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EXAMPLES OF THE INAPPLICABILITY OF THE RISING GROUNDWATER MODEL FOR DRYLAND SALINITY

The Rising Groundwater Model

The rising groundwater model derives from consideration of irrigation salinity early last century. The model was extended to dryland salinity with explanations concocted as to how such a coincidence could arise. As irrigation salinity is caused by increased accessions of water into the soil the explanation for dryland salinity was given as tree clearing reducing soil water use and thereby increasing accessions of water into groundwater systems. The groundwater is identified as mobilising salt in undefined stores and bringing it to the surface at low lying positions in the landscape. The identification of a link between tree clearing and dryland salinity is often ascribed to general observations made by the engineer W E Woods in a public presentation in Perth in 1923.

The rising groundwater model has been presented in various forms and not all are physically valid. Moreover, it is seldom clear whether the groundwater rises in the sense of moving vertically upwards or simply fails to drain away. A recent explanation of the development of dryland salinity is flexible in allowing for both. The Queensland NRM Salinity Facts Sheet (Fig. 1) has water moving vertically upwards but is physically unsound.

The salt stores that are said to be mobilised were originally identified as occurring somewhere below the soil but almost invariably from only under plains. The new variants that allow for lateral movement of water in soils axiomatically have the salt deriving from the soil. Such variants incorporate the usual failure to discriminate between soil water and groundwater. Groundwater is effectively identified as all water that can flow freely in the ground thus, as virtually all salt is transported in water flows, the pointless situation arises whereby dryland salinity arises through changes to groundwater flows by definition.

Some of the anomalies in the Queensland representation of the rising groundwater model

The following points are illustrative and are not exhaustive. Also, they apply to many representations of the model and are not restricted to the representation discussed. The general context for assessment is that any exception negates a hypothesis and hence negates a model as being general.

Infiltration inputs are only occurring on the hills containing trees

Dryland salinity is said to arise through tree clearing increasing the infiltration of water into the soil when in Fig. 1 the water said to be causing the adverse salinity apparently comes from forested areas. There is no water infiltrating downward on the plains despite the lack of woody vegetation and arrows indicating that water can flow vertically through the soil.

Water is flowing vertically upward on the plains

The pressure from water upslope can force water vertically upward at lower elevations (confined aquifers can operate similarly to a hydraulic jack) but for this to occur there must be a resistance or blockage to flow. There is no such blockage in the illustration hence the flow directions indicated for the plains defy physics.

The sequence of increasing resistance for water flow pathways to the plains is

- Surface runoff
- Lateral flow through the A soil horizon
- Potentially lateral flow through the B horizon
- Lateral flow through sub soil material

But in Fig. 1 the only lateral flow is in the underlying subsoil material. The pathway of least resistance for the groundwater flow identified in Fig. 1 would be directly into the stream line. However, the only flow to the stream in Fig. 1 is over the surface after the water has taken a tortuous path and defied gravity in getting there.

The representation in Fig. 1 is a corrupted version of a confined aquifer system where water permeating the hills pressurises an underground aquifer that lifts groundwater to the surface on the plains. The salt is said to derive from subsurface salt stores under the plains. Such systems are physically possible but an issue common with Fig. 1 remains, there is no consideration of the contribution to groundwater from the plains when the plains were the first to be cleared and for the water to be able to rise upwards it must also be able to move down.

The realised outcomes with confined and semi-confined aquifers depend on a number of factors but the net vertical flow of water of water on the plains would generally be down. Salt would therefore not be bought to the surface by 'rising' groundwater. However, in many systems the underlying groundwater system is not connected to the soil hence it cannot increase soil salinity through an upward flow of water.

The occurrence of a piezometric head on a plain above the level of the soil surface has been used to justify the application of the rising groundwater model when it often identifies its inapplicability. This situation identifies that the soil is either not connected or is poorly connected with the underlying groundwater system. Locally soils can function independently of any underlying groundwater systems.

The involvement of groundwater systems was promoted by geologists to justify their obtaining funds to address dryland salinity. However, the model is poorly understood and has been variously interpreted. In particular, rising groundwater has been used to describe the situation

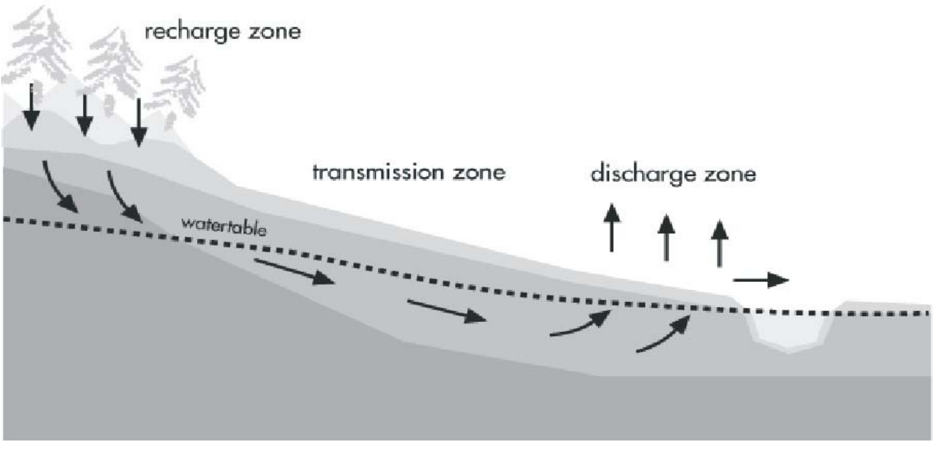


Fig. 1 Schematic model of dryland salinity taken from a Queensland NRM Salinity Facts Sheet

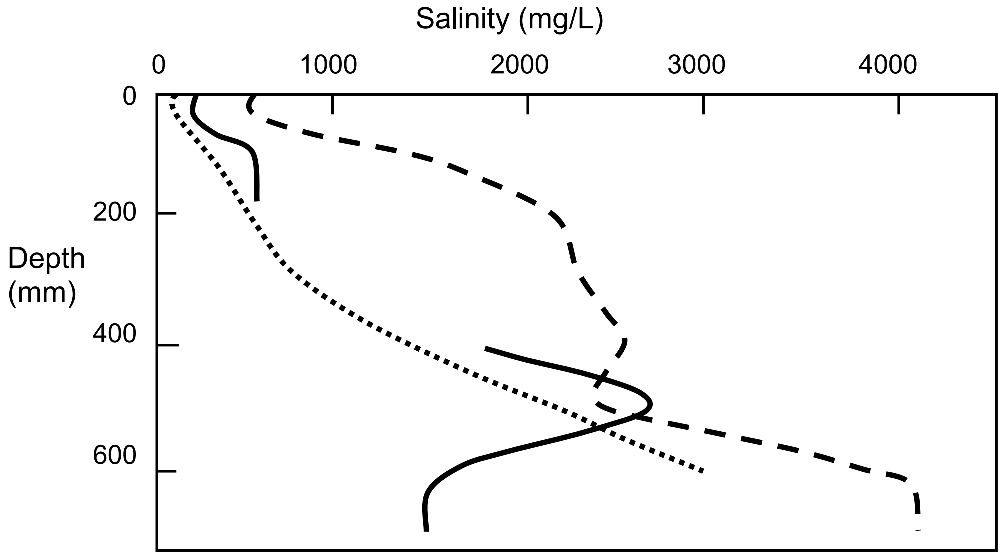
where water fails to drain. The mechanisms for salt transport differ dramatically between water flowing vertically upwards and simply failing to drain.

With a confined aquifer the salt can be rapidly bought to the surface in a flow of water hence adverse impacts are rapid. The entire soil profile initially becomes uniformly wet and salty and then salt accumulates at the surface. Its occurrence is obvious. With failure to drain the salt initially moves upwards through diffusion which is slow and is readily counteracted by infiltration of water into the soil flushing salt downwards. When the water is sufficiently close to the surface it can be drawn upwards through evaporation of water from the soil surface but there is considerable impact from waterlogging before salinity becomes an issue. These different forms of development of salinity can be discriminated by observations of the development of soil salinity profiles.

The most common situation is where water flows laterally through the soil and accumulates on the flats. It is associated with an increased lateral flow of water through the soil and a decrease in infiltration of water into groundwater systems. The salt derives from the soil rather than subsurface salt stores. The hazardous levels of salt arise through concentration by evaporation. While dryland salinity can develop in situ, which does not require the lateral movement of water or salt, most expressions of dryland salinity arise through surficial lateral drainage.

Fig. 2 illustrates the insitu development of dryland salinity whereby salt moves vertically depending on the local surficial hydrology. The woodland profile exhibits the typical pattern for natural woodland vegetation of leached surface soil, accumulation in the B horizon, and leaching of the C horizon. It follows the classic description of the development of a soil profile. The normal farmland shows pronounced accumulation of salt. The Eco-plow (equivalent to the Wallace plough) increases the infiltration of water but maintains the soil profile. This has produced leaching of the surface soil compared to the normal farmland. The increasing salinity at depth indicates that an equilibrium has yet to develop.

Fig. 2 Soil salinity profiles for adjacent sites in natural woodland (———), 'normal' farmed land (– – – –) and land cultivated with an Eco-plow (…………).



The results in Fig. 2 are for the Tragowel Plain in central northern Victoria. The marked differences in salinity profiles for sites in close proximity and the decrease in soil salinity with increase in infiltration are contrary to all representations of the rising groundwater model.

This note focuses on deficiencies in the rising groundwater model and is not directed at identifying how dryland salinity arises[1]. However, it appears that land use has likely increased surface runoff and decreased percolation into groundwater systems. This accords with observations such as changes to seasonal patterns of water flows in rivers but is contrary to the suggestion that dryland salinity arises through increased groundwater accessions.

Queensland Salinity Hazard Mapping

To obtain Australian Government funds for salinity Queensland was obliged to map salinity hazard according to the official rising groundwater model. The mapping achieved its prime purpose as Queensland obtained the funds.

The maps below are for two regions in the Queensland part of the Murray Darling Basin extracted from the hazard map produced using the model SHAM (Salinity Hazard Mapping). The acronym likely reflects what the developers of the model think of the approach. The Talwood example (Fig. 2) identifies areas of high and moderate salinity hazard in a region with no groundwater system within 100m of the surface. Piezometers installed by Dr Joe Walker and Dr Baden Williams (CSIRO Water Resources) in the early 1990s never contained water but the result was not published. This result would be expected from observations of water use and soils made there in the mid 1970s and the only bore in the vicinity being over 300m deep. There is salt redistribution in the landscape through lateral flow in the A horizon during prolonged wet periods (seepage) but no water table as needed for the groundwater flow system used in SHAM to be applicable.

The Meandarra example (Fig. 3) identifies high salinity hazard in gilgaied brigalow country that, similarly to Talwood, does not have a water table or any effective water percolation below the rooting depth. However, the brigalow system additionally has NO surface or sub-surface lateral flow of water over distances greater than around 10m due to the gilgais. The subsoils do contain high levels of salt but the rising groundwater model invokes groundwater flow systems and cannot be rationally applied to this system.

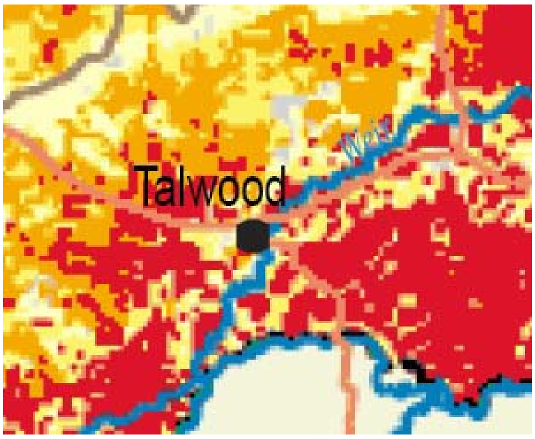


Fig 2. Queensland salinity hazard map around Talwood

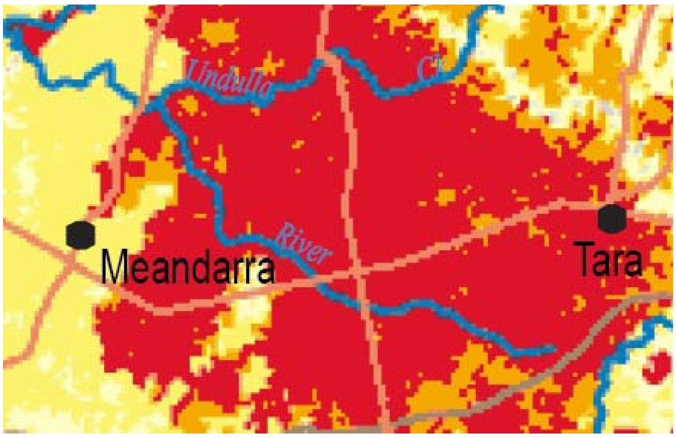


Fig 3. Queensland salinity hazard map between Tara and Meandarra.

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[1] Addressed in Scenario for Dryland Salinity and What Model for Dryland Salinity on www.eric.com.au

The imperative for the mapping illustrated in Figs. 2 and 3 arose from the National Land and Water Resources Audit (NLWRA) identifying that Queensland lacked appropriate salinity hazard maps. Given the lack of reference salinity mapping the NLWRA projection of the expected salinity outcomes for Queensland for the year 2050 (Fig. 4) is irrational.

The two salinity maps in Fig. 4 were produced using the same basic precepts as to how dryland salinity occurs, namely groundwater flows in landscapes (groundwater flow systems). While there are also commonalities in the reference data the results have few commonalities. Some of the differences are obvious, as with the Queensland mapping having appreciable salinity in the western areas when none is identified in the NLWRA map. This situation also arises in the encircled area A where the Queensland map identifies high salinity hazard over most of the area when there is little in the NLWRA map.

Some commonality exists in area B as both maps identify appreciable hazard, but the patterns differ markedly. However, in area C the Queensland map has no salinity hazard, a condition that has low occurrence, whereas the NLWRA map identifies appreciable hazard similar to area B. Despite the suggested consensus on the rising groundwater model, and its official status, there are marked differences in the 'understanding' of what it means that are associated with irrational applications.

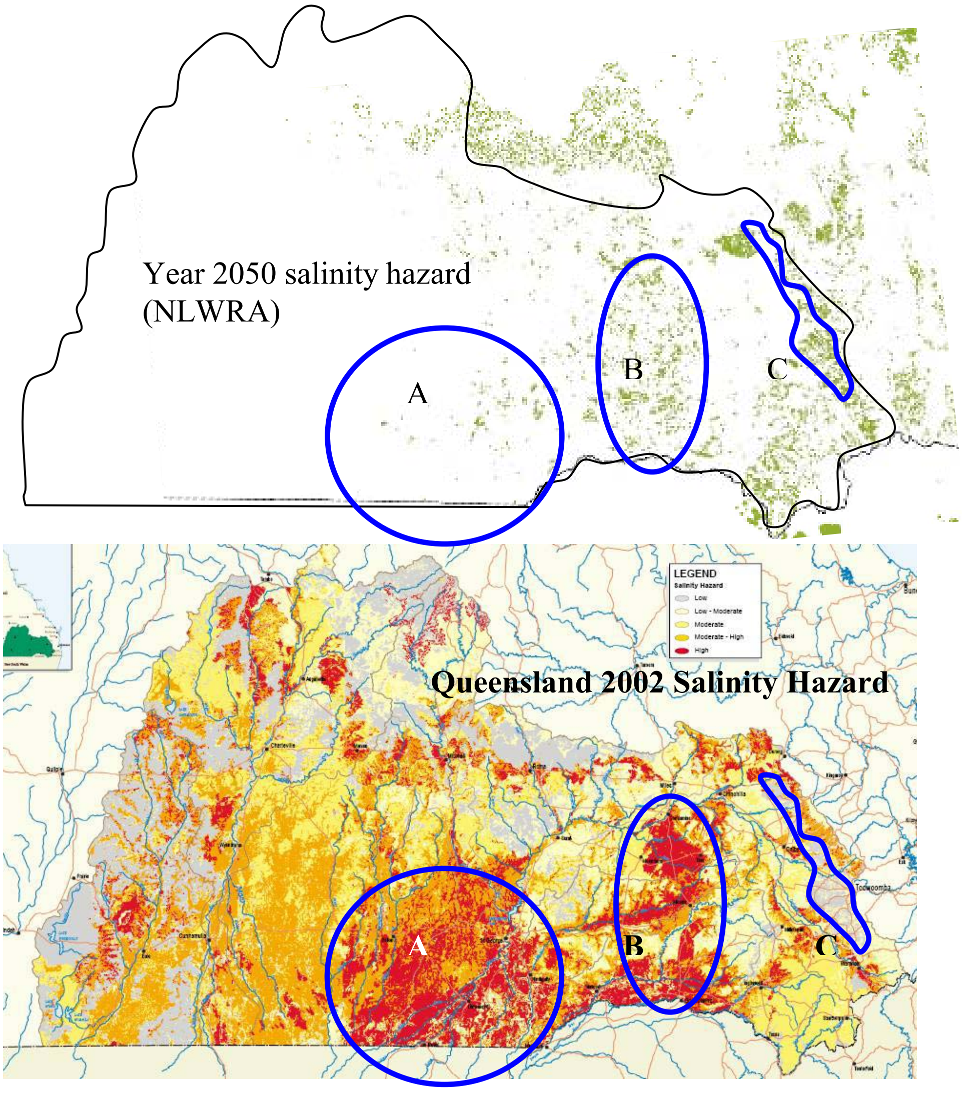

Fig. 4. Salinity risk/hazard predicted in the National Land and Water Resources Audit (NLWRA) for the Queensland part of the Murray Darling Basin in 2000 and the salinity hazard mapping produced by Queensland in 2002.