Potential for Salt Water Intrusion at the Secondary Containment Line on Foreshore Road

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August 29, 2006

1 Introduction

The Community Liason Committee (CLC) have requested a brief paper concerned with the potential for sea water intrusion along Foreshore Road. The task description is given as:

> The CLC asks that Ian Acworth provide a brief paper on the potential for salt water intrusion at the secondary containment line on Foreshore Road. The paper is to provide comment on how the containment line has been designed and operated to minimise salt water intrusion and is to include pictures or diagrams to explain how the system does that.

Water in the Botany Aquifer moves slowly through the aquifer to discharge at the coast. As a result of the di®erence in densities between sea water and groundwater, in a uniform sand, the sea water tends to move under the groundwater as shown in Fig. 1.

Where the height of the freshwater aquifer is greater than the ocean, then the interface tends to be pushed out to sea at shallow depths, but sea water can move inland at greater depths. This situation is complicated by the presence of tides, waves breaking on the beach and by regions of higher or lower hydraulic conductivity associated with clay beds or impermeable rock. In practice, the position of the interface between saline water and fresh groundwater is the subject of a delicate balance that can easily be modi¯ed. Heavy rainfall and recharge to the aquifer may cause the water in the aquifer to move seaward; spring tides or storms with excessive wave run up can cause seawater to move on top of the

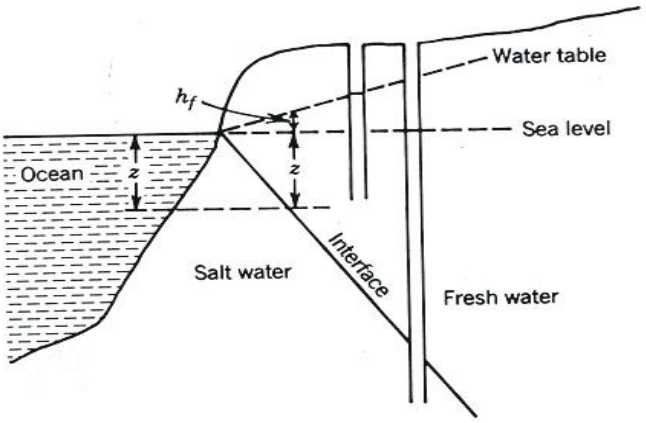

Figure 1: Shape of the interface between sea water and ground water for a stationary interface

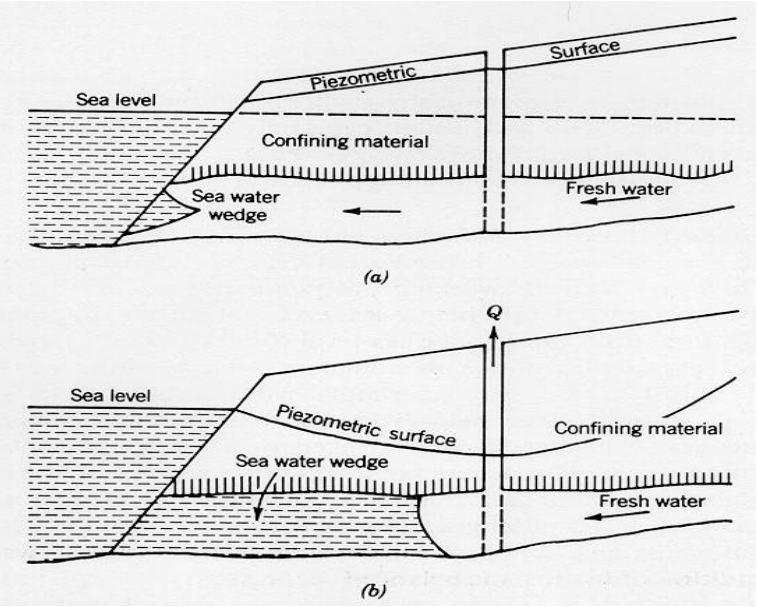

Figure 2: Sea water intrusion in a con¯ned layered aquifer system

discharging freshwater giving rise to complex mixing between the two. Fig. 2 shows the possible impact of fresh water abstraction with sea water moving inland in response to the reduction in hydraulic head of the fresh water.

The distance between the Foreshore Road abstraction wells and the coast is only a few tens of metres. The groundwater model prepared by Alan Laase indicates that there will be some movement of water from the coast to the containment line pumps for each of the modelling scenarios. The quantity varies between 0.016 ML/d and 0.034 ML/d. I would consider these results to be unreliable for two reasons:

- The model takes no account of the density di®erence between sea water and fresh water, and
- The model assumes that the hydraulic head of groundwater at the coast is 0 mAHD.

It is not possible to accurately predict movement of the interface between fresh water and sea water without taking account of these factors. It is acknowledged that the practice of ignoring the density di®erence and assuming a regional discharge at 0 mAHD are common. However, it has been shown that they lead to considerable inaccuracy in predictions close to the beach - for example, in the vicinity of the Foreshore Road containment bores.

The operator implicitly acknowledges the probable inaccuracy of the modelling by relying upon a more pragmatic approach. The main mechanism by which the operator seeks to prevent the contaminant plume from reaching the ocean, is to keep the hydraulic head at, or marginally below, 0.0 m AHD and to monitor the °uid electrical conductivity of the water removed from the abstraction bores. What is proposed is a delicate balancing procedure where just enough contaminated groundwater is abstracted to eliminate discharge to the beach, yet as little as possible sea water is drawn into the containment line bores. This balancing act is being carried out with no possibility of observing the impact between the containment line bores and the Botany Bay. The ¯rst that the operator will know that the saline interface has signi¯cantly moved will be an increase in °uid EC in the discharge water.

The inaccuracy in modelling caused by the incorrect ocean boundary level has caused the optimisation routines used in the groundwater model to predict high hydraulic conductivities in the beach zone. This has translated into greater actual drawdown in the aquifer (than that predicted by the model) as the actual hydraulic conductivity is probably lower than that modelled.

It can be seen that there are a number of complicating factors all compounded by the lack of observation well data between the abstraction bores and the coast. The solution is clearly to establish monitoring bores in this region and to undertake routine monitoring using geophysical logging in these bores. Geophysical logging using an induction technique will allow the movement of saline water to be easily detected. It is not necessary to carry out extensive geochemical sampling and analysis.

The presence of contaminated groundwater in the deeper aquifer closer to the coast was established in the Stage 2 investigation and geochemical sampling is part of the routine sampling program undertaken by Orica. These analyses have clearly indicated discharge of a number of chemicals into the intertidal zone on the beach. This monitoring should be continued to investigate the impact of the possible movement of the discharge zone as a result of pumping from the containment line bores.