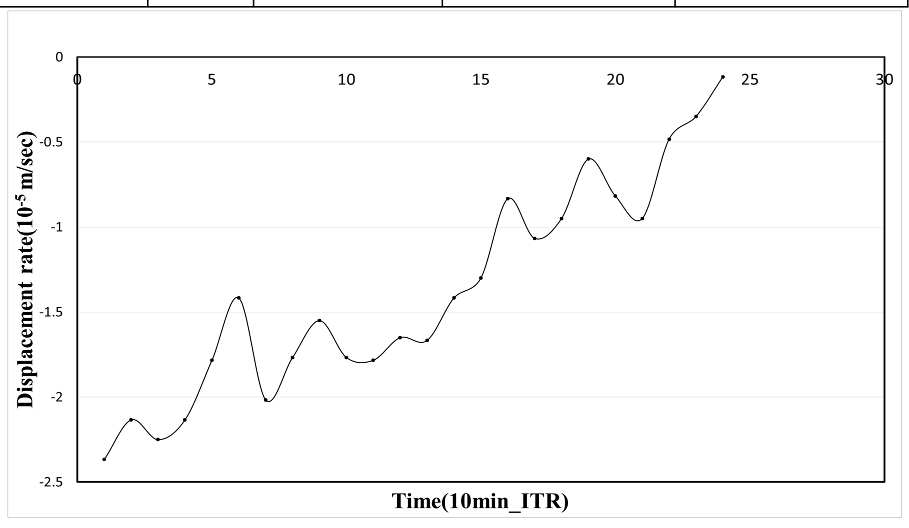

Fig 7. 02/16 Tide Displacement Rate

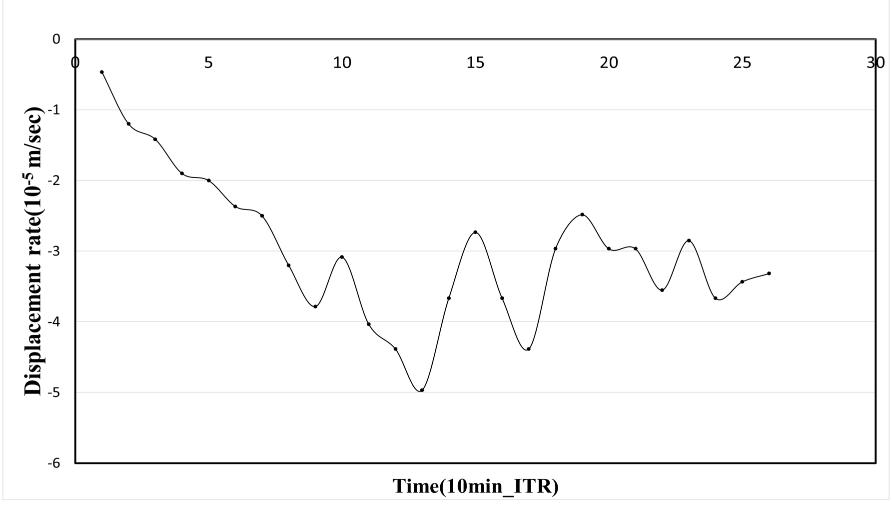

Fig 8. 02/20 Tide Displacement Rate

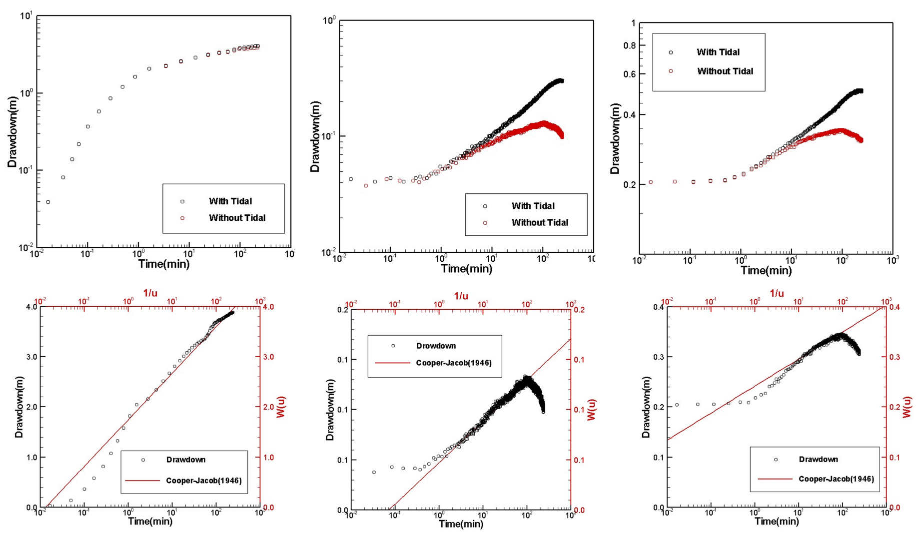

Fig 9. 02/16MWPT_Result Calibrate with tidal effect and fit with Cooper-Jacob(1946)

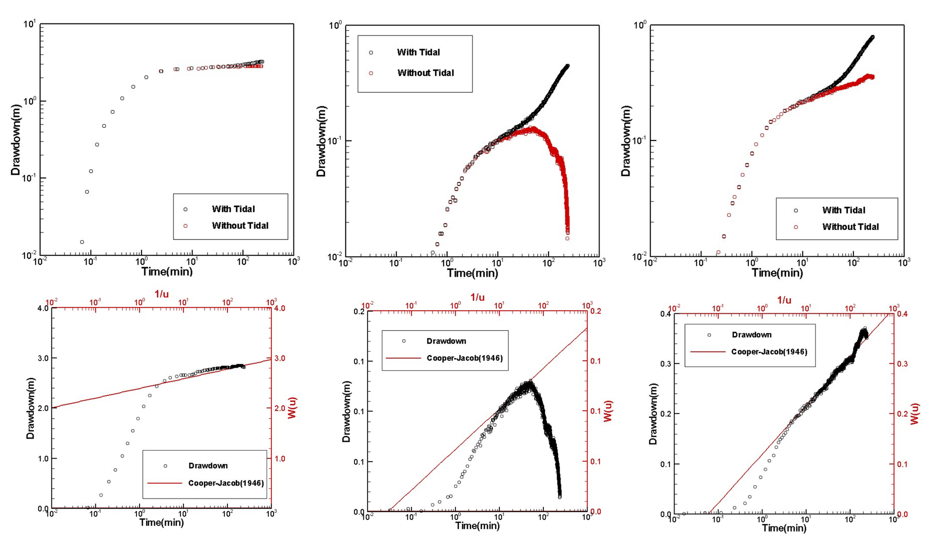

Fig 10. 02/20MWPT_Result Calibrate with tidal effect and fit with Cooper-Jacob(1946)

By using the field test data to be the hard data, and combine the slug test to draw a distribution of hydraulic conductivity values, this study build a inverse model base on the core samples and the site experiment data, which shows that the aquifer could be roughly separated into two layers by the material of the porous media at a depth of 18.5 m. And then, put the result from the forward model into the inverse model, can figure out the distribution of K value in 2D scale (Figures11-12).

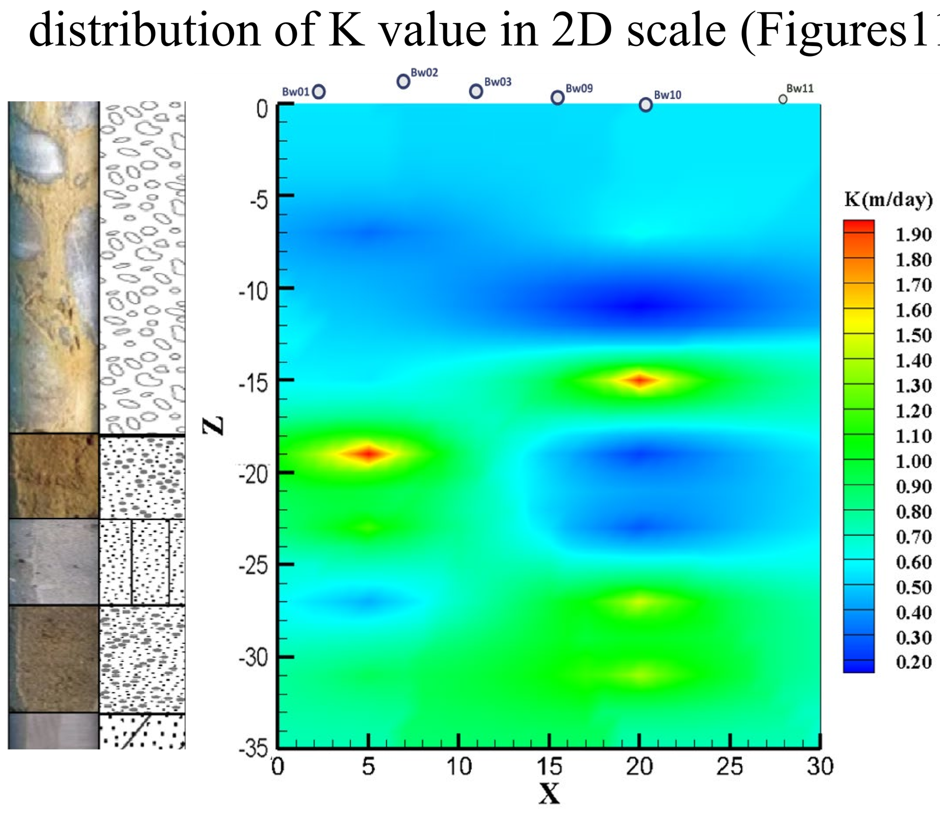

Fig 11. Utilizing kriging interpolation for the distribution of hydraulic conductivity values from the Slug test.

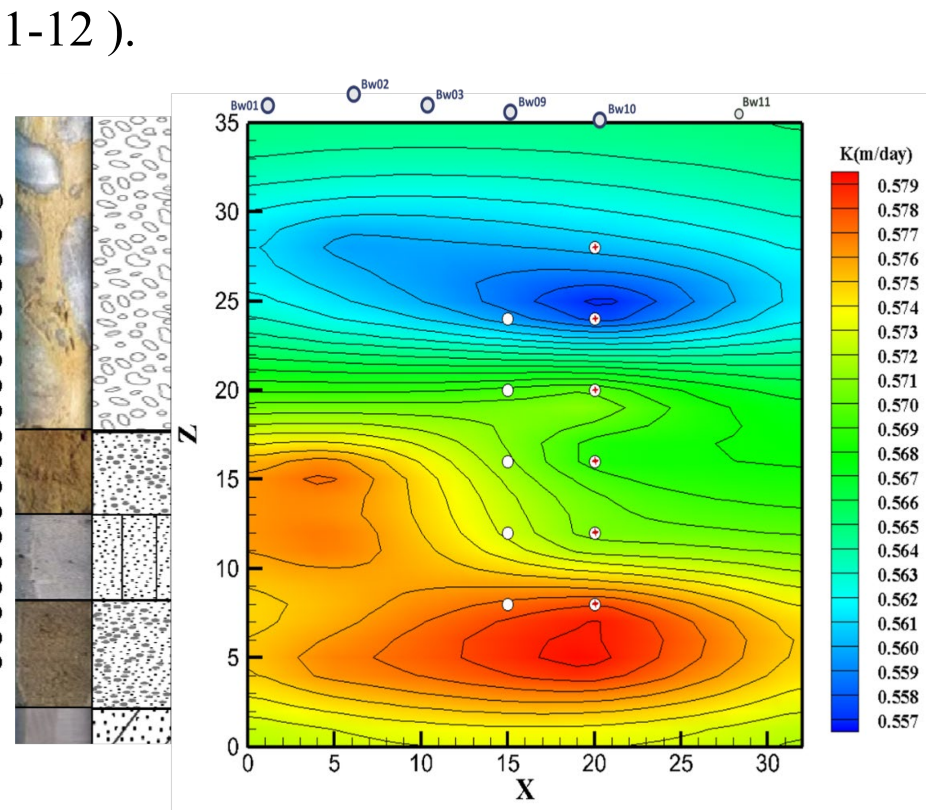

Fig 12. K distribution by using the result of the site experiment result to do the inversion

Conclusions

This study find out that the tidal can intensely effect the field tests results from the costal aquifer. Therefore, by comprehensively comparing the estimated hydraulic conductivities before and after excluding tidal influences, it is observed that after tidal effects are excluded, there is an order of magnitude difference in the estimated hydraulic conductivities. Specifically, pumping tests in multiple wells yield higher K values, while layered pumping tests yield lower K values. Despite the apparent difference in hydraulic parameter estimation by approximately an order of magnitude after reducing tidal interference, this discrepancy reflects only a portion of the observed data analysis. Next, this study results indicated with a fair amount of observation points, the inversion model would efficiently describe the heterogeneity of the aquifer system.

To sum up, this study not only have avoid the tidal effect to let the result to be more in line with the real situation, but also well depicted the synthetic spatial distributions of the K value and the aquifer heterogeneity of this site.