Burkes Flat - A Salinity Treatment Success Story

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Introduction

A 900 hectare catchment at Burkes Flat, near St. Arnaud, (Figure 1) was chosen for investigation and treatment of salinity in the rolling sedimentary rises country of Central Victoria. Salinity was first recognised as a problem at Burkes Flat in the 1930s. Aerial photographs confirm the development of severe salinity at breaks of slope and within drainage lines between 1947 and 1963. By the mid 1980s, the salt affected areas occupied 12% of the catchment, causing substantial losses to farm production and exporting 700 tonnes of salt to the Avoca River each year (CLPR, 1993).

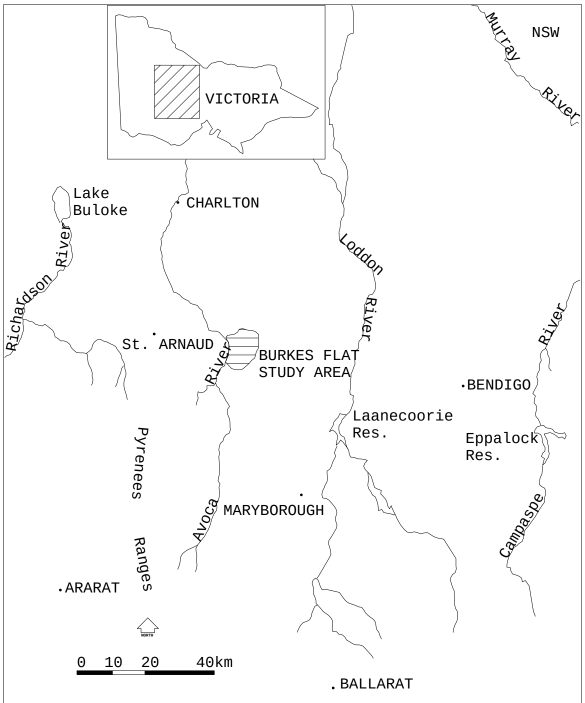


FIGURE 1. LOCALITY PLAN

The Burkes Flat Group Conservation Area was declared in November, 1968. In early 1983, a pilot project in this area was funded by the National Soil Conservation Program for investigation, treatment and monitoring of dryland salinity. With the support and assistance of the four landholders in the selected project area (J.Gallacher, B.Scollary, B.Rinaldi and W.Rodger) and other members of the local community, a catchment treatment plan was developed. Investigations carried out by Day (1985), including recharge mapping, provided the hydrogeological framework upon which the treatment plan was based and assisted greatly in targetting the treatment. The plan covered the whole catchment, its aim being to establish a farming system which would increase the uptake of annual rainfall, thereby lowering, or at least stabilizing, groundwater levels (CLPR, 1993).

Between 1983 and 1986, native trees were planted on the mapped high recharge areas and lucerne and phalaris-based perennial pastures were established on the low to moderate recharge country between the tree plantations and the discharge area. The discharge area was fenced off and planted to salt tolerant grasses, primarily tall wheat grass. By August, 1986, 90% of the catchment had been treated. Financial assistance was provided for tree and pasture seed with labour provided by each of the four participating landholders.

Twenty-six (26) observation bores have been established within and adjacent to the catchment (Figure 2) and monitored consistently at monthly intervals. By 1992, the watertable monitoring results were quite clear for most of the catchment. Watertables had dropped by between 1 and 4m in the middle to upper parts of the catchment and by up to 1m in the lower parts. In the discharge areas, the effect was not so apparent with watertables remaining stable, allowing for seasonal variability (Day et al, 1993).

This paper presents updated information and interpretation on groundwater trends and effects of salinity treatment at Burkes Flat. It describes and demonstrates the considerable benefits achieved through well managed perennial pastures and trees. These benefits include reductions in groundwater discharge with resultant improvement in the condition of the discharge areas.

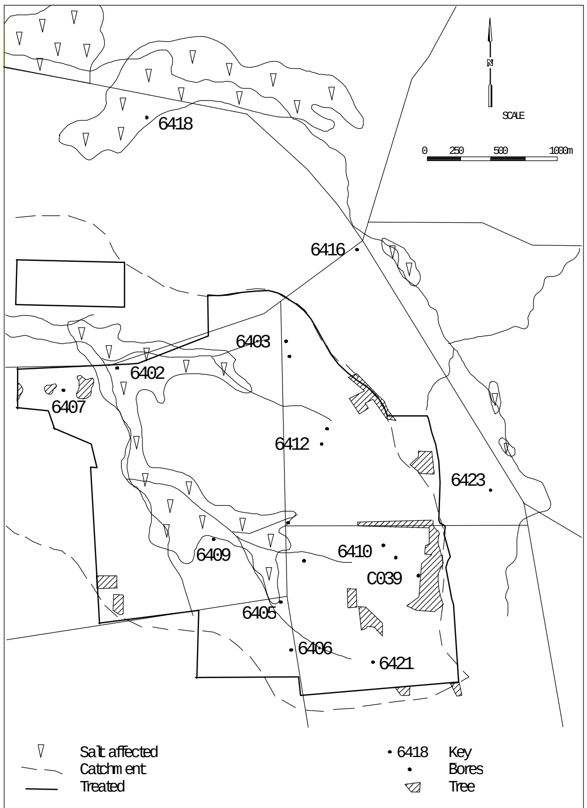


FIGURE 2. PILOT CATCHMENT & BORE LOCATION

Hydrogeology

The geology at Burkes Flat primarily comprises thinly bedded Ordovician (450 million years old) sandstones, siltstones and mudstones which form a landscape of rolling hills with slopes up to 15% (Day, 1985; CLPR, 1993 and Day et al, 1993). Weathered to depths of up to 70m, these rocks hold naturally high salt storages. Soils are typically shallow with rock outcrop common along the eastern and southern catchment divides. Average annual rainfall is approximately 450mm.

Groundwater flow at Burkes Flat occurs within a network of connected fractures in the Ordovician bedrock. The low permeability of the weathered bedrock zone has given rise to relatively steep hydraulic gradients between the catchment divide and discharge areas. Day (1985), and Day and Dyson (1990) have shown that the groundwater flow system controlling the occurrence of salinity in the pilot catchment is localised and confined within the catchment boundary. The ramification of local flow conditions is that the recharge areas exist immediately adjacent to the discharge zones and complete treatment can be more easily devised and managed than for larger scale flow systems.

The work by Day (1985) also revealed that high recharge areas exist along the eastern and southern rims of the catchment on rocky ridges. Middle and lower slopes, with their deeper duplex soils, were mapped as moderate to low recharge.

Groundwater salinities in the weathered bedrock are typically high (>10,000mg/L TDS; CLPR,1993) and show a tendency to increase down the flow path. Values range from as low as about 300mg/L TDS in the upper parts of the catchment to as high as about 15000mg/L TDS in the salted areas (Day, 1985).

Groundwater Trends

Based on regional data, Day and Ryan (1992) estimated that the watertable in the Burkes Flat pilot catchment would have risen by an average of 10cm per year if it was untreated. This would broadly translate to an increase in salt affected land of about 1 or 2% per year.

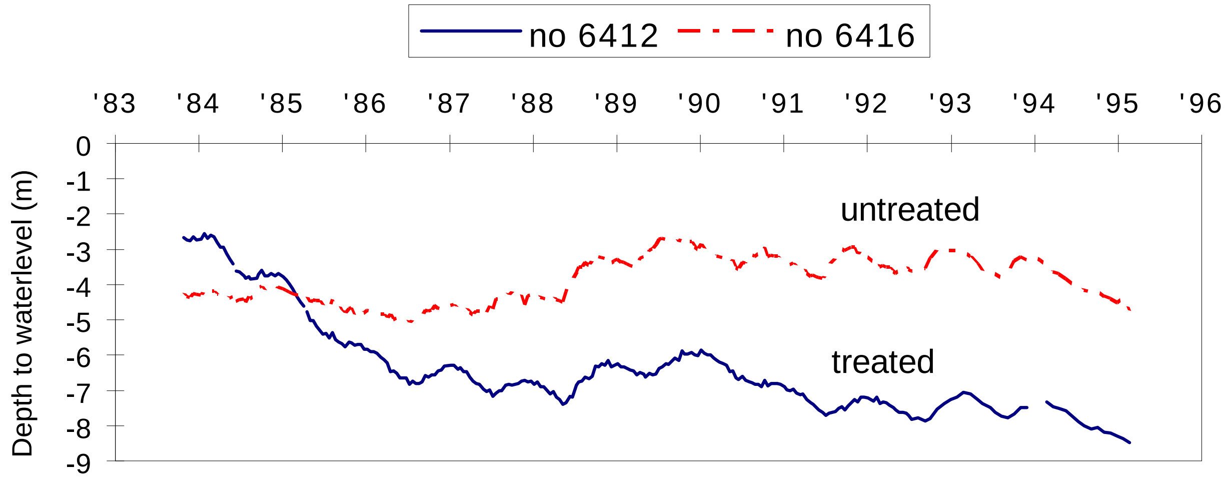
Monthly measurement of groundwater levels at the pilot catchment commenced in 1983, the year that treatment commenced. In the middle to upper parts of the catchment, substantial drops in levels of up to 4m were recorded as early as 1987, with the most significant decline occurring during 1985 and 1986. Despite wet years in 1988, 1989 and 1992, a general downward trend has continued in these areas (e.g, Bore 6412, Figure 3). Recorded total drops since 1983 are now up to 6m.

The actual impact of the treatment becomes more apparent when comparing groundwater trends in the pilot catchment with those in untreated areas outside the catchment. Figure 3 shows, as an example, the comparitive hydrographs of Bores 6412 and 6416 for the period, 1983 to 1995. Bore 6412 is situated within the upper reaches of the treated catchment in a lower to mid-slope position, while Bore 6416 is located amongst annual pasture in a lower slope position, approximately 500m outside the catchment.

In terms of general trend, the two hydrographs in Figure 3 can be subdivided into two periods, namely, 1983 to 1986 and 1986 to 1995. The first period records the steepest and largest drop in the 6412 level (approx. 4m) and the largest relative change between the two bores. The second period shows much less relative change but, nevertheless, a steadily increasing separation in the respective water levels until 1992. Since 1992, the separation has remained consistently around 3.8 to 4m and represents an overall turnaround of some 5.4 to 5.6m.

The most significant seasonal response differences between 6412 and 6416 have mainly occurred between mid summer and early winter. This is particularly the case for the years 1984 to 1988, and 1991, where 6412 records substantial drops while 6416 is only stable to slightly dropping during the same periods. This indicates that the perennial pastures were using much more water than the annual pastures during the dry summer/autumn seasons of these years.

Figure 3. Burkes Flat Bore Hydrographs



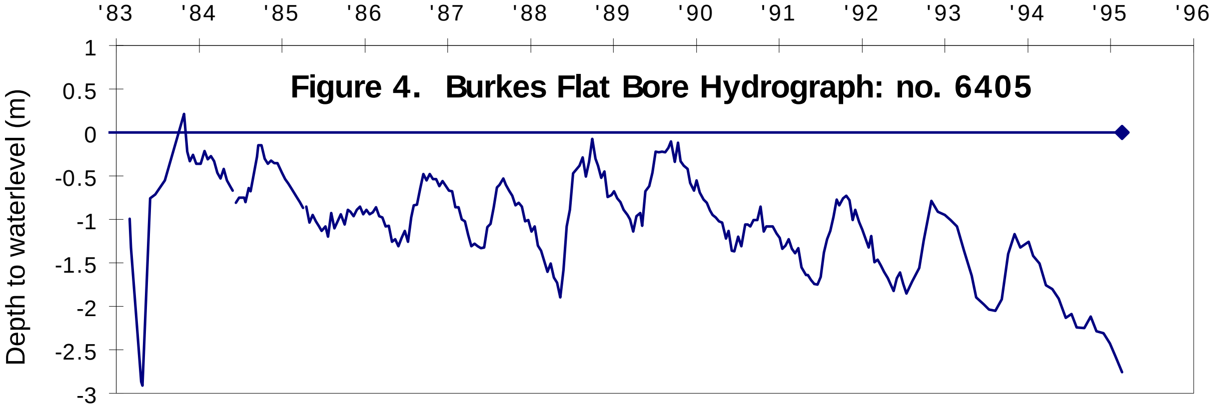


Figure 4. Burkes Flat Bore Hydrograph: no. 6405

Another very interesting feature of Figure 3 is the comparitive responses during the period from 1988 to 1991. The years 1988 and 1989 were wetter than average and the responses of the two bores are very similar in shape and magnitude, somewhat dispelling the "reducing recharge" reasoning in the strict sense. However, following these wet years, Bore 6412 recorded a fairly steep decline to a level which, by winter 1991, was actually about 35cm lower than the 1988 low, completely reversing the effect of the 1988/89 recharge. This contrasts strongly with 6416 which recorded only a relatively slight drop to a level about 65cm above the equivalent 1988 low. The 1990 winter/spring peak evident in 6416 is virtually absent in the 6412 hydrograph, suggesting that perennial pastures were using up more of the excess soil water store during the drier weather conditions which followed 1988/89.

The above observations reveal two important points regarding the effect of perennial pastures on groundwater levels at Burkes Flat, particularly in the middle to upper parts of the catchment. One is that, in the early, formative phase, the pastures had a telling impact on groundwater levels, either by just depleting the soil moisture store or by also directly tapping into the watertable where it was sufficiently shallow. The other point is that, later, when mature, they were successful in totally negating the initial effect of the wet 1988/89 period by presumably using up most of the high soil moisture store and possibly also tapping from the watertable during the following drier period of 1990/91.

Further corroboration of the above observations is provided by hydrographs of other bores within and outside the middle to upper catchment. Within the catchment, similar downward trends and behaviour to Bore 6412 are observed in bores such as 6403, 6406 and 6410 which occupy lower to upper slope positions (Figure 2). Outside the catchment, to the east, another control bore, 6423, has record going back to 1987 which shows a slightly rising trend and behaviour similar to that of 6416.

Bore C039 is located in a rocky crest area planted to trees (Figure 2), and has recorded an overall drop in groundwater level of about 1m since early 1984. This appears to be a reasonable result given that the trees are not yet fully mature and that the area is regarded as high recharge. Downslope influence of the trees is not certain but the timing and larger magnitude of the drops recorded in bores further down strongly suggests that the perennial pastures have been providing the main controlling influence on groundwater levels.

It is now clear from the hydrograph record that seasonal groundwater levels under the pilot catchment's upper discharge area have been steadily becoming lower. Dropping trends of 5 to 11cm/year have been recorded at three sites in this area (e.g, Bore 6405, Figure 4). In early 1995, the level in 6405 was approximately 2.5m lower than it was in early 1984.

At the lower end of the pilot catchment discharge area, the trend is not as clear. Allowing for the strong seasonal fluctuations, the Bore 6402 hydrograph seems to show a slight rising trend from 1983 to 1989 (approx. 3.5cm/year) and perhaps a slightly dropping to flat trend since 1989. It is probably reasonable to expect that changes at this end of the catchment will be more subtle and gradual than at the upper end of the catchment. The nearby lower slope bore, 6407 (Figure 2), seems to support this argument with its subdued and slightly dropping trend. Although the results from these two bores are not totally conclusive at this stage, the condition of the lower discharge area has markedly improved in the opinion of landholder, James Gallacher (pers. comm.).

Further substantiation of the watertable controlling effects of the salinity treatment is provided in two ways by results from another control bore, No. 6418, which is situated in a large discharge area to the north of the pilot catchment (Figure 2). Firstly, the bore shows a steadily rising watertable trend of about 8cm/year from late 1983 to 1989. This contrasts greatly to the dropping trends of discharge site bores in the upper pilot catchment (e.g, Bore 6405) during the same period and is greater than the rising trend of Bore 6402 at the lower end of the pilot catchment discharge area. Secondly, since 1990, Bore 6418 has recorded a fairly strong declining trend of about 11cm/year despite wet springs in 1991 and 1992. Further enquiries (James Gallacher, pers. comm; Matthew McCarthy, Department of Agriculture, Energy and Minerals, pers.comm.) suggest that this could be explained, partially at least, by effects caused by significant land management changes in the adjacent area from 1990 to 1992. These changes include the establishment of lucerne and phalaris in a number of paddocks between Bore 6418 and the pilot catchment's northern boundary.

Figure 5 shows a schematic profile of ground and watertable elevations along a transect of bores in the pilot catchment (see Figure 2 for bore locations). The watertable elevations have been plotted, where known, for January 1984, January 1988 and January 1995. It can be seen that the watertable surface along the whole profile has dropped at each stage, and by a substantial amount overall. As is typical for the pilot catchment, the greatest magnitude of change has occurred in the upper reaches, leading to a general "flattening" of the watertable surface and, hence, a reduction in hydraulic gradient. From the available information, the reduction in watertables and hydraulic gradients appears to have occurred over the majority of the pilot catchment. If so, then this must mean there are now mostly lower horizontal groundwater fluxes and, therefore, significantly reduced groundwater discharge.

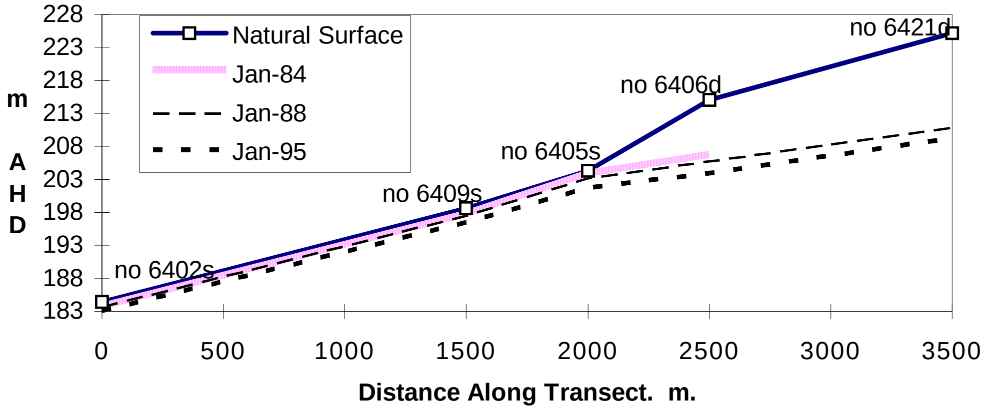


Figure 5. Time Series Watertable Profile.

Pilot Catchment Condition and Production

Most of the ridgetop tree planting has now been established for ten years and the success of the establishment is reflected by the generally good health, density and growth of the trees. It is expected that the trees will achieve maximum water uptake during the next five years. Lucerne and phalaris pastures have consistently achieved good strikes and flourish on the middle and lower slopes. The pastures have outperformed annual pastures in adjacent catchments and their condition has been generally better during dry spells.

Records kept by James Gallacher for his property, which is 729ha in area and occupies the majority of the pilot catchment, show an almost 100% increase in annual wool production between 1983 and 1990 (from about 12kg/ha/yr to 24kg/ha/yr). Production levels since 1990 have been maintained at around 23 to 26kg/ha/yr (James Gallacher, pers. comm.).

Recent inspections and discussions with James Gallacher strongly point to a considerable improvement in the condition of the pilot catchment discharge area since 1983. The improvement has been qualitatively gauged from observations of the following:-

a) general appearance;

b) plant cover;

c) soil stability;

d) extent of bare soil; and

e) overall extent of the degraded area.

Improvements have been observed in the first three of these criteria and a significant reduction has been observed in (d). It could be inferred from this that some improvement in the productive value of the catchment discharge area has also occurred.

In regard to (e), there is not yet clear evidence on change, one way or the other. Despite this, common opinion (anecdotal) seems to be that so far there has been little, if any, change in the actual area affected by salt (originally estimated to be approx. 100 ha). If true, this in itself should be regarded favourably because, based on the local and regional evidence, a further significant expansion of salt affected land was highly probable if the treatment was unsuccessful. If the groundwater levels had continued to rise at an average rate of 10 cm per year (estimated for untreated conditions by Day and Ryan, 1992; see **Groundwater Trends**), a noticeable expansion would have been expected by now (possibly up to 25% expansion from 1983 to 1995). That apparently little or no expansion has occurred is a good sign, particularly considering the number of wet years that have occurred since treatment began.

In contrast to the pilot catchment discharge area, the condition of some untreated discharge areas (i.e, no recognised effective treatment to control the recharge) in similar, neighbouring catchments to the west and south, has noticeably deteriorated and expanded in the last five or so years, according to local landholders. An inspection of these catchments has shown that their discharge areas are currently in much worse condition than that of the pilot catchment.

Accurate, quantitative assessment of changes to salt affected land in the Burkes Flat area will be possible in the future with the recent establishment of a treated and untreated pair of monitored discharge sites. The treated site is within the pilot catchment and the untreated site is within a catchment to the south, mentioned above. Both catchments are similar in terms of climate, topography, geology and groundwater systems. The monitored discharge sites have been established as part of a Statewide initiative to measure the effectiveness of salinity management plans.

Conclusions

Success in terms of a significant decline of groundwater levels in the upper part of the pilot catchment and an improvement in agricultural production has been previously documented (Day and Dyson, 1990; Day and Ryan, 1992; CLPR, 1993 and Day et al, 1993), though the effect on the catchment discharge area was not clear. This paper has presented updated evidence to show that the groundwater declines have continued to occur, are more widespread than previously documented, and are occurring in the discharge area.

The main conclusions drawn from the updated evidence are, (i) that the salinity treatment has been effective in reducing watertables and providing productivity benefits over most of the catchment, including the discharge area, and (ii) that the perennial pastures have had the greatest controlling influence on watertables in the catchment over the past eleven years.

Virtually all observation bores in the pilot catchment, including most of the discharge site bores, have shown declining groundwater level trends. Many of the bores, particularly in the upper part of the catchment, now have substantially lower levels (by up to 6m) than when first measured during or following the salinity treatment in the eighties. In contrast, two control bores located in untreated areas outside the pilot catchment (Bores 6416 and 6423) show rising trends with current levels higher than or similar to original levels. A third control bore in a discharge area to the north (Bore 6418) has displayed a marked dropping trend since 1990. However, it could be argued that this is in response, partially at least, to salinity treatment and improved land management in the adjacent area between 1990 and 1992. Prior to 1990, this bore recorded a consistent rising trend.

It is concluded from the reduced groundwater levels across the catchment, combined with the generally lower hydraulic gradients, that the amount of groundwater discharge has reduced. While retraction of the pilot catchment's discharge area is not obvious from the information available at this stage, it can be concluded that there has been considerable overall improvement in its condition and little, if any, expansion. This has happened despite several years of above average rainfall during the period from 1988 to 1993 and is attributed partly to the actual discharge area treatment and partly to the recharge treatment. By comparison, the conditions of discharge areas in a couple of neighbouring untreated catchments are noticeably worse, and deteriorating.

The evidence presented and discussed in this paper provides compelling confirmation of the salinity control and productivity benefits of well managed perennial pastures and trees on ridges in a localised sedimentary bedrock groundwater system in undulating, moderate rainfall country. The Burkes Flat pilot catchment project has proven to be an excellent example of salinity control through community involvement in catchment planning and productive land management. Its success should provide strong encouragement for the adoption of similar strategies in this commonly occurring type of area.

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