ANALYSIS OF GROUNDWATER FLOW OF COASTAL AQUIFER IN TAOYUAN AREA BY COMBING HEAT TRACER TEST AND NUMERICAL MODEL

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Date : 2023.3.24

Outline

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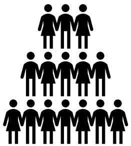
/ Future Work

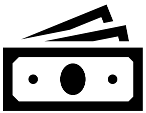
Globally, the need for freshwater is increasingly rapidly.

(Badiuzzaman et al. 2017)



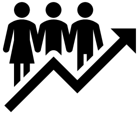
Rapid population growth

Growing agricultural activities



Economic development

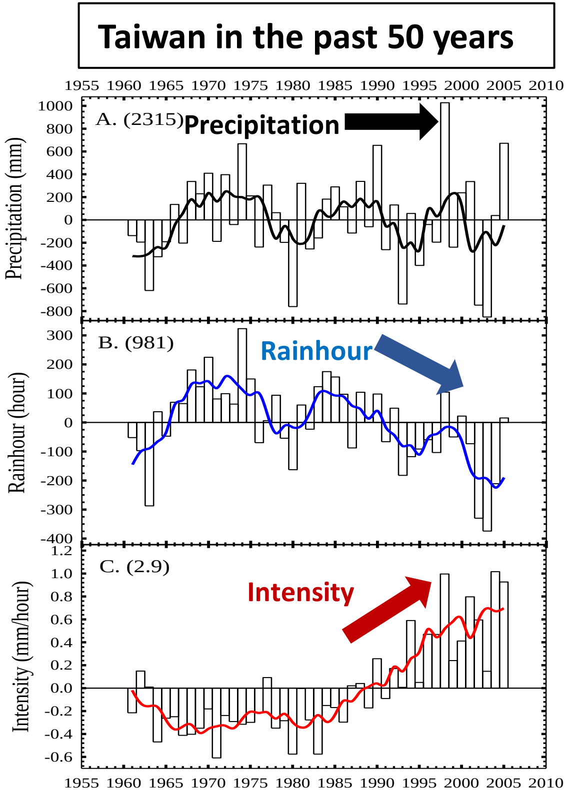
Increased urbanization



Improving living standards

(Dey et al. 2017)

Surface Freshwater



Adaptation Strategy to Climate Change report., 2010

No significant change in annual precipitation

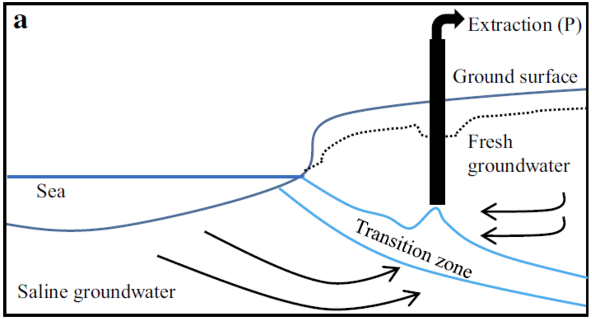
Rainhour tends to decrease

Rainfall intensity tends to increase

Groundwater

- **Aquifer Storage and Recovery (ASR) is a promising approach for maintaining water levels in wells and increasing the sustainability of groundwater resources. (Alqahtani et al., 2021)**

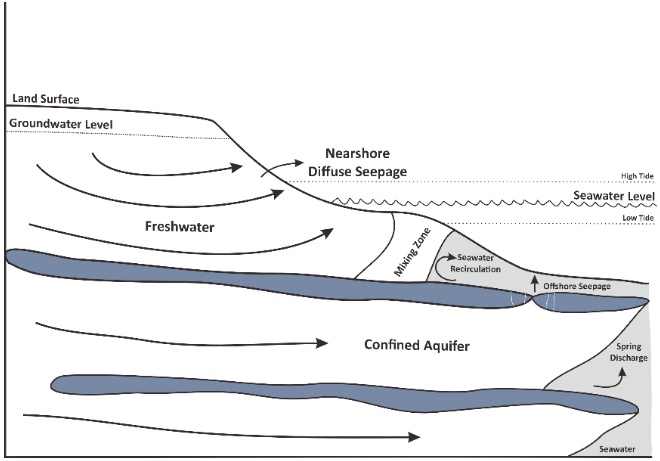
- **The need of managing groundwater resources by sustainable groundwater withdrawal pattern is a priority in many coastal areas. (Lal et al., 2017)**



Lal et al., 2017

Coastal Aquifer

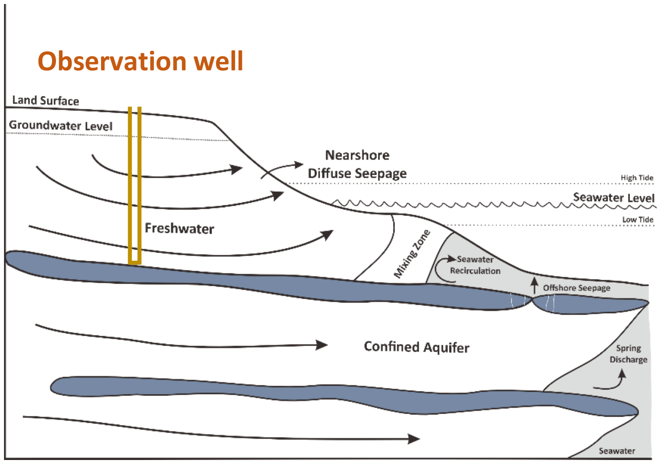
The flow of fresh groundwater may provide substantial inputs of nutrients and solutes to the oceans. However, the extent to which hydrogeological parameters control groundwater flow to the world's oceans has not been quantified systematically. (Luijendijk et al., 2020)



- **Groundwater recharge**
- **Quantify groundwater flux**

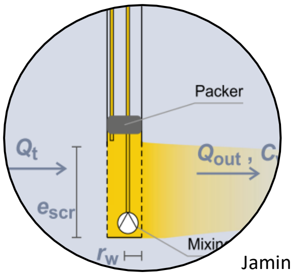
Objective

- General models ➡ Groundwater level variation ➡ Not represent vertical distribution
- Vertical flux distribution in borehole.
- Verify the model to formulate pumping strategy management.
- Groundwater Sustainability



Tracer

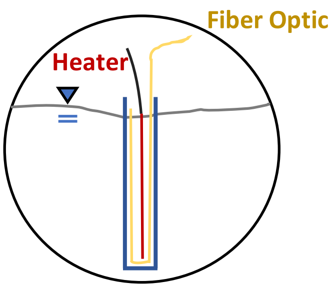
These methods rely on the interpretation of the temperature increase measured along a single heated fiber-optic (FO) cable and consider heat transfer processes occurring both through the FO cable itself and through the porous media. (Simon et al., 2020)



Jamin et al., 2020

Solute

- Require a long duration
- Environmental risk



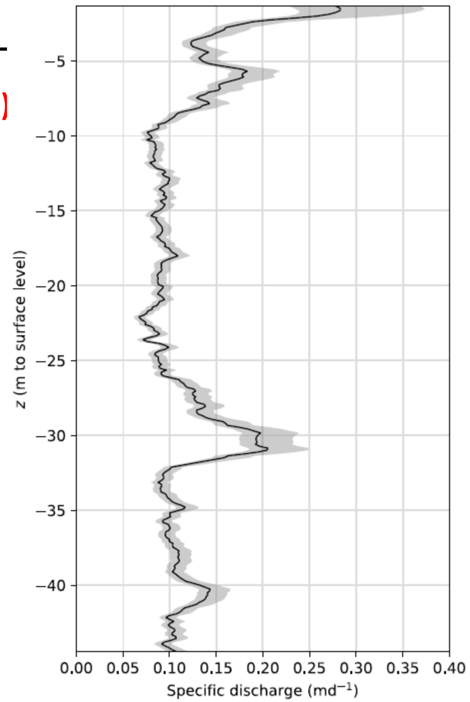
Heat

- Heat convection by groundwater
- Reduce environmental pollution

Heat tracer Test

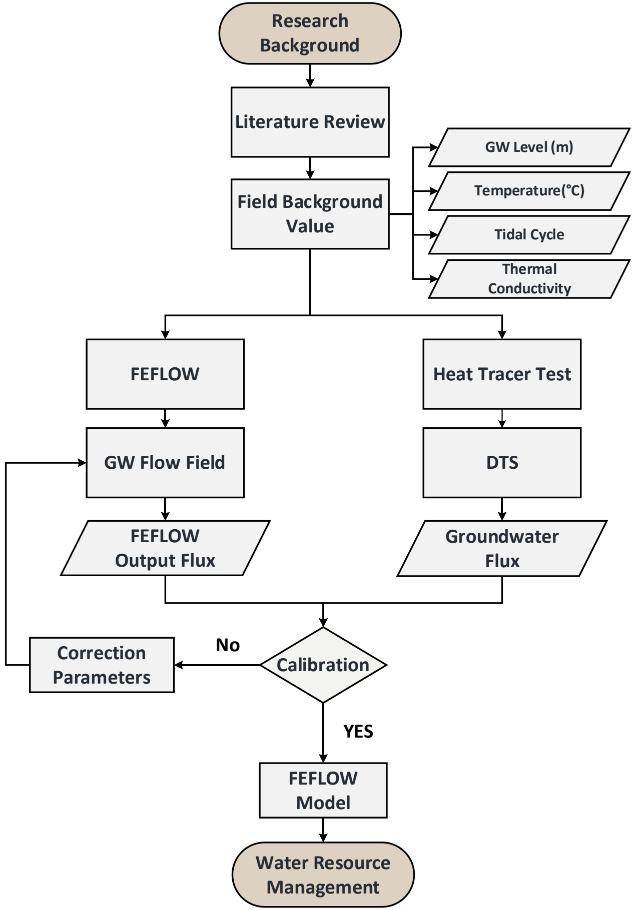
- The temperature response is measured along the fiber-optic cable with Distributed Temperature Sensing (DTS) from which the specific discharge is estimated without knowledge of the position of the fiber-optic cable relative to the heating cable. (Tombe et al., 2019)

- Implying that thermal dispersion is an important parameter in subsurface heat transfer, at least in situations with relatively high groundwater flow rates. (Chiasson et al., 2011)



(Tombe et al., 2019)

Flow Chart

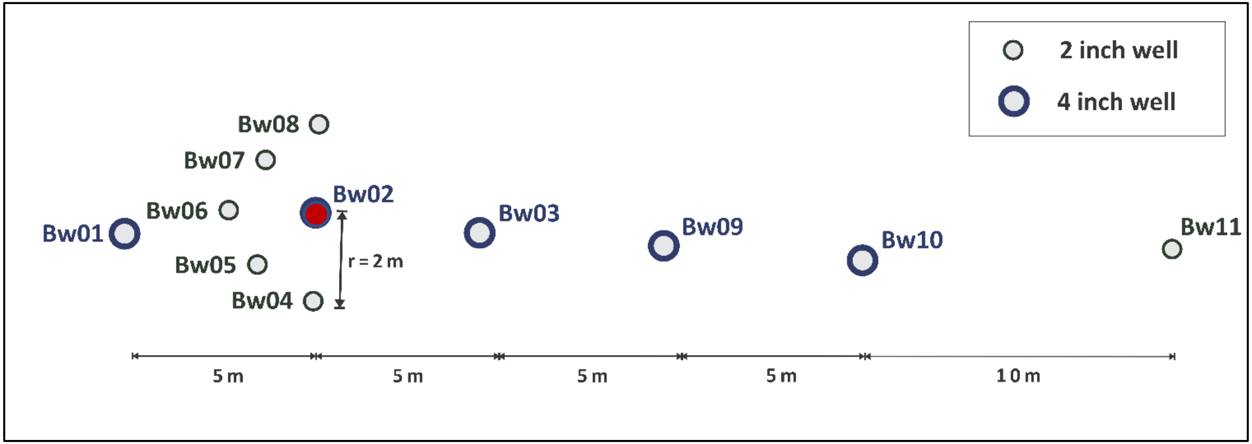


Research Background
Literature Review
Field Background Value
GW Level (m)
Temperature(°C)
Tidal Cycle
Thermal Conductivity
FEFLOW
Heat Tracer Test
GW Flow Field
DTS
FEFLOW Output Flux
Groundwater Flux
Correction Parameters
No
Calibration
YES
FEFLOW Model
Water Resource Management

METHODOLOGY

Study Area

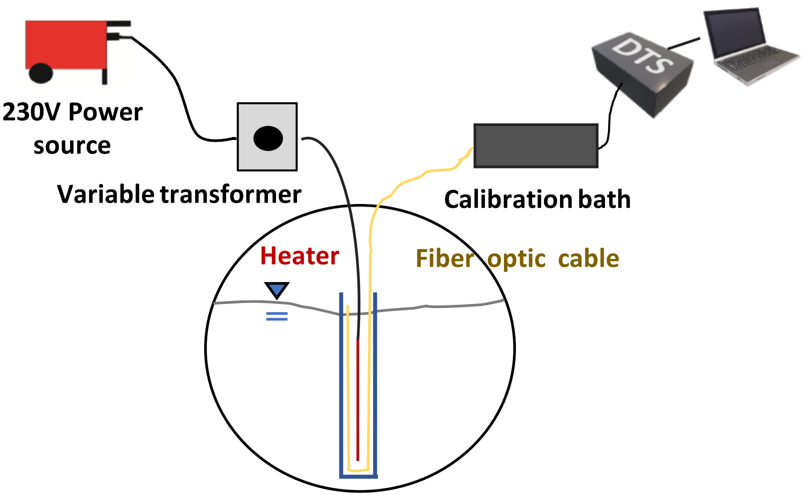
Observation wells in TaiCOAST station



Heat Tracer Test

DTS (Distributed Temperature Sensing)

- **Measurement point distance = 0.254M**
- **Time interval = 20 sec**



Heater

Fiber optic cable

Governing Equation

Dispersion | Advection

$$\boxed{D_x \frac{\partial^2 T}{\partial x^2} + D_y \frac{\partial^2 T}{\partial y^2}} - \boxed{q \frac{\rho_w c_w}{\rho c} \frac{\partial T}{\partial x}} = \frac{\partial T}{\partial t}$$

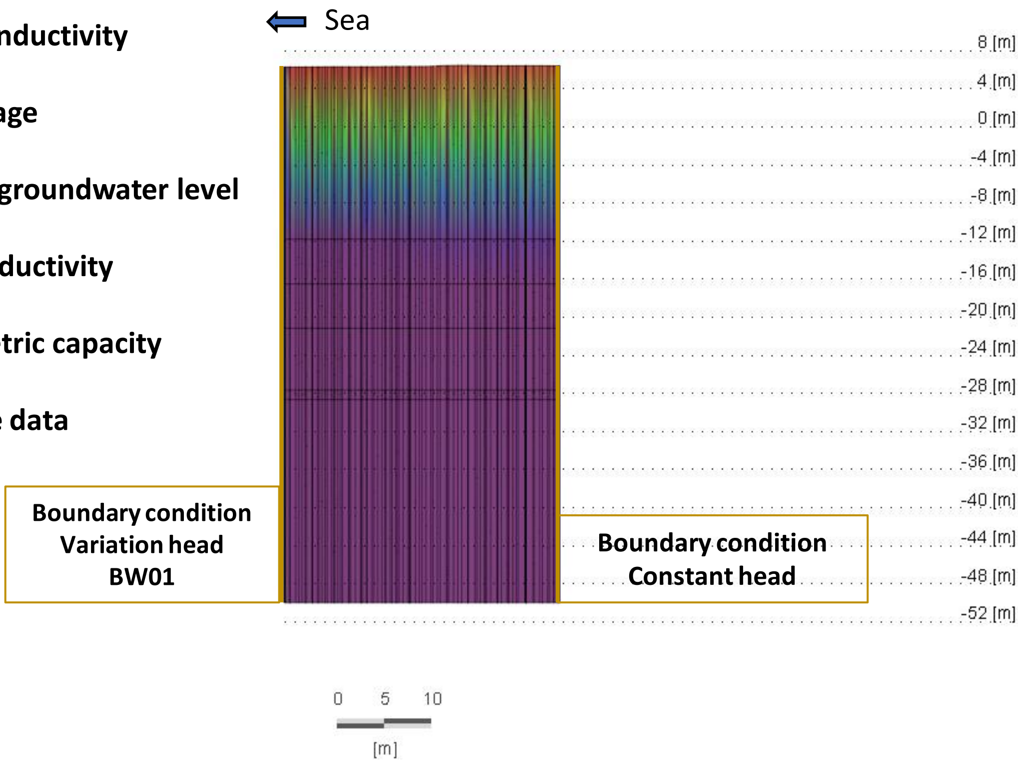
(Tombe et al., 2019)

Parameter
$T[\theta]$: Temperature
$D_{x,y}\left[\frac{L^2}{T}\right]$: Thermal dispersion coefficient in x and y direction
$q\left[\frac{L}{T}\right]$: Specific discharge in x dierection
$\rho c\left[\frac{M}{LT^{-2}\theta}\right]$: Volumetric heat capacity of saturated soil
$\rho_w c_w\left[\frac{M}{LT^{-2}\theta}\right]$: Volumetric heat capacity of water

vertical transfer between layers is neglected

Conceptual Model

- **Hydraulic conductivity**
- **Specific storage**
- **Background groundwater level**
- **Thermal conductivity**
- **Heat volumetric capacity**
- **Temperature data**



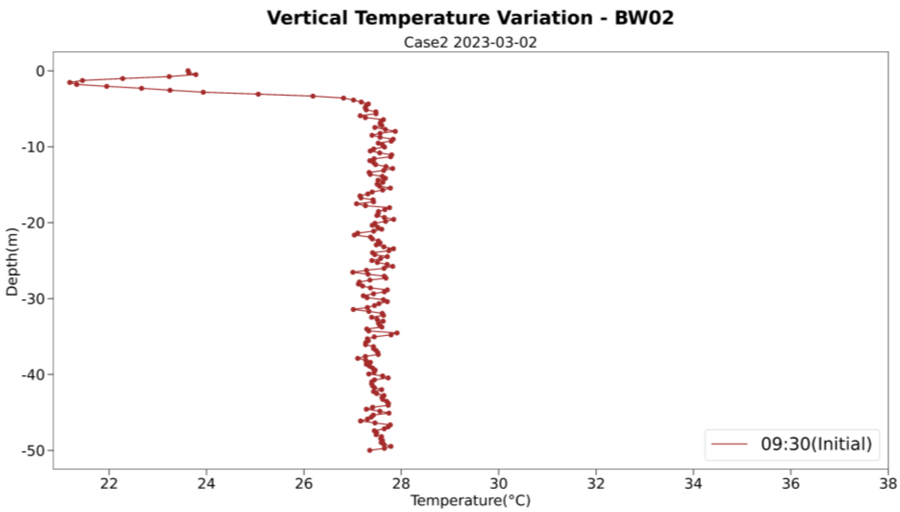
RESULT

Temperature Data varied with Depths

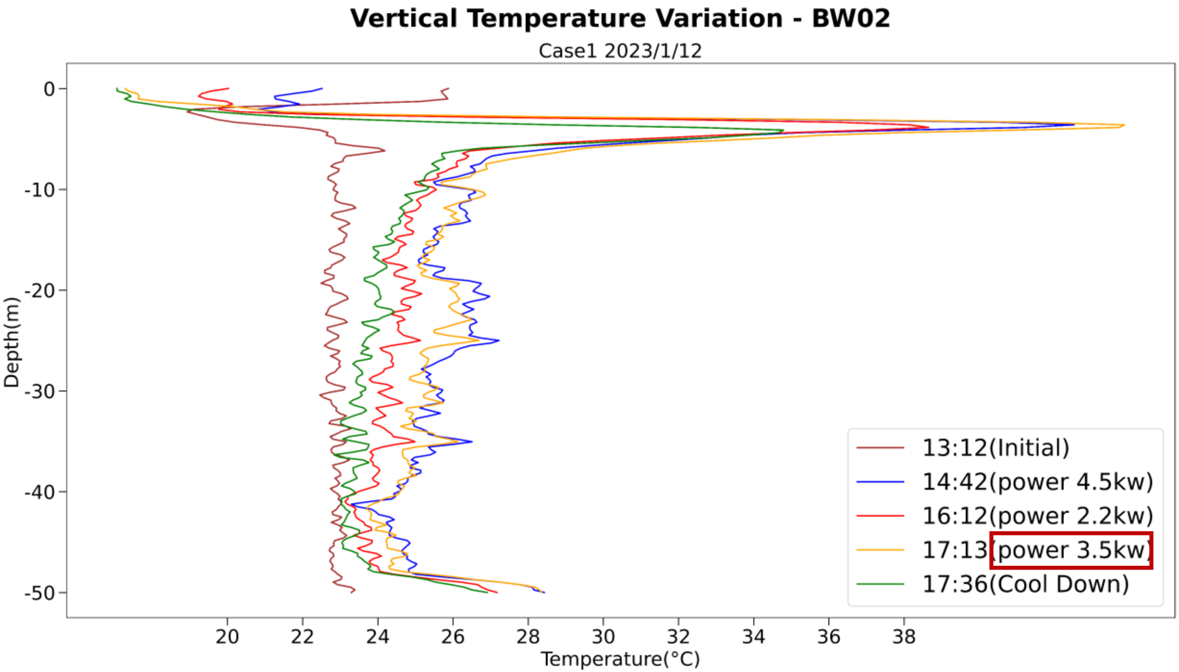
- Choose a specific time 9:30
- Plot temperature every 0.25 m depth
- Connect scatter diagram.

Depth \ Time	9:30
0.00	23.95
-0.25	23.62
-0.50	23.64
-0.75	23.78
-1.00	23.23

Measurement interval = 0.25 meter

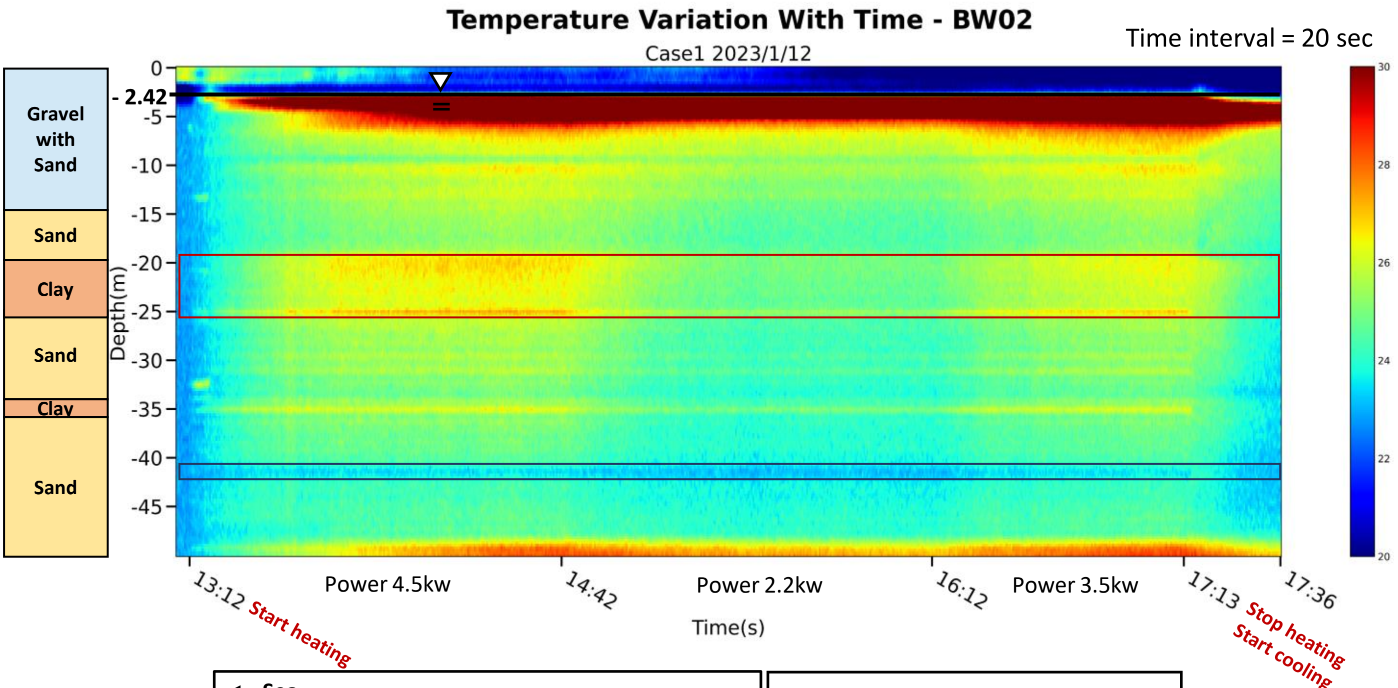


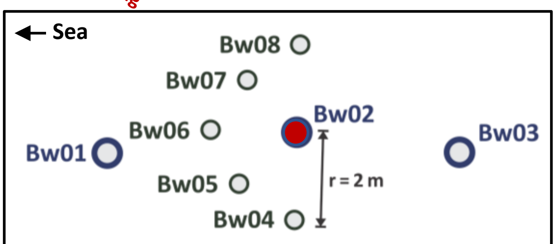
Case1 2023/1/12 (Power Test)

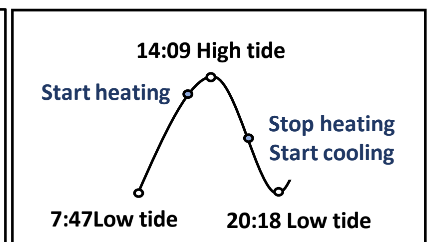


- **Select 3.5 kW**
- **To avoid the overload of the generator**
- **2.2 kW cannot produce enough heat**

Case1 2023/1/12

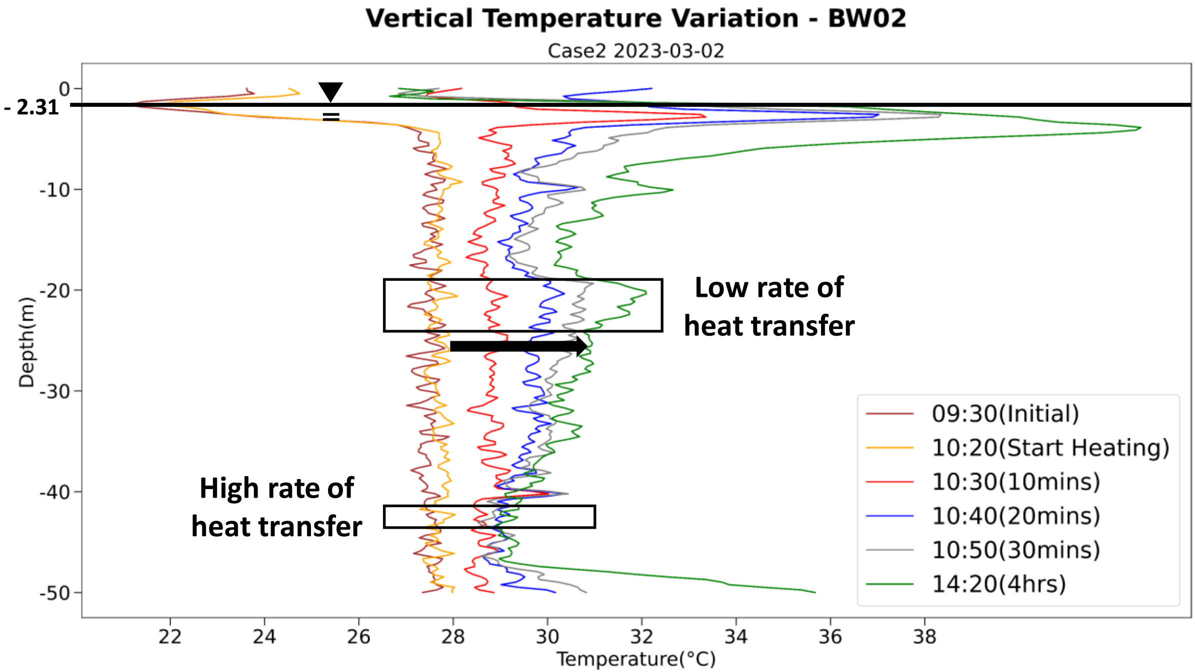




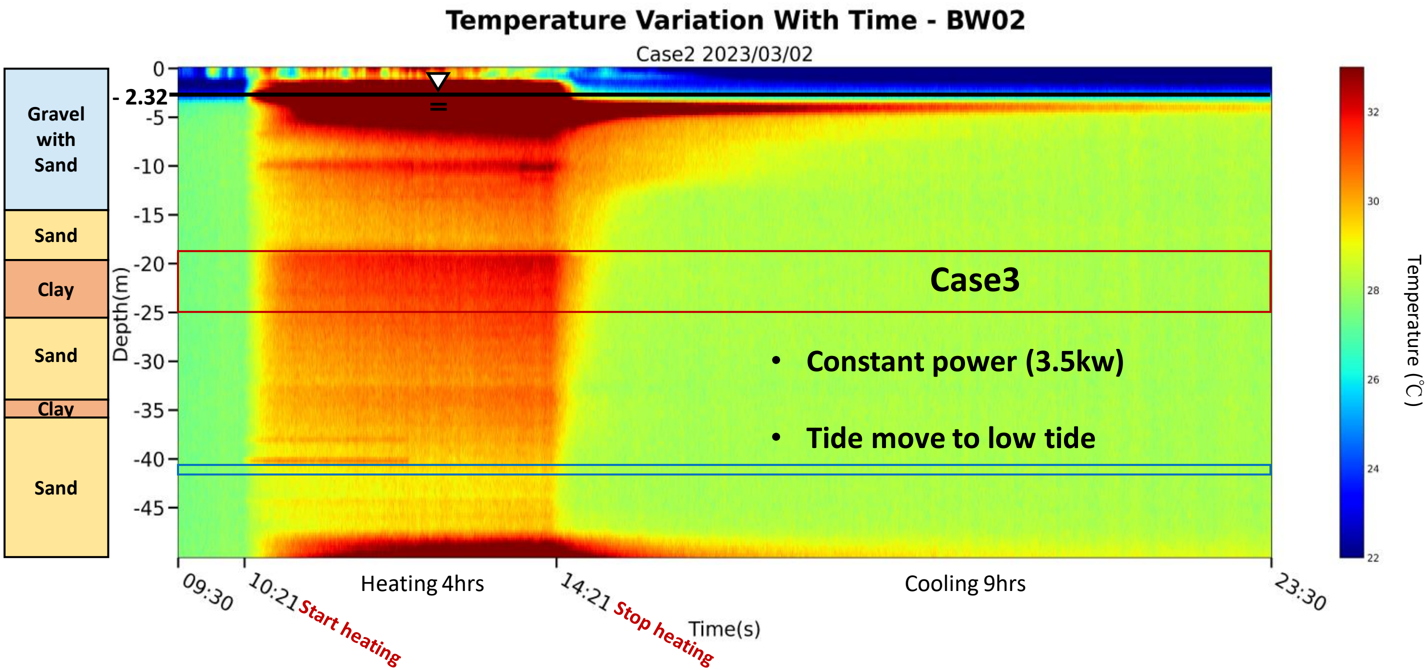


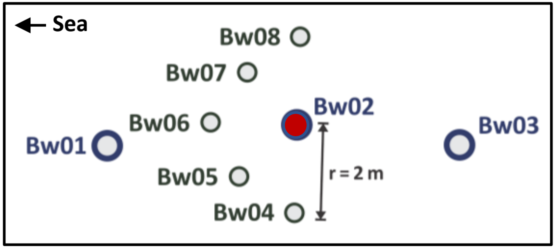
Case2 2023/3/2 (Constant Power)

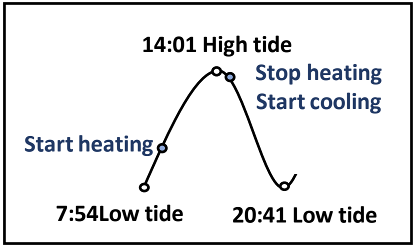
Power = 3.5 kW



Case2 2023/3/2







Summary

- Low rate of heat transfer at depth 20-25 M.
- High rate of heat transfer at depth 42 M.
- Corresponding to core data.
- Different material temperature response.

Future Work

- Estimate the vertical specific discharge distribution.
- Field test temperature data modify FEFLOW model.
- Groundwater flux validation.

THANK YOU FOR YOUR ATTENTION