

7TH ASIA PACIFIC COASTAL AQUIFER MANAGEMENT MEETING

Assessment of Saltwater Intrusion Potential in the Coastal Aquifer of the Lower Kelantan Basin

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Introduction

- Saltwater intrusion refers to the process which saline water infiltrates and mixes with freshwater sources
- This phenomenon occurs primarily due to the movement of saltwater from adjacent seas into the underlying groundwater/surface water systems.
- Saltwater intrusion poses significant challenges to the availability and quality of freshwater resources
- Any coastal regions worldwide are at risk due to rising sea levels and human activities.

Importance of Freshwater

Freshwater is a precious and finite resource that plays a critical role in sustaining life. It serves as the backbone for numerous aspects of human well-being and environmental equilibrium.

- **Drinking Water:** Access to clean and safe drinking water is crucial to prevent waterborne diseases and promote public health.
- **Agriculture:** Adequate water supply ensures healthy crop growth and high agricultural productivity
- **Industrial/** manufacturing, energy production, and mining require freshwater for cooling, processing, and other essential activities.

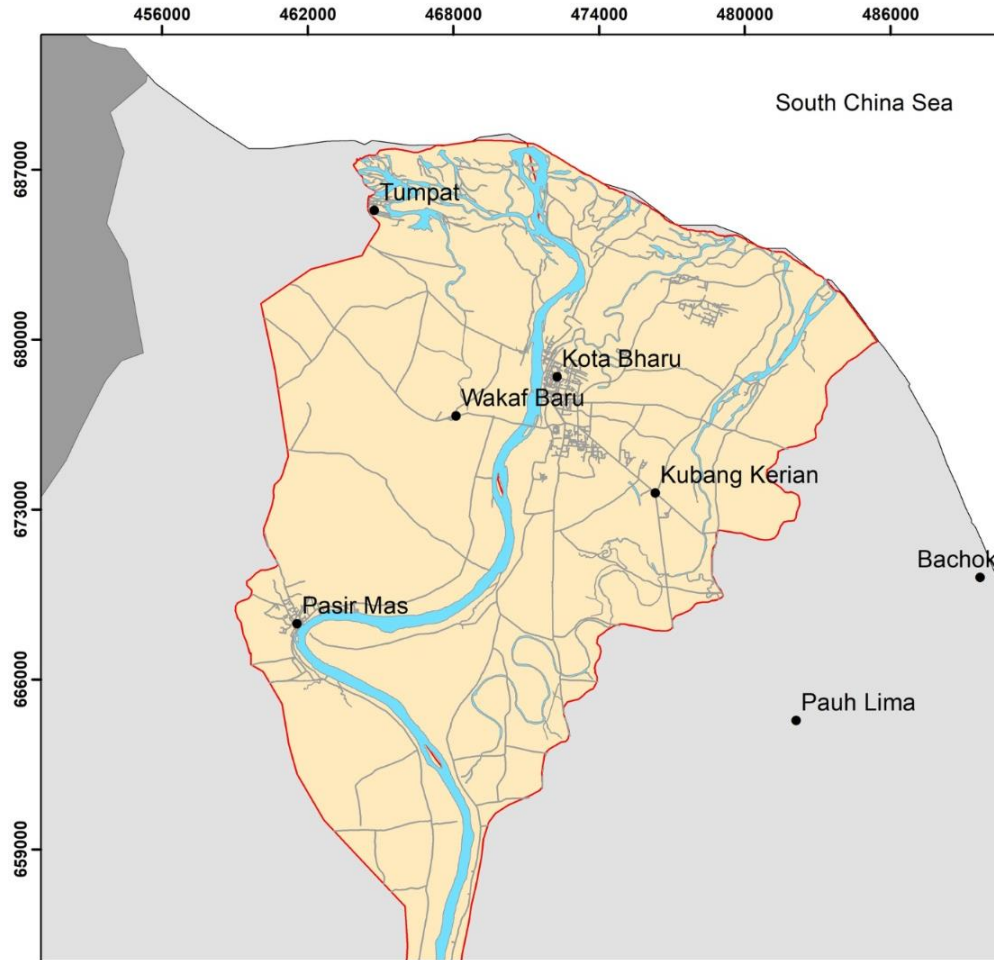
Problem Statement

- Most of the residents rely on groundwater (either treated or untreated) because it is cost effective and gives adequate water supply throughout the year
- Groundwater consumption is significant due to unsatisfactory quality condition of public water supply.
- Generally groundwater is obtain from unconfined shallow aquifer with depth of less than 6 m
- 90% wellfields (study area), large-scale abstraction might cause regional water level lowering and induce saltwater intrusion

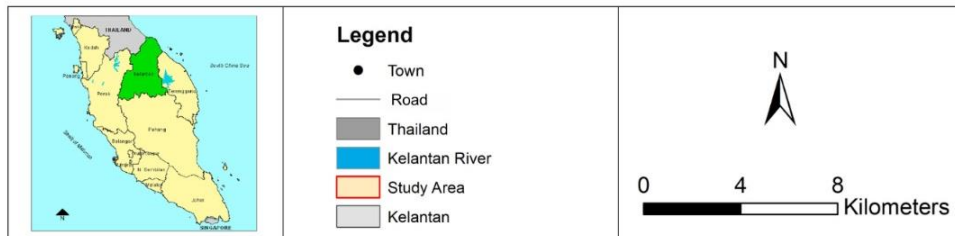
Objectives of the Study

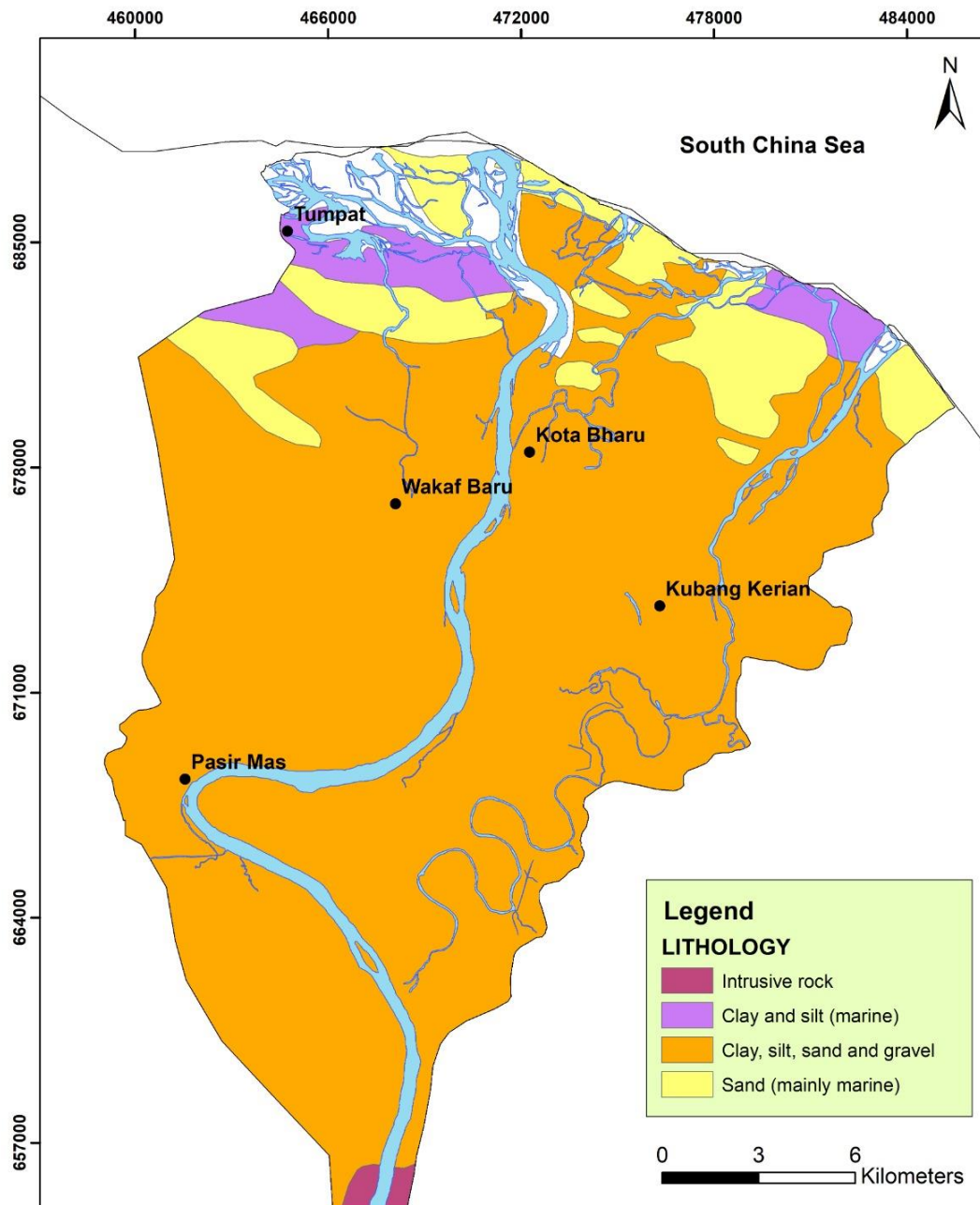
- i. To assess the extent, depth, and severity of saltwater intrusion in the coastal aquifer/river
- ii. To identify the underlying causes and mechanisms driving saltwater intrusion.

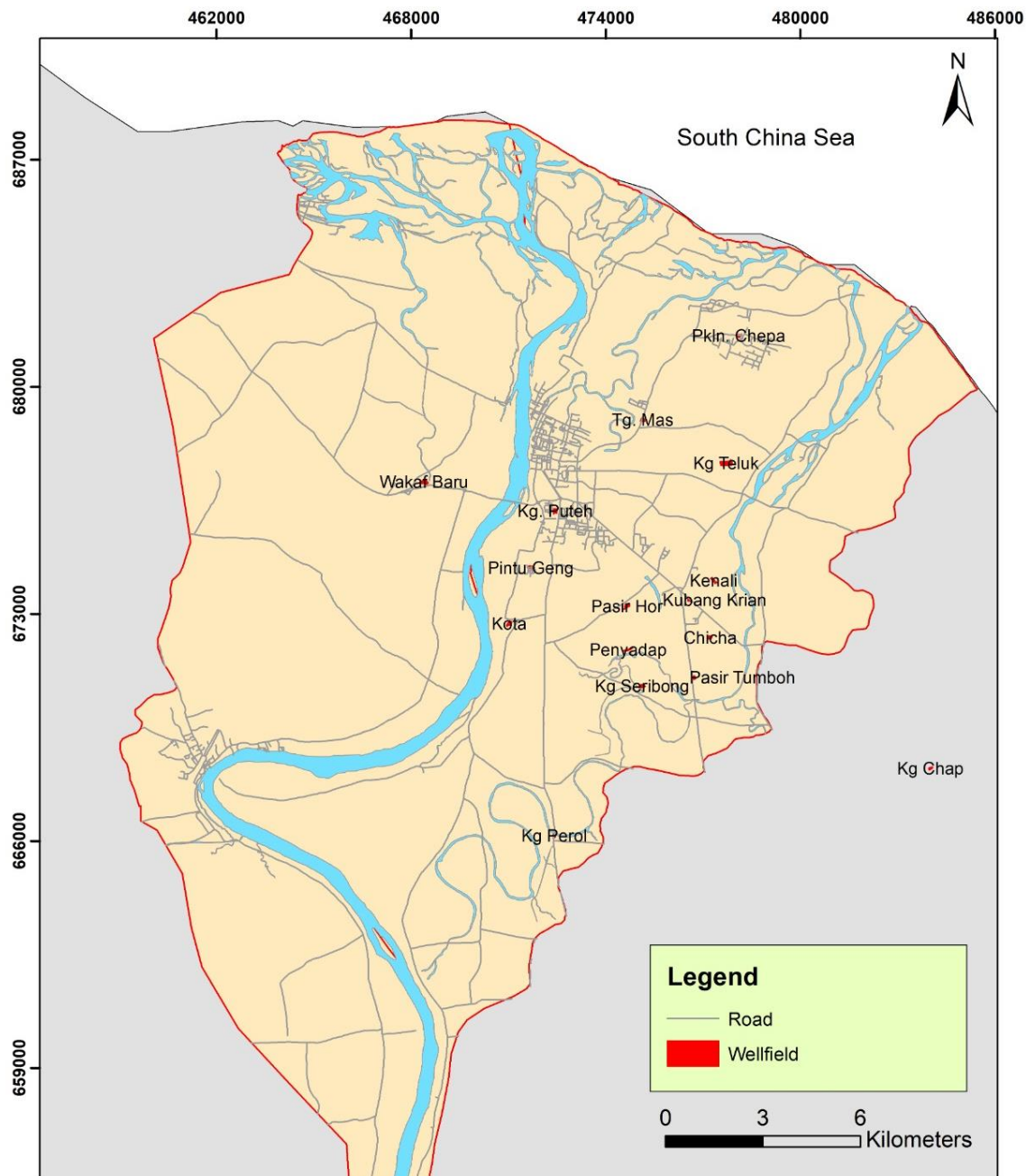
Study area



- located in the northern part of Kelantan and covers Kelantan river and Pengkalan Datu river basin
- river systems flow northeast direction before discharging to South China Sea

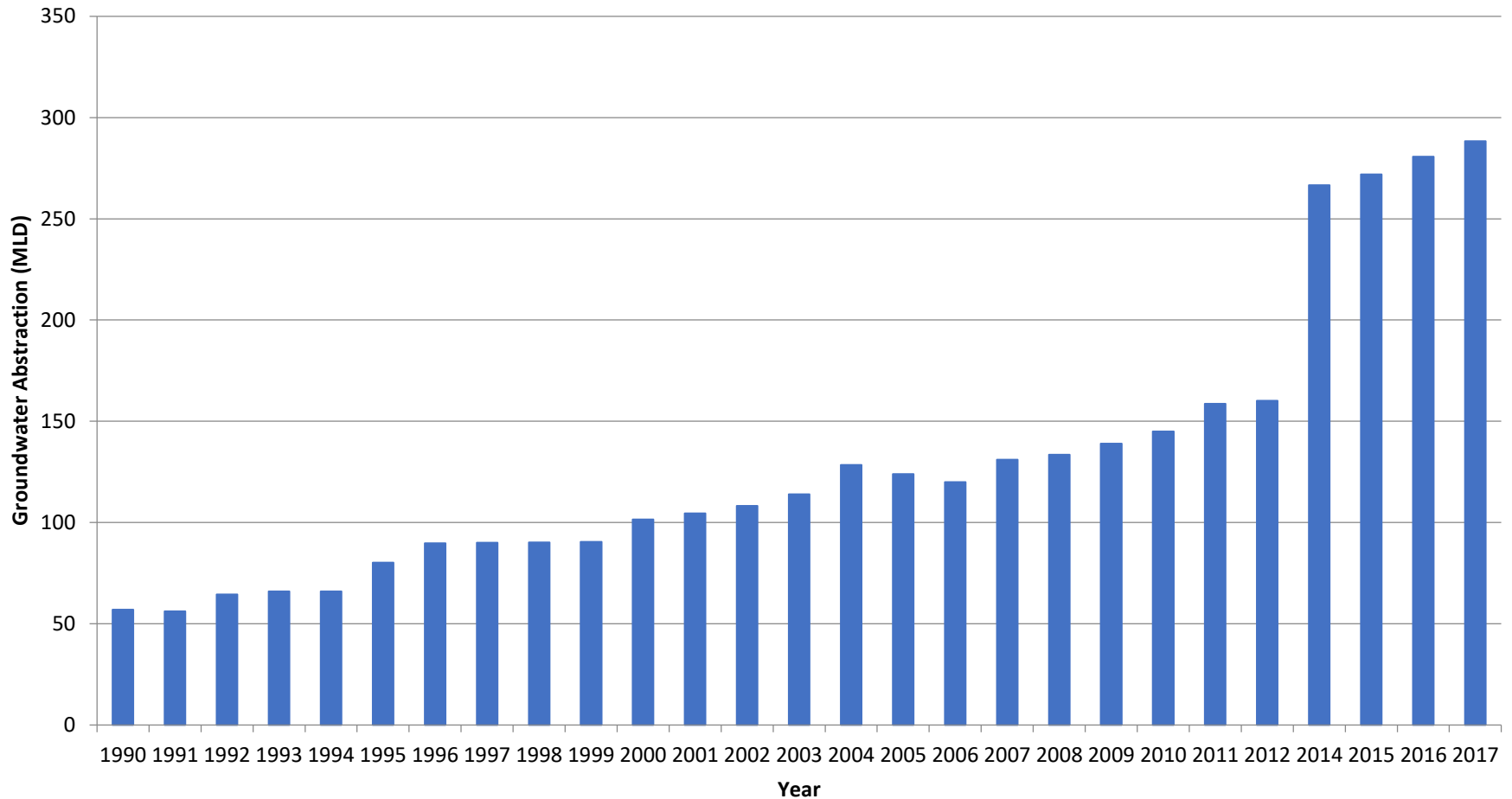






Groundwater Treatment Plant	Wellfield
Chicha	Pasir Hor
	Penyadap
	Seribong
	Pasir Tumboh
	Kubang Kerian
	Kenali
Kg. Puteh	Chicha
	Kg. Puteh
Pintu Geng	Kota
Tanjung Mas	Pintu Geng
Wakaf Bharu	Tanjung Mas
Perol	Wakaf Bharu
Kg Telok	Perol
	Kg Telok

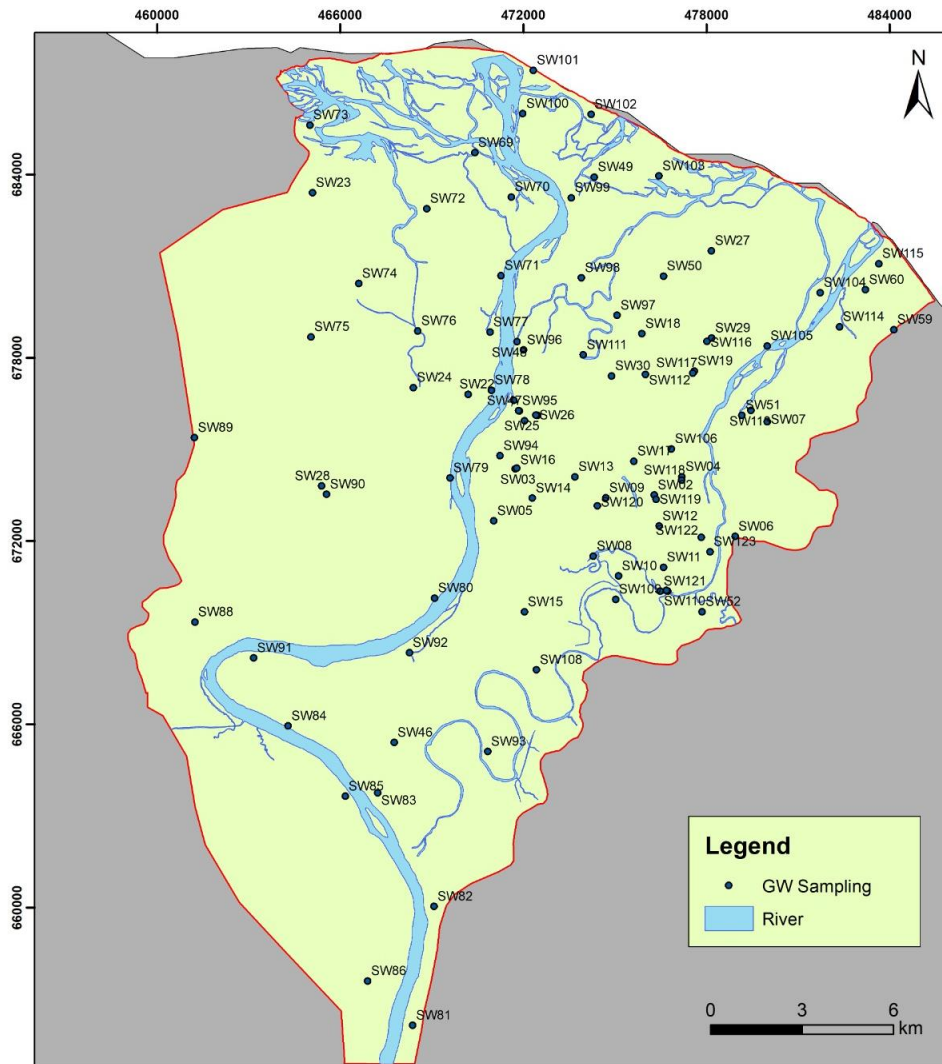
Total groundwater production from 1990-2017



Groundwater abstraction in 2012 (160 MLD) and 2017 (288 MLD)

Methodology

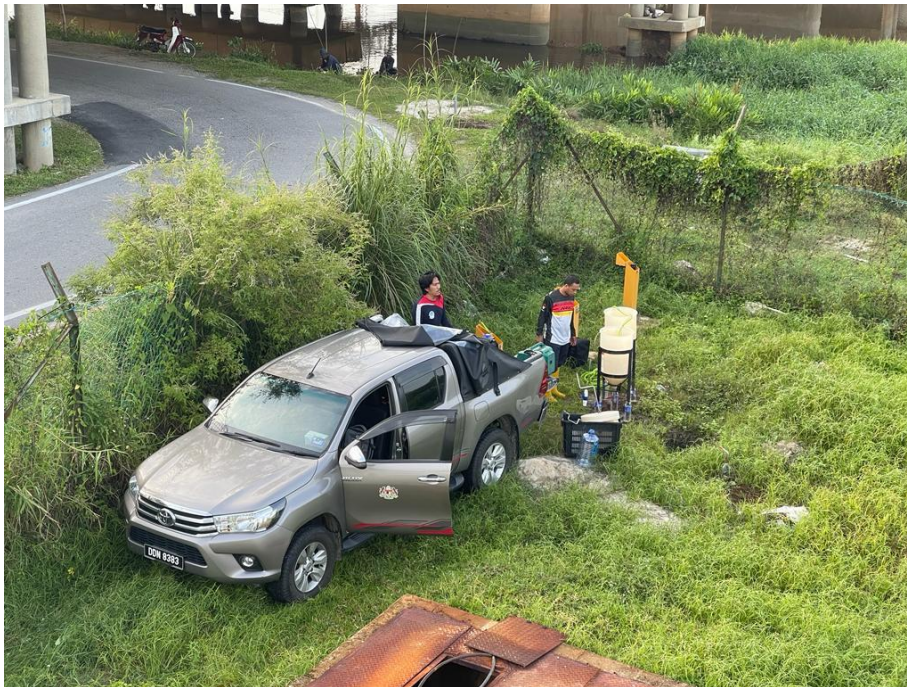
Groundwater Sampling and Analysis



- A total of 93 groundwater samples were collected
- pH, temperature, EC, and TDS measurement using the Aqua TROLL 600 multiparameter
- filtered through 0.45 μm and acidified with nitric acid (HNO_3)
- Major cations - Ca^{2+} , Mg^{2+} , Na^+ , K^+ , Fe^{2+} and Mn^{2+} were measured by ICP-MS; NexION[®] 300, PerkinElmer, USA).
- Major anions CO_3^{2-} , HCO_3^- , Cl^- , SO_4^{2-} and NO_3^- were measured by Ion Chromatography (IC; DX-500, Dionex, USA).
- Chemical analyses were performed at the Chemistry Department (Petaling Jaya)

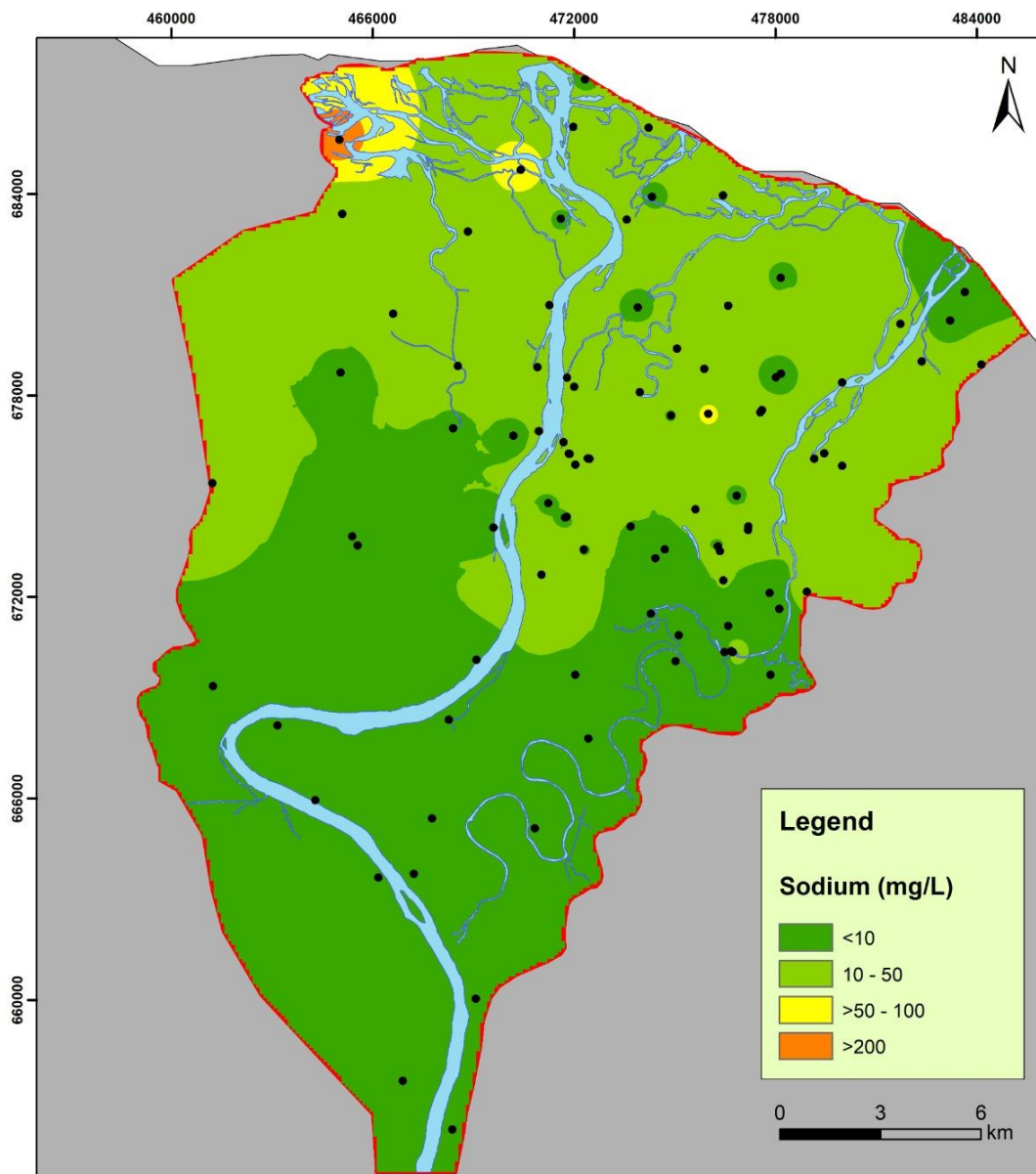


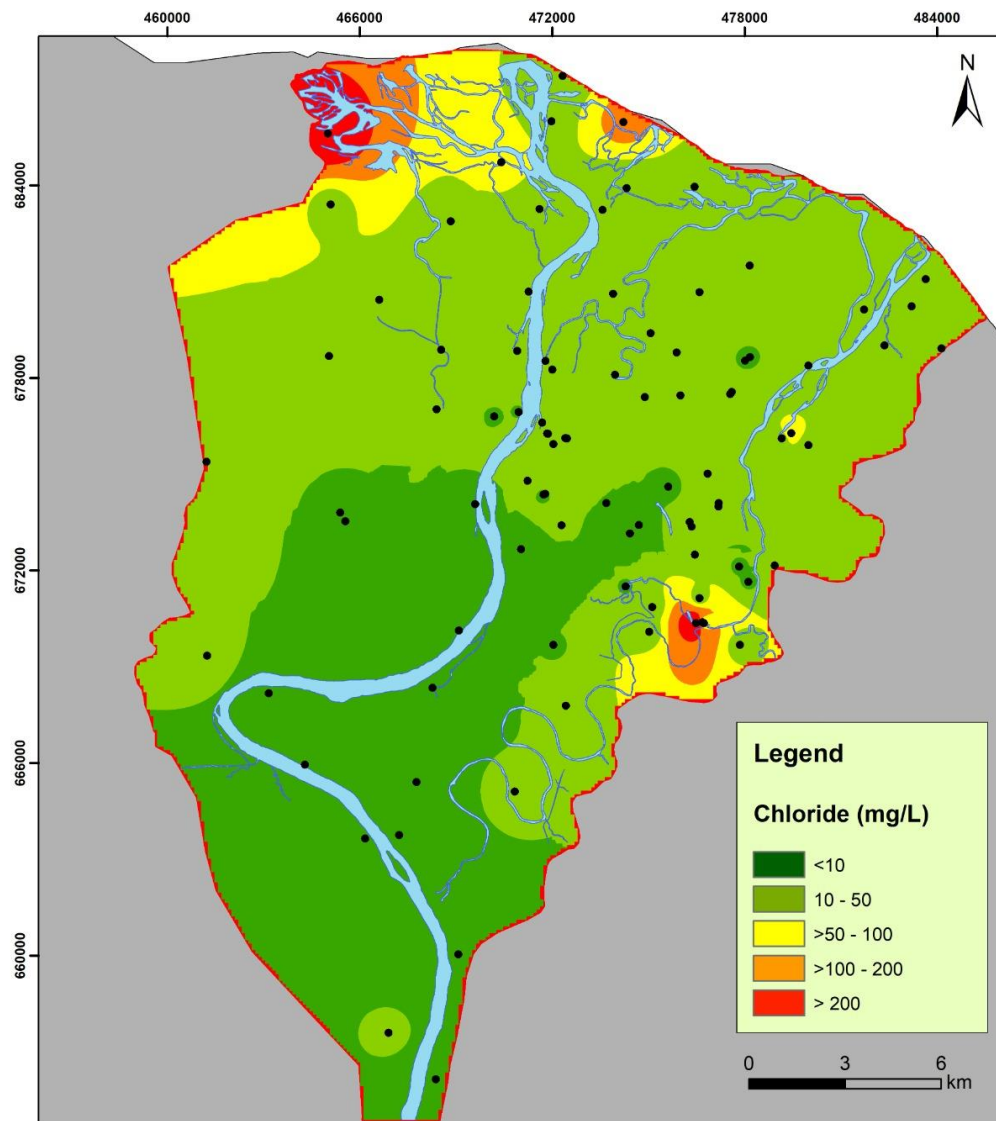
Groundwater sampling and data retrieval

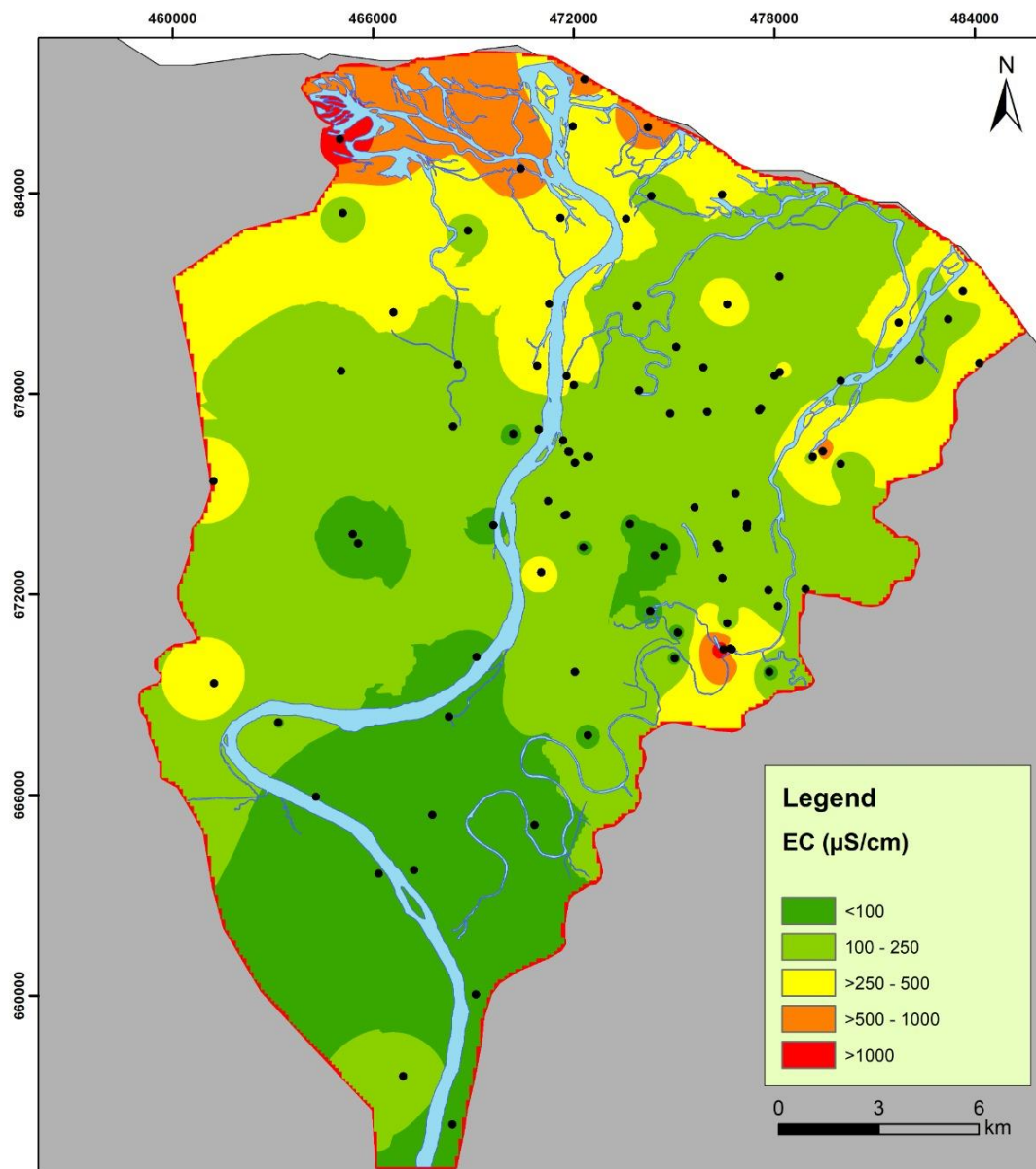


Groundwater sampling and data retrieval

Results and Discussion

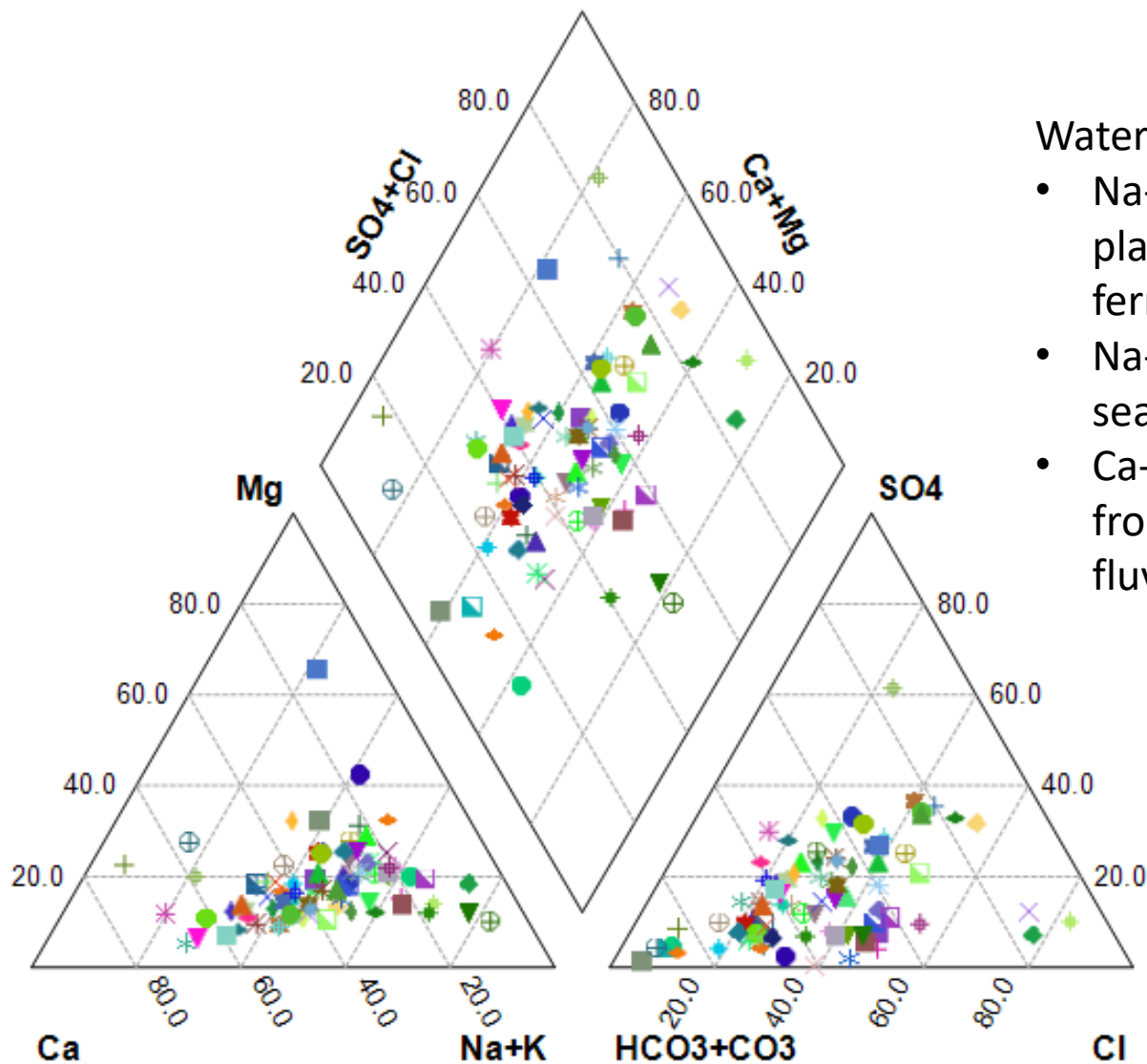






Class	EC ($\mu\text{S}/\text{cm}$)	Cl- (mg/L)
Fresh groundwater	<700	<2.8
Slightly saline groundwater	700-2,000	2.8-7.1
Moderately saline groundwater	2,000-10,000	7.1-14.1
Highly saline groundwater	10,000-25,000	14.1-28.2
Very highly saline groundwater	25,000-45,000	28.2-282.2
Seawater	>45,000	>282.2

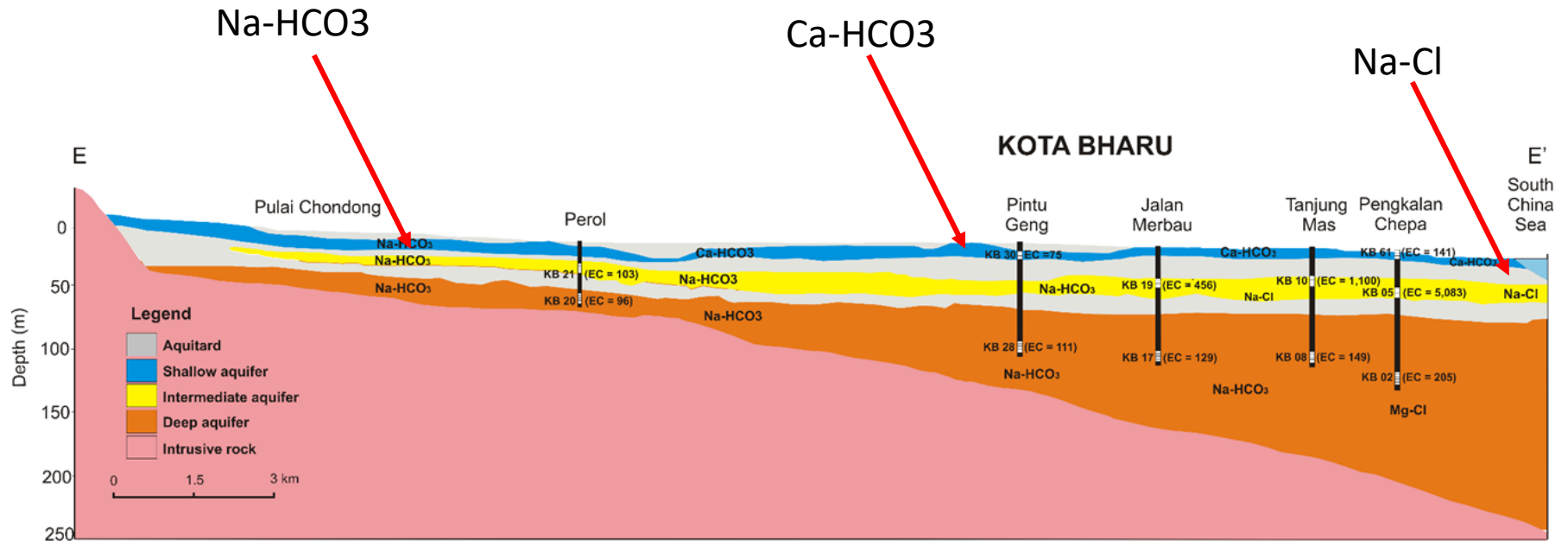
Adapted from Konikow and Reilly, 1999: Rhoades et al., 1992



Water type is dominated by:

- Na-HCO_3 ; weathering of plagioclase feldspar (schist and ferruginous shales)
- Na-Cl ; indicating the effect of seawater
- Ca-HCO_3 ; calcite dissolution from sea shell fragments of the fluvial-marine deposits

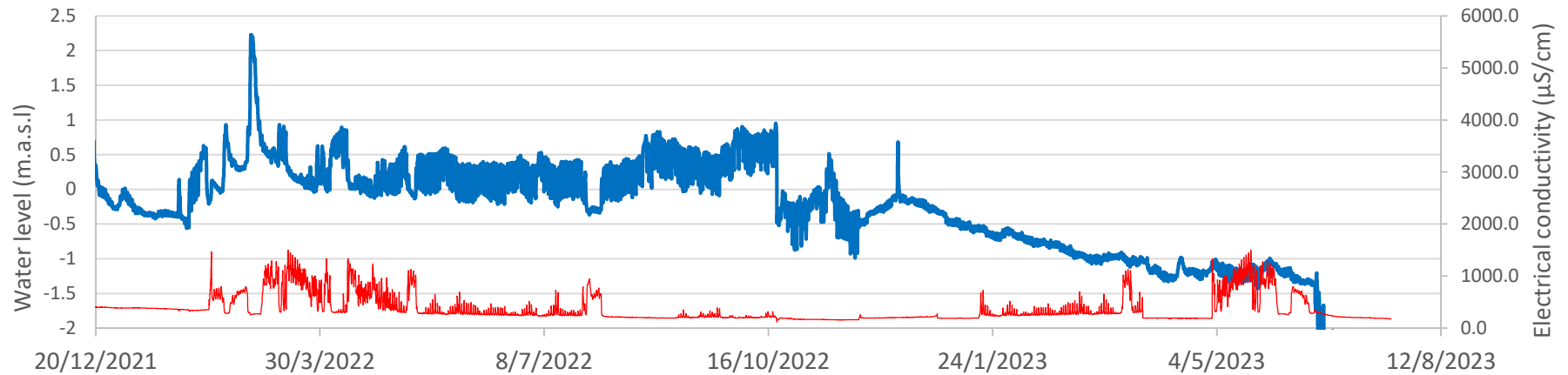
Water type is dominated by Na-HCO_3 , Na-Cl , Ca-HCO_3



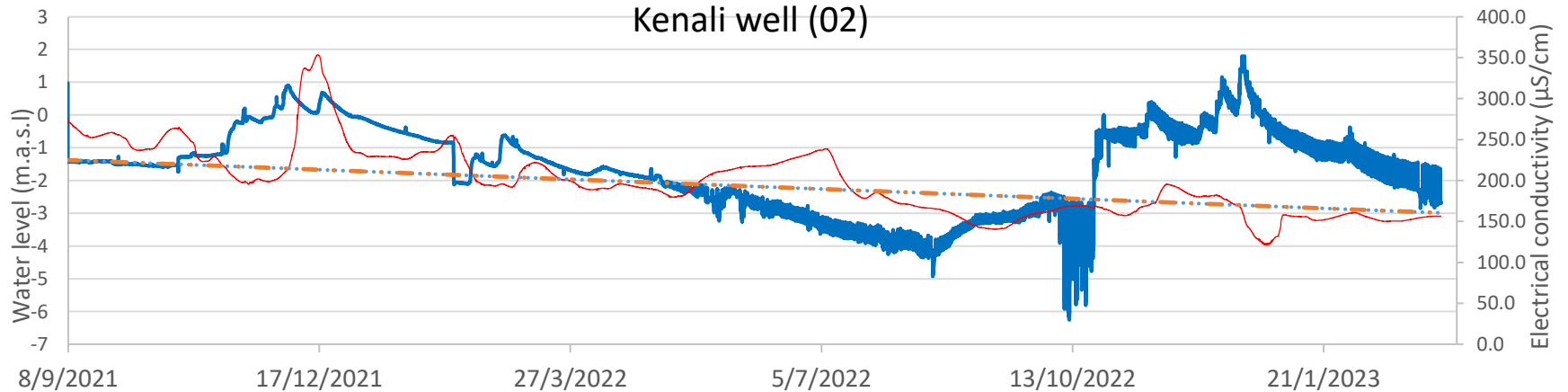
Hydrogeological profile in relation to EC and water types

Water level and EC fluctuation from selected monitoring wells at Pasir Tumboh, Kenali, Kg Telok, Pasir Hor

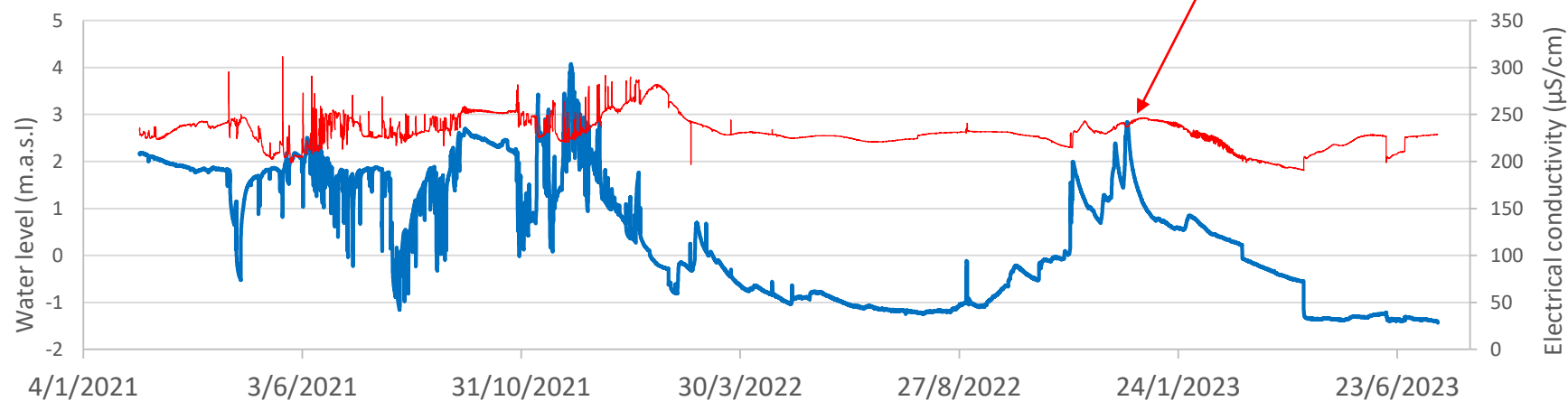
Pasir Tumboh well (01)



Kenali well (02)



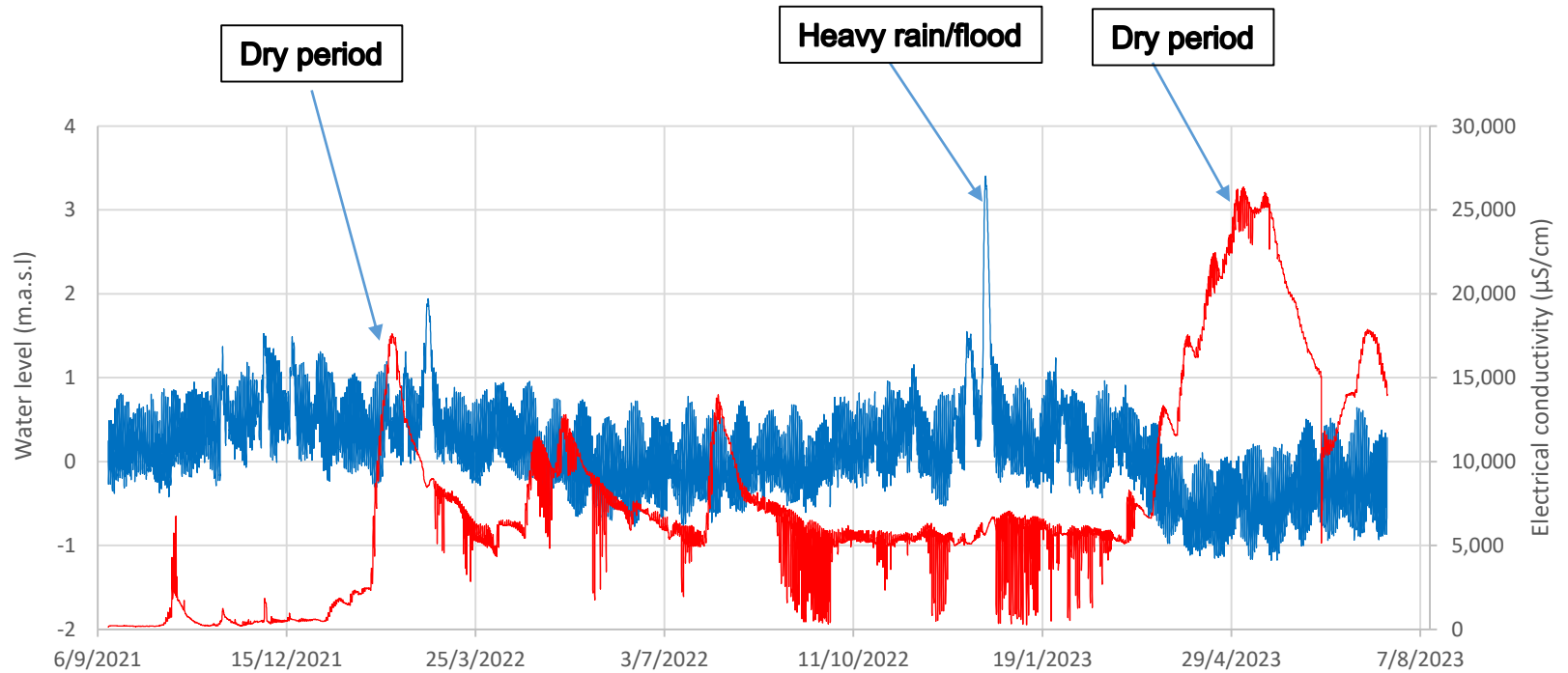
Kg Teluk (01-shallow)

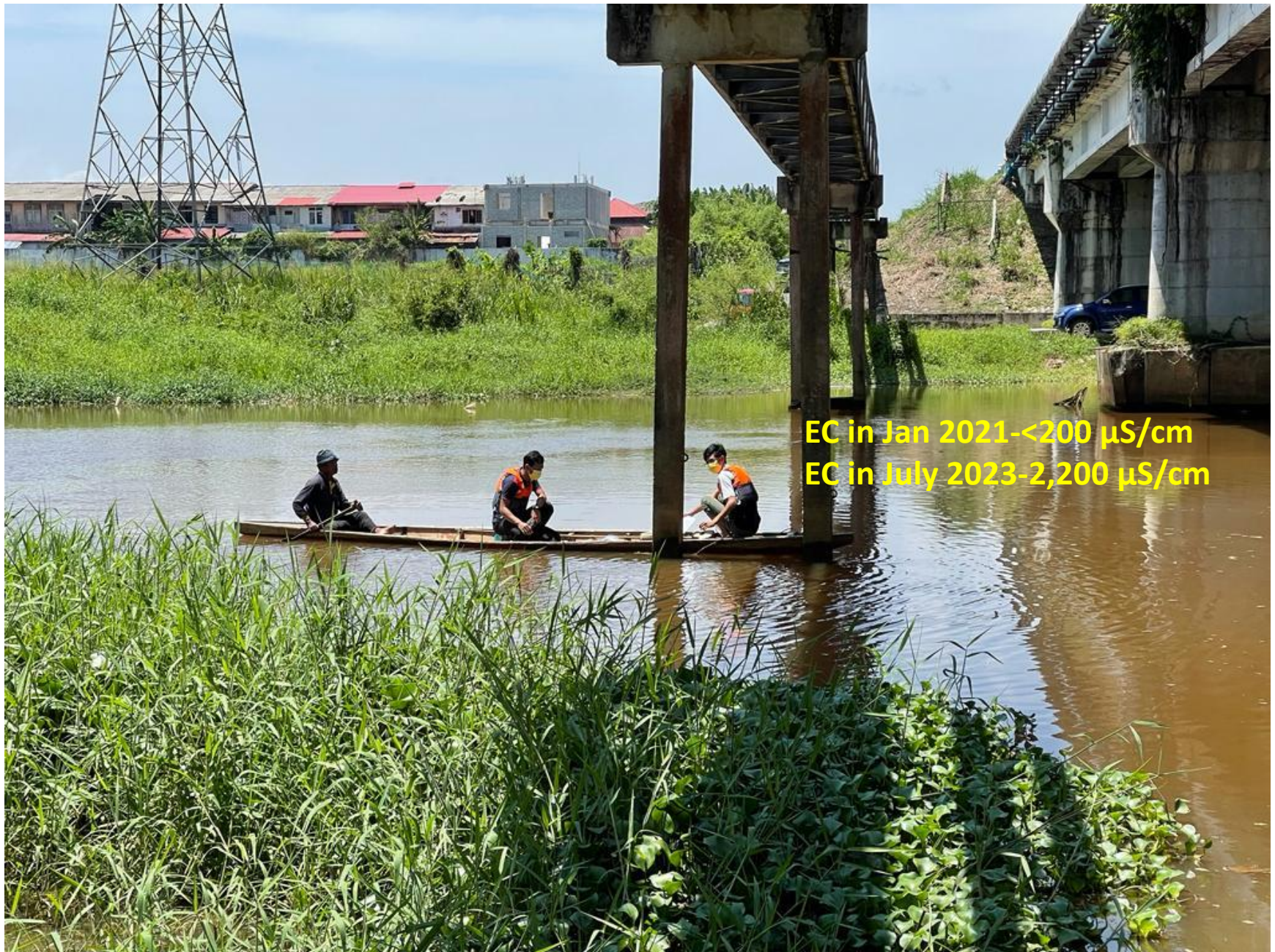


Pasir Hor (03-deep)



Pasir Tumboh Bridge (river)

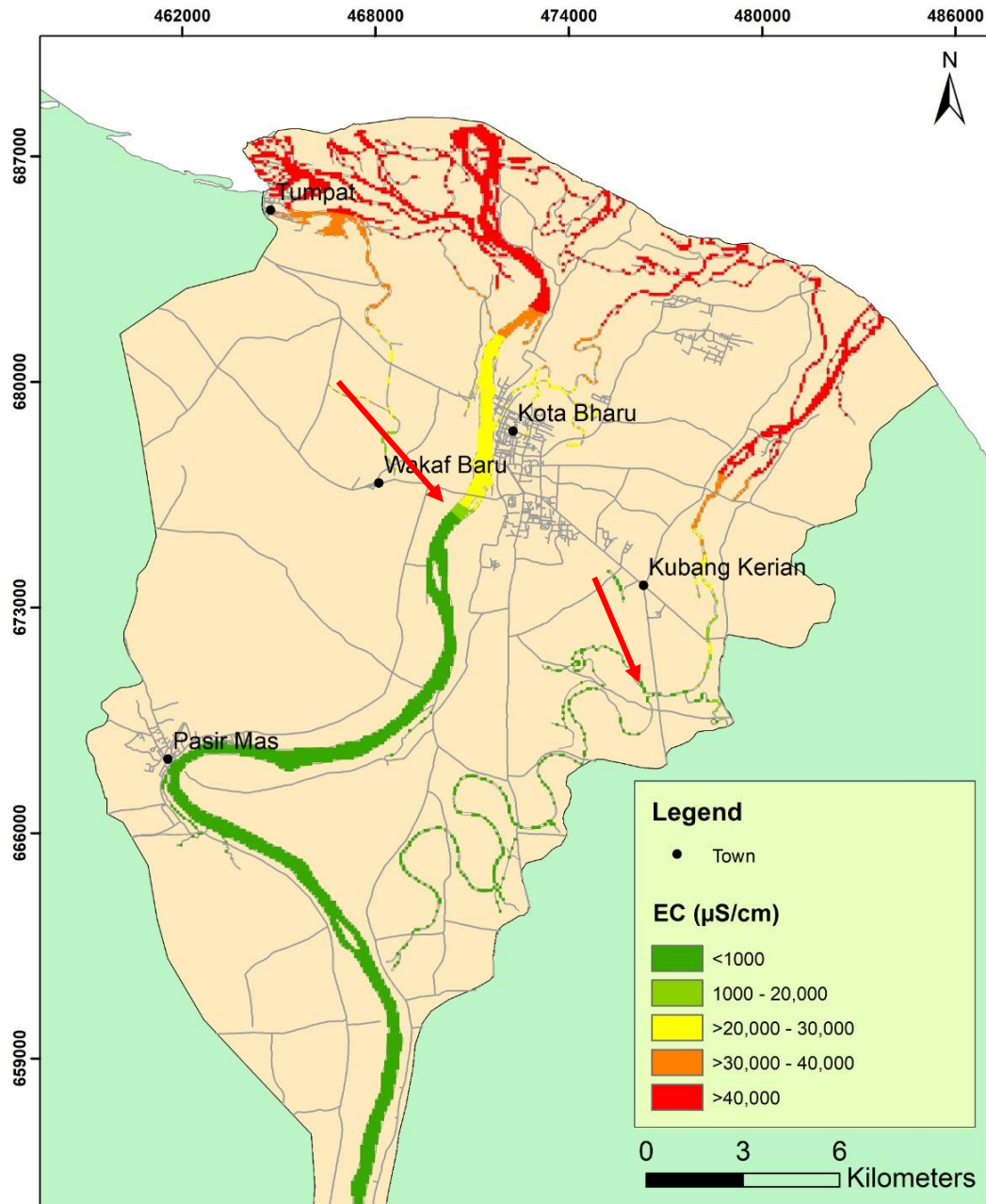




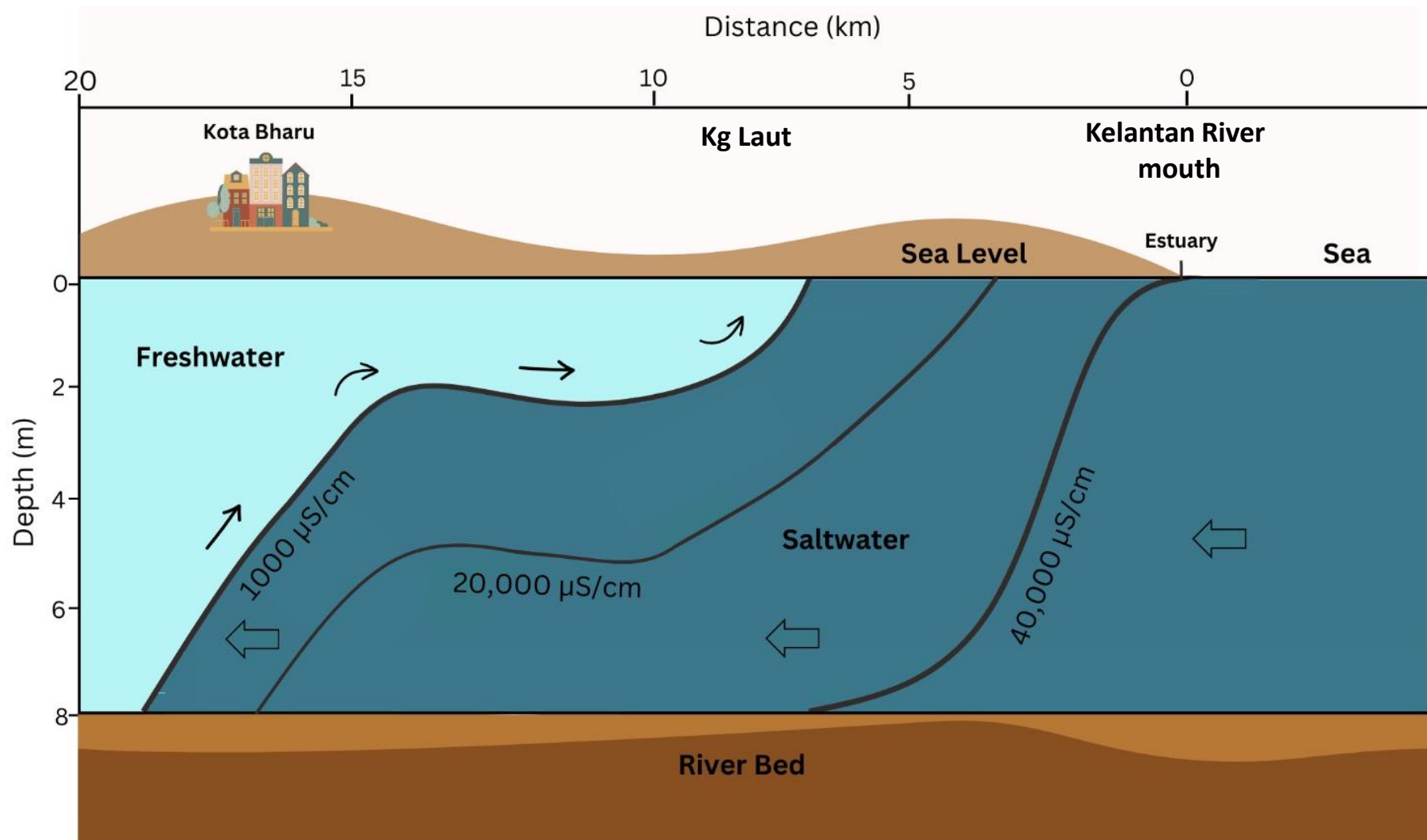
EC in Jan 2021-<200 $\mu\text{S}/\text{cm}$
EC in July 2023-2,200 $\mu\text{S}/\text{cm}$



Pengkalan Datu river (Pasar Hor)-20 km from coast



- For Kelantan River -15 km from river mouth
- Pengkalan Datu- 21 km from river mouth



Conclusion

- Saltwater intrusion extends up to 15 km in Kelantan river and 21 km in Pengkalan Datu River inland, with the intrusion interface reaching depths of 6-8 m (Sulta Yahya Petra bridge Kota Bharu)
- The main drivers of intrusion are low water level and river discharge especially Pengkalan Datu river as the source of water is from groundwater seepage and excess of irrigation water
- There is no significant increase in electrical conductivity in production wellfield for the intermediate and deep aquifers.
- However, the area located to the east of the Chicha water treatment plant is at risk of increasing salinity levels and lowering groundwater levels that could potentially affect individual tube wells.

Thank You