

## **10. HYDROGEOLOGY**

### **10.1 INTRODUCTION**

Hydrogeology is the movement of water beneath the ground surface through fractured and permeable rocks, in unconsolidated alluviums and through the soil profile. Some knowledge of hydrogeology is necessary, as hydrogeology is the driving process behind dryland salinity, as well as groundwater availability. Groundwater systems are closely linked to surface water, so the quality of groundwater and any accumulation of salts or chemicals within it can have a dramatic impact on surface water quality. (The basis of the calculations used in the recent MDBC Dryland Salinity Audit has been the contribution of salts from the groundwater system into the rivers and streams of the Murray Darling River system.)

#### **10.1.1 "Shallow water tables" and "Deep aquifers"**

All bodies of water beneath the surface are technically referred to as "aquifers". They are either "unconfined" (not under pressure) or "confined" (under pressure from surrounding material). Figure 11 illustrates the difference in the two types of subsurface water bodies.

##### **10.1.1.1 Water table**

Water table is the term commonly applied to the level of the shallowest "free lying" body of water in the soil (i.e. saturated zone of soil). It is unconfined – i.e. not under pressure - but is "held up" in the soil due to upward pressure from a deep aquifer, or prevented from draining out of the soil profile due to an impermeable layer of soil or rock.

Rainfall also affects the level of the water table. In periods of high rainfall, low evaporation or limited plant growth, most of the rain is not utilized, so it drains below the root zone, either into the rocks to recharge the deep aquifers, or into the saturated zone i.e. the shallow water table. Conversely, during droughts, the water table may fall substantially, as plants extract all available soil moisture.

The shallow water table can be monitored with small piezometers, such as those installed for landcare groups. These readings can be very useful as a warning to land managers that a change in land management is needed.

##### **10.1.1.2 Deep aquifers**

Deep aquifers can be found in the following geological formations:

Unconsolidated alluvial aquifers are found along old or present day creeks and rivers or in the underlying geology. Alluvial aquifers are found along the Macquarie River and in the lower reaches of Little River itself. Because they are under pressure i.e overlain by an impervious material, the standing water level (SWL) - termed the potentiometric surface - may be much higher than the actual water body and may rise to quite near the surface. The SWL is NOT the same as the water table. (See Figure 11.) Alluvial aquifers often have very high porosity, particularly if they are in coarse gravels, and may store up to 30% of their volume with water. They can yield 20-80 l/ second of water, making them very suitable for irrigation supplies. There can be a number of deep aquifers within one location i.e. able to tap water from more than one aquifer with a single bore, which may or may not be connected. The aquifers can be very large and continuous or small, sometimes "shoestring" gravel formations.

Consolidated aquifers have primary porosity i.e. hold water in the grains, and are usually sandstones or siltstones. The Jurassic sandstones north of Dubbo are consolidated aquifers, and are part of the Great Artesian Basin (GAB). The GAB is artesian water i.e. the pressure head moves the water to above ground level without pumping.

Fractured rock aquifers have secondary permeability i.e. water is held in and moves along fractures in the rocks. More than one aquifer may be able to be accessed with a single bore, and these may or may not be connected, depending on the pressure head of each aquifer and the geological formations. However, fractured rock aquifers have very low storage capacity and yield at most 5 litre/sec, but more commonly <1 litre/sec.

The whole of the Lachlan Fold Belt is comprised of fractured rocks and numerous small stock and domestic bores are located within these rock formations. The aquifers in the limestone formations tend to have a larger water holding capacity as fracturing is very significant, and consequently they are sometimes used for irrigation.

### **10.1.2 Groundwater Flow**

Faulting is an extremely important process in ground water movement. Faults are found at all scales, from very large regional scale to minor ‘splays’, which branch off larger faults in various directions and may be repeated frequently across the landscape. Faulting and folding is at macro and micro scales and all the scales may be repeated. Whole zones of faulting occur, and may include regional linear faults, which can transfer water over very large distances in the landscape, e.g. the limestone formations in the Lachlan Fold Belt.

Fractures can be dilational i.e. opening up and allowing water to flow through or they can be compressional, which means very little or no water can flow through them, and water may accumulate. Fractured rocks allow flow in one direction i.e. anisotropic. This is the case in the granite rocks of the Yeoval Batholith.

Fractures in outcropping rocks, exposed to the rain, allow water to permeate below the ground surface at differential rates, causing differential weathering. The watertable and depth of soil can vary markedly due to these differences in decomposition of parent materials.

Nested deep piezometers, which tap into the individual aquifers, are needed in various parts of the subcatchments, (not only discharge areas) to obtain information on groundwater flows and pressures, and the extent of the supply. While existing production bores can provide some useful information, they may be yielding water from more than one aquifer, so their chemistry, yield and pressure are a reflection of all the aquifers and may give meaningless or misleading information. Continued monitoring is essential to understand what is happening with recharge and whether watertables are rising.

Discharge causes waterlogging and if the ground water contains salts or mobilizes salts in the soil, then salinisation occurs as the salts are concentrated at the surface through evaporation and chemical reactions. Rising water tables do not cause dryland salinity in every catchment - it is dependent on the geological structures and landscape processes as to whether groundwater is forced upwards until it ultimately discharges. Even then, the chemistry of the soils, rocks and groundwater will govern whether deposition of toxic salts will lead to salinisation.

Figure 12 shows the landscape processes of recharge and discharge in a local groundwater system. Figures 13a-h illustrate some of the possible soil and geological barriers that can increase either the potentiometric head or shallow water table, resulting in discharge at the surface. Locations where these processes are probably occurring in Little River are cited.

Figure 11. Shallow watertables and deep aquifers

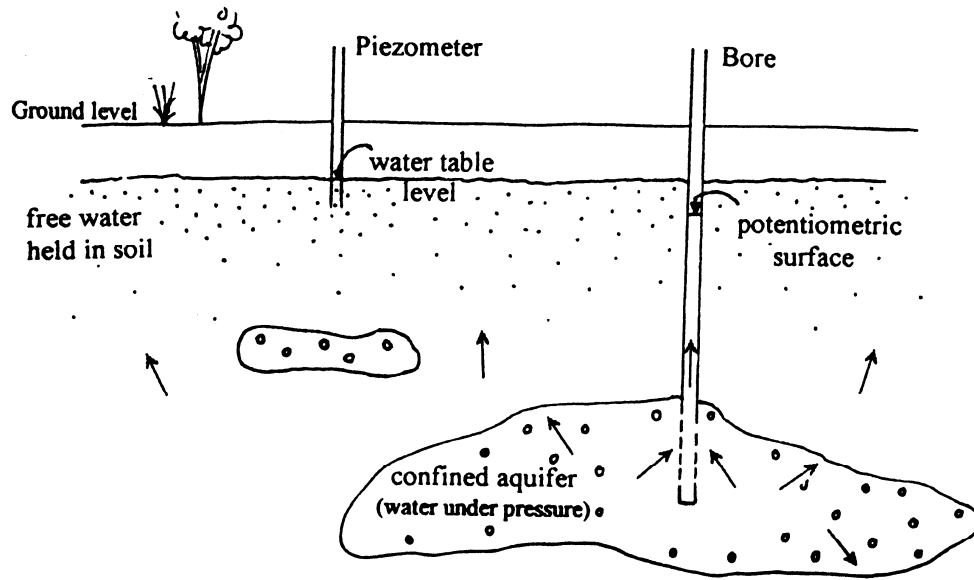
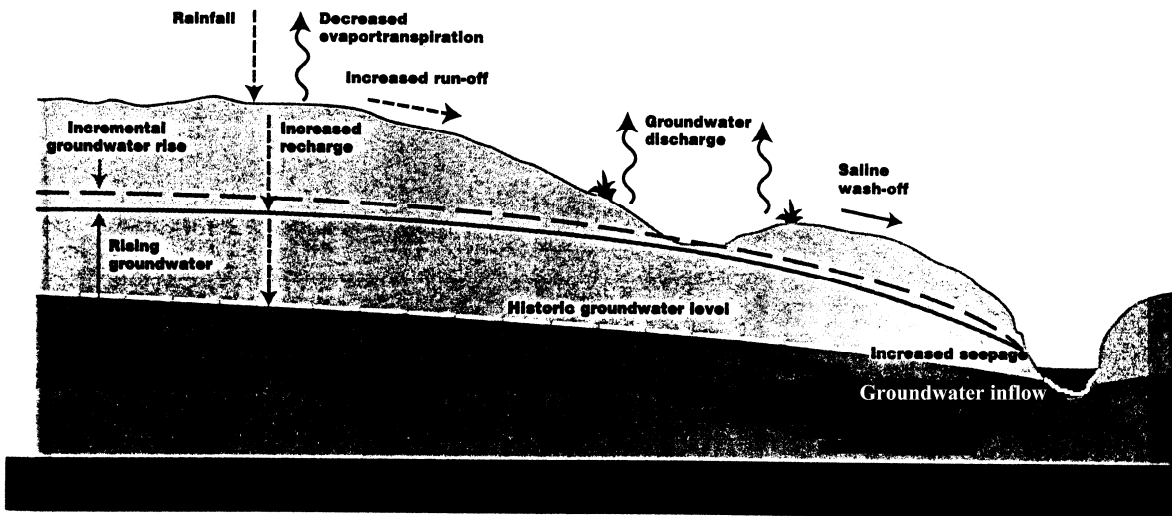
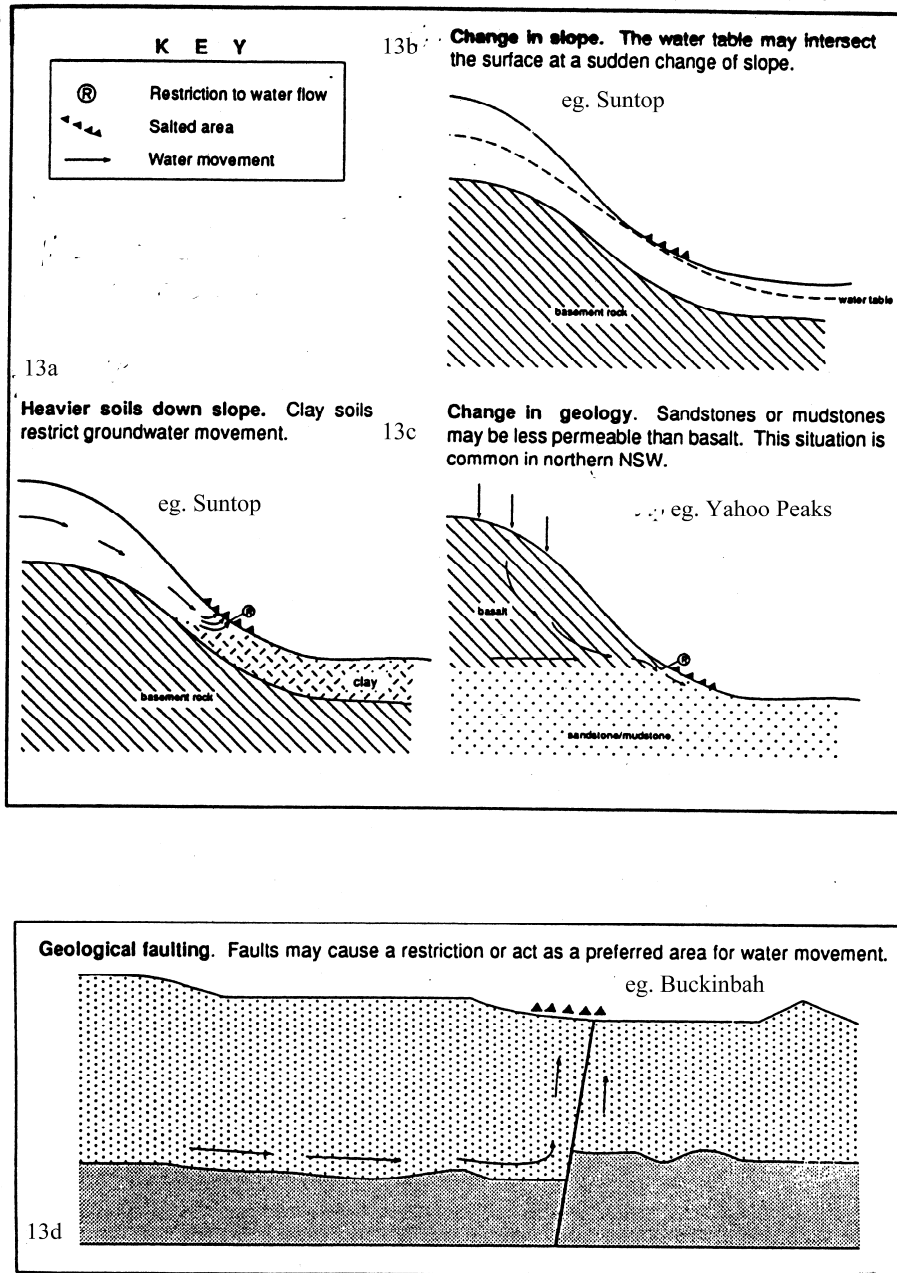


Figure 12. Groundwater system driving salinisation



**Figures 13a-d: Geological constrictions that can cause groundwater to rise**

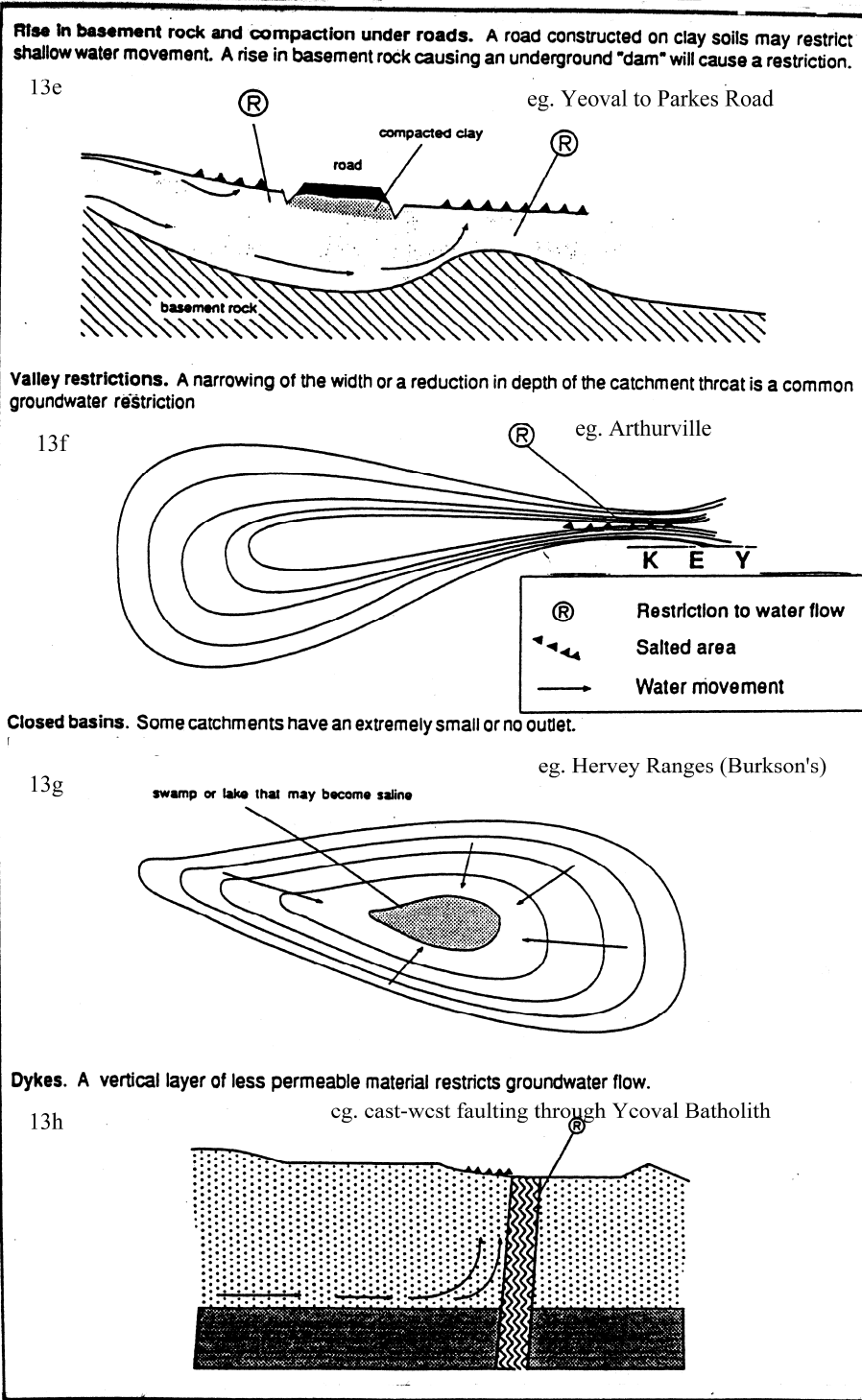
Figures 13a-d: Geological constrictions that can cause groundwater to rise



(After Anderson, Britten & Francis, 1993)

**Figures 13e-h): Geological constrictions that can cause groundwater to rise (cont.)**

Figures 13e-h: Geological constrictions that can cause groundwater to rise (cont.)



(After Anderson, Britten & Francis, 1993)

## **10.2 HYDROGEOLOGY IN THE LITTLE RIVER**

There have been no detailed regional hydrogeology studies completed for this area. The only mapping with full coverage is the 1:1 000 000 hydrogeology map completed by the Australian Geological Survey Organization (AGSO), which has not been accessed for this report.

Some small scale studies have been undertaken through the HASLAM (Hydrogeological Assessment for Salinity Landscapes Management) project that provide some insight into the processes driving ground water movement in the catchment. The findings for Suntop (2) and Upper Buckinbah (50) are provided in Appendix 6. Other studies have been undertaken at Yahoo Peaks and Arthurville.

### **10.2.1 Recharge processes**

The sedimentary formations in the catchment have been extensively folding and layered, and many of these are exposed vertically at the surface. This provides an easy path for water to enter the ground and pass into the fractured rock through the permeable layers between the deposited beds. Ridge tops with gravelly, coarse sands or shallow soils (with high infiltration rates and permeability) underlain by pervious lithologies are also potentially high groundwater recharge areas. Recharge also occurs through streams, particularly in areas where there are coarse textured alluvials on the creek flats, or the streambed or banks consist of highly permeable materials.

Recharge is exacerbated when rainfall exceeds evaporation. Although this is not the case on average in any month at either Wellington or Molong (see Section 4 – Climate, Figure 3a and b), this situation probably occurs in the upper reaches of the catchment in winters with above average rainfall. Here, temperatures are cooler, resulting in lower evaporation. In addition, crop and pasture growth is negligible during the winter months, so very little water is being used, allowing deep drainage to occur.

Numerous dams have been constructed in the upper catchment areas. While there has been little comment on their role in recharge, consideration should be given to their location relative to coarse intake beds or fractured rock outcrops, and the potential of dams to recharge the groundwater system.

### **10.2.2 Discharge processes**

In the Suntop area, Callen (2) concludes that it is likely that the scenario shown in Figure 13a represents the actual situation. Heavy clay soils act as an aquitard (layer of low or negligible permeability) and force the groundwater upward in the lower lying areas where clay subsoils are present. These often coincide with the break of slope between the hillside and footslope. Clay subsoils are considered to be a primary process in salinisation in this district.

Permeability contrasts between different rock types e.g. granites to sandstone can cause a change in groundwater flows. (See Figure 13 b.) This can also be described as changes in lithology with inherent contrasts in hydraulic conductivity.

Dykes (which are generally impermeable because they have been hardened by metamorphism), may result in rising groundwater as they present a barrier to lateral flow. Kazemi suggests this process may occur in the Upper Buckinbah Catchment.

Faults and major lineaments on both a regional (deep aquifers) and local (shallow aquifers) scale can act as conduits for focussing water flow and hence may allow water rises to occur upwards through such faults. This may be the case in the Baldry Catchment on the granites, where the faults run at right angles to the natural drainage pattern. This can also trap water behind the structures, increasing the potentiometric pressure.

Discharge of saline groundwater onto the soil surface causes concentration of salts.. These are flushed from the surface in rainfall events and end up in the surface water. Where the groundwater is not forced to the surface, it continues along its flow path until it discharges into a stream. This process can add significant salt loads directly to the surface water if the groundwater has come in contact with a lot of minerals along its flow path, and is carrying high concentrations of ions. All groundwater carries some dissolved salts.

### 10.2.3 Sources of Salt

There are four different sources of salt. These are:

- Connate salt – salt trapped in sedimentary deposits laid down in marine conditions. However, the salts are flushed out over time, so very old marine sediments eg Mesozoic formations may not have much salt left. However, if these rocks were inundated by more recent marine incursions, additional salt would have been added to these rocks. Rocks vary in their salt content with some formations storing up to 5% sodium chloride. (See also Section 5 - Geology.)
- Physical and chemical weathering of rocks - the movement of groundwater through rock formations can dissolve salts through weathering processes, increasing the concentration of salt in the groundwater.
- Aeolian deposits – salt is picked up from the ocean by wind and blown from inland Australia
- Recycling of Salt through -
  - Mobilizing through water table movements
  - Irrigation
  - Human influences e.g. application of chemicals and fertilizers

Additional information on the source of salts is provided in Section 14 – Dryland Salinity.

As no detailed investigation has been completed on the regional groundwater system, and very little work has been done yet on analysis of bore data over time, it is risky to draw conclusions about the processes that are occurring within the catchment. The two localised studies available tend to suggest that salinisation in these locations is occurring as a result of local groundwater systems, even though regional systems occur in the area. These studies have both been on the edge of the Molong High in old highly faulted sediments.

**References:**

- (2) T. Callen (1995) *The Hydrogeology of a Dryland Salinity Affected Catchment and Recommendations for Site Specific Remediation - Suntop, Wellington.*
- (50) G.A. Kazemi (1999) *Groundwater Factors in the Management of Dryland Salinity and Stream Salinity in the Upper Macquarie Valley, New South Wales, Australia*
- (51) J. Chivers (1994) *Investigation of Suspected Groundwater Inflows to the Macquarie River in the Guerie - Suntop area between Wellington and Dubbo.*
- (74) L. Abel (1996) *Upper Breeza Landcare Catchment Plan*