2. Rosedale

2.1. Physical setting

The salinity occurrence that lies approximately 3 kilometres to the south east of Rosedale is classed as medium to low level salinity (from DSE Corporate Geospatial Data Library). Approximately 150 ha in area, the location is less than 40 metres above sea level has less than 1 degree slopes and lies to the southern edge of the Latrobe River floodplain.

The land rises gently to the south east towards Holey Plains Park, where Honeysuckle Hill (10 km south east of Rosedale) has an elevation of 195 metres.

The photograph on the front cover shows a view across the Rosedale dryland salinity area.

2.2. Climate

2.2.1 Rationale for climate analysis

Average annual rainfall at Rosedale is between 600 to 700 mm. Average monthly rainfall in Sale (BoM, 2006) ranges from 41mm (February) to 62 mm (November), with August and September having the highest number of wet days.

In order to gain an appreciation of the likely recharge characteristics of the landscape, annual and monthly rainfall data is inadequate with respect to understanding soil wetting and drying processes that result in groundwater recharge. Daily rainfall and evaporation data provide the means to see when rainfall and evaporation sequences during each year are favourable to recharge occurring.

Daily rainfall and evaporation data was downloaded from the SILO website (www.nrw.qld.gov.au/silo/datadrill/). From this site, two sets of climate data can be obtained. These are called "Patched Point Data' and 'Data Drill'. Both datasets provide continuous daily climate data, suitable for use in simulation models. However there are subtle but important differences between the two sets.

The Patched Point Dataset uses original Bureau of Meteorology measurements for a particular meteorological station, but with interpolated data used to fill ("patch") any gaps in the observation record.

The Data Drill accesses grids of data derived by interpolating the Bureau of Meteorology's station records. Interpolations are calculated by splining and kriging techniques. The data in the Data Drill are all synthetic; there are no original meteorological station data left in the calculated grid fields. However, the Data Drill does have the advantage of being available for any set of coordinates in Australia.

The PPD would typically be used when an analysis or simulation is needed quite close to a meteorological station. However, if an analysis is required for a location which has no meteorological station nearby, then the Data Drill is the more relevant product.

The method used for this analysis was developed as research on groundwater - climate interaction in other dryland salinity locations in northern Victoria (Gill, 2004). In essence, the daily rainfall and evaporation data is manipulated to yield an estimation of recharge each year. It assumes that recharge will only occur when rainfall periods are of sufficient duration during times of low evapotranspiration so that soil profile saturation is likely. It essentially identifies times during the year when recharge was likely to have occurred across the landscape. The objective of this is threefold:

1. To determine if there has been any change in climatic conditions over time,
2. To determine the relative recharge rates occurring in different areas, and
3. To prepare recharge data for comparison to observation bore records (if available).

This form of analysis provides essential background understanding when considering dryland salinity. The salinisation process associated with land clearance, removal of perennial plants, increased recharge, groundwater system filling and development of discharge could take decades to develop. Being able to visualise past wetter and drier periods and see the longer term rainfall trends will add depth to understanding the results from modelling of the salinity processes at the sites. For example, knowing that in one location, annual recharge events are still occurring every winter - spring, despite an overall drying climate trend highlights the need to increase plant water use. Conversely, a site with lower rainfall and a trend to seasons where recharge conditions are less frequent indicates a lesser need for significant remedial work.

However, analysis of the climate data can only show what has happened, not what might be, hence the value of simulating the groundwater response under different land treatments using FLOWTUBE.

2.2.2 Rosedale Site Climate

Fifty-six years of Data Drill climate data (1950 to July 2006) that includes daily rainfall and evaporation data was obtained from the SILO website for coordinates 38^{o} 10' S and 146^{o} 39' E. This data was subsequently processed using a 20 day rolling average rainfall minus evaporation method that aims to simulate wetting and drying cycles in the soil profile. To allow for runoff losses, daily rainfall is capped at 10mm, so while actual permeability is likely to be lower or higher than 10mm, at the landscape scale, 10mm is a reasonable average. Results from northern Victorian study sites that have good bore water level records indicate that the permeability is not important at the catchment scale because rainfall is the main driver of decadal fluctuations in watertable levels.

The plot of daily potential recharge is valuable in illustrating the variability over the years. Some years, for example 1952 and 1991, have had significant periods of high recharge events, whereas other years, for example 1982 and 1999, have no periods when rainfall has exceeded evaporation. (See Appendix 1, Figure 1)

The 'estimated total annual recharge' plot (**figure 3**) shows that in most years, recharge conditions have occurred. However, of note is the trend towards drying conditions. Whereas the 1950's had an average of 110 mm/year recharge, the 1990's had an average of 54 mm/year. The 5 year rolling average line also highlights this declining trend.

While the absolute recharge values and the method of their calculation could be debated, the method treats the raw daily rainfall and FAO *evaporation data consistently over the period of analysis, so there is no doubt that there is a trend to lower recharge at this location.

(*Potential Evapotranspiration in the Data Drill is calculated using the FAO Penman-Monteith formula as described in FAO Irrigation and Drainage paper 56, http://www.fao.org/docrep/)

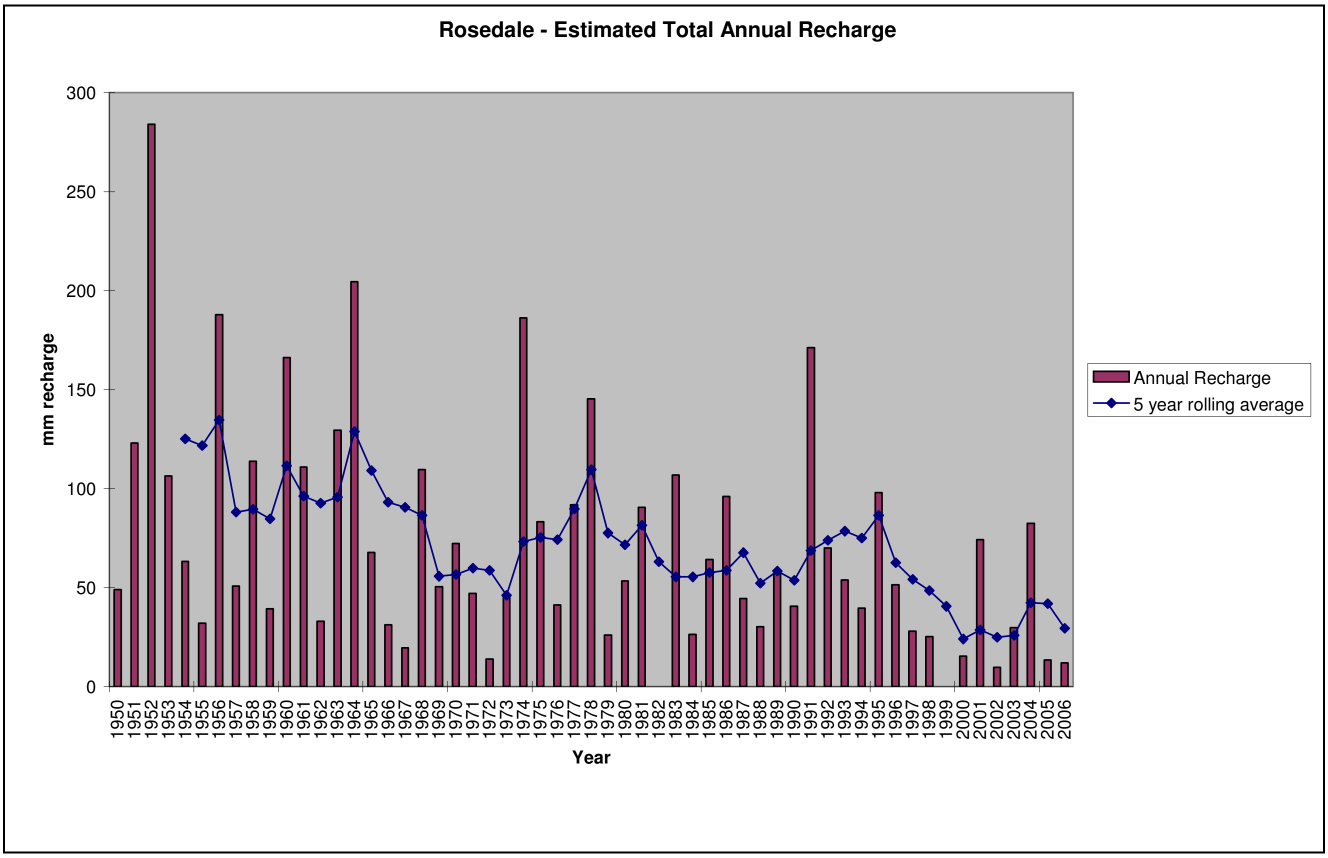

Figure 3. Estimated annual recharge for the Rosedale area.

2.3. Rosedale Groundwater Flow Systems

SKM (2005) defined GFS 4, Tertiary Sediments (Rosedale, Sale to Moe), as the major groundwater flow system south of the Latrobe River in the Rosedale vicinity. It is considered to be of intermediate scale. It is overlain by a thinner veneer of Recent Alluvials (GFS 12) along the Latrobe River north of the salinity discharge location. Groundwater movement from GFS 4 into GFS 12 is likely.

For the full characterisation of GFS 4, see SKM 2005. The key characteristics of most importance in this Flowtube modelling exercise are as follows:

Salinity Process - Recharge is likely to be occurring on upper parts of low hills and discharge occurring on lower floodplains. An additional (river) terrace south of Rosedale may be influencing salinity in the area.

Groundwater Level Trend - Not known.

Groundwater salinity - Generally less than 500 mg/L TDS

Topography - less than 2^o slope

Soil Permeability - Generally moderate to low, with some areas of high to low permeability.

Geology - Sands, gravels and yellow and grey clays.

Hydraulic conductivity - 1 to10 m/day

Current landuse – Grazing, forestry at higher elevations

2.3.1 Rosedale conceptual model

The conceptual model developed for GFS4 (**Figure 4**, from SKM 2005) is of recharge on the low hills to the south and north, with groundwater flow direction following ground surface gradient and discharging along the Latrobe River floodplain. The mapped extent of discharge supports this conceptual model, with converging flow from the north and south producing high watertables under low elevation parts of the Latrobe River Floodplain. It is suspected that the majority of recharge relevant to the mapped discharge area is occurring to the south of the Rosedale township, as geologic logs and field inspection indicated a greater sand component. The location is also geomorphologically suitable for high watertable development, with break of slope along the river terraces. The drainage lines (shown on figure 5) also suggest poor drainage.

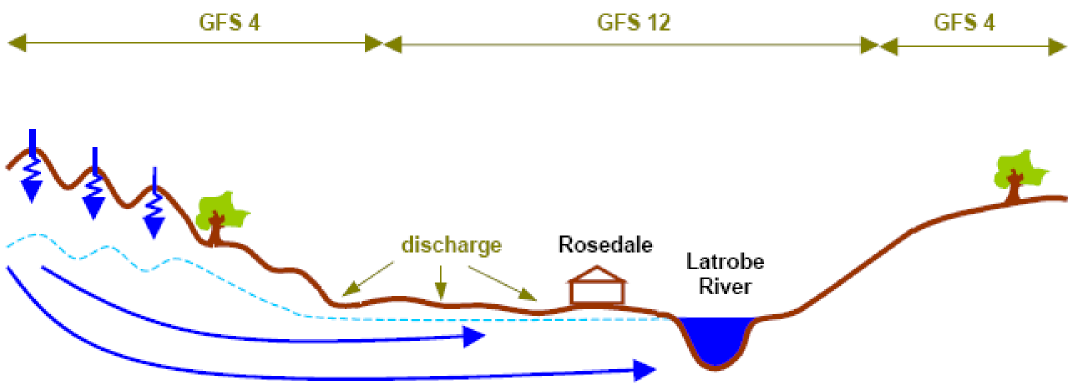

Figure 4. Rosedale conceptual model. (taken from SKM 2005)

2.3.2 Shallow groundwater behaviour

Depth to watertable data has been collected in the vicinity of the study site since March 1992 but appears to end in 2001. **Figure 5** provides a selection of the depth to watertable data from natural surface in the form of a time series hydrograph. The monitoring bores are positioned adjacent to discharge zones south of the township. (Bores 105a and 105b are also identified as bores 89845 and 89846 in the State groundwater data warehouse).

The bores are located in a discharge zone and show elevated shallow groundwater levels within 2 metres of the natural surface. Groundwater behaviour shows some seasonal variation, with an approximate 0.5m decrease in the overall level since 1997. This corresponds to below average rainfall conditions over this period.

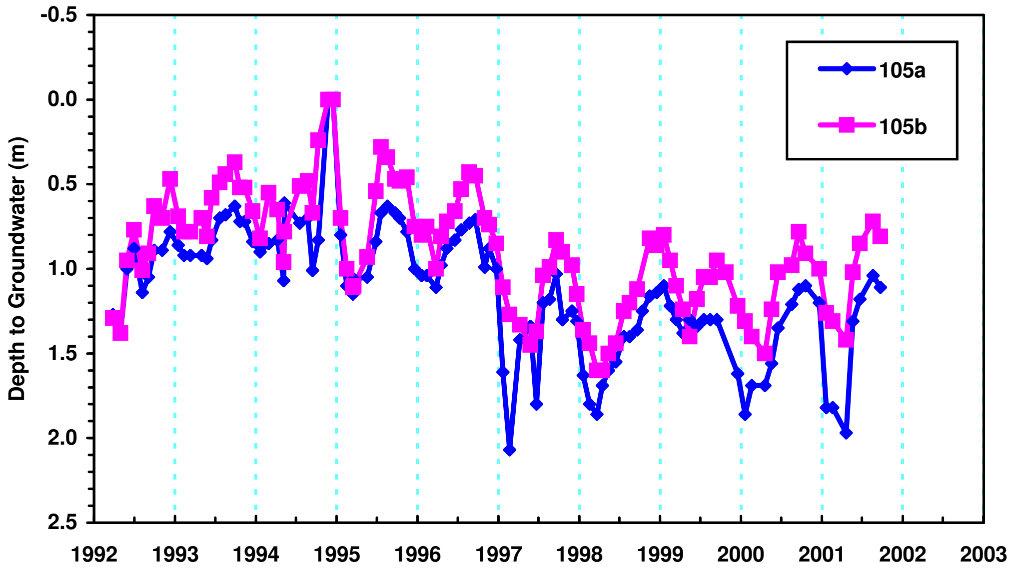

Figure 5. Hydrograph of the groundwater monitoring bores close to Rosedale.

2.4. Rosedale FLOWTUBE Modelling

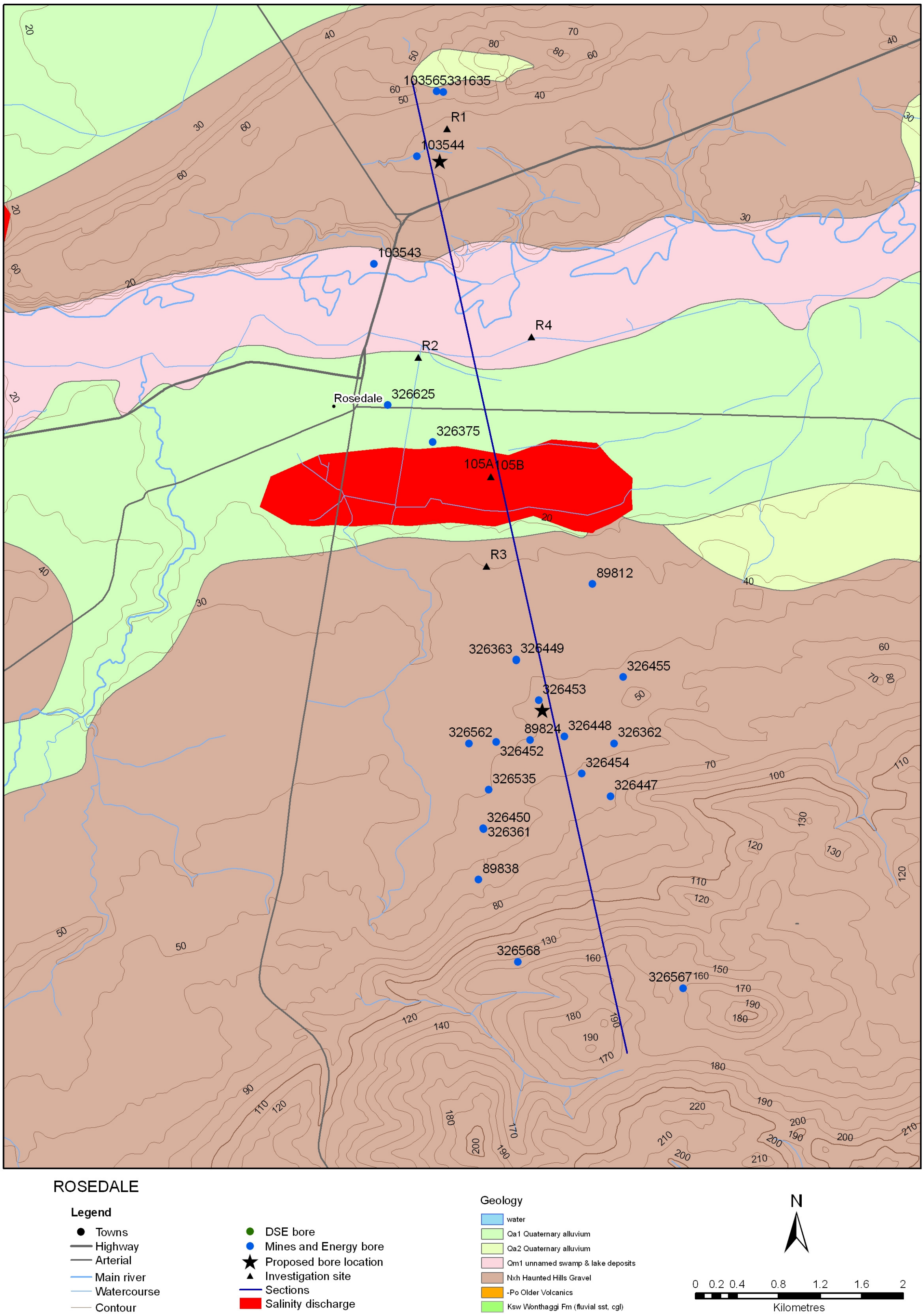

Figure 6. Rosedale Locality Plan

2.5. Rosedale - model application

A cross-sectional landscape profile (along line, **Figure 6**) up-gradient of the Rosedale discharge site was initially proposed to be developed into a FLOWTUBE aquifer transect, based on topography, groundwater flow system and groundwater bore data. However, when it became apparent that the groundwater levels upslope from the discharge area were not known (no groundwater data and too deep for the depth to groundwater investigation method available), an alternative, smaller section to the north was developed instead. It was agreed that this would allow representative watertable impacts from changed land use to be simulated for the location. A schematic cross-section (**Figure 7**) was constructed based on the bore lithology logs to provide a model of below surface structure. The aquifer is modelled as a single layer thinning towards the discharge site south of the township.

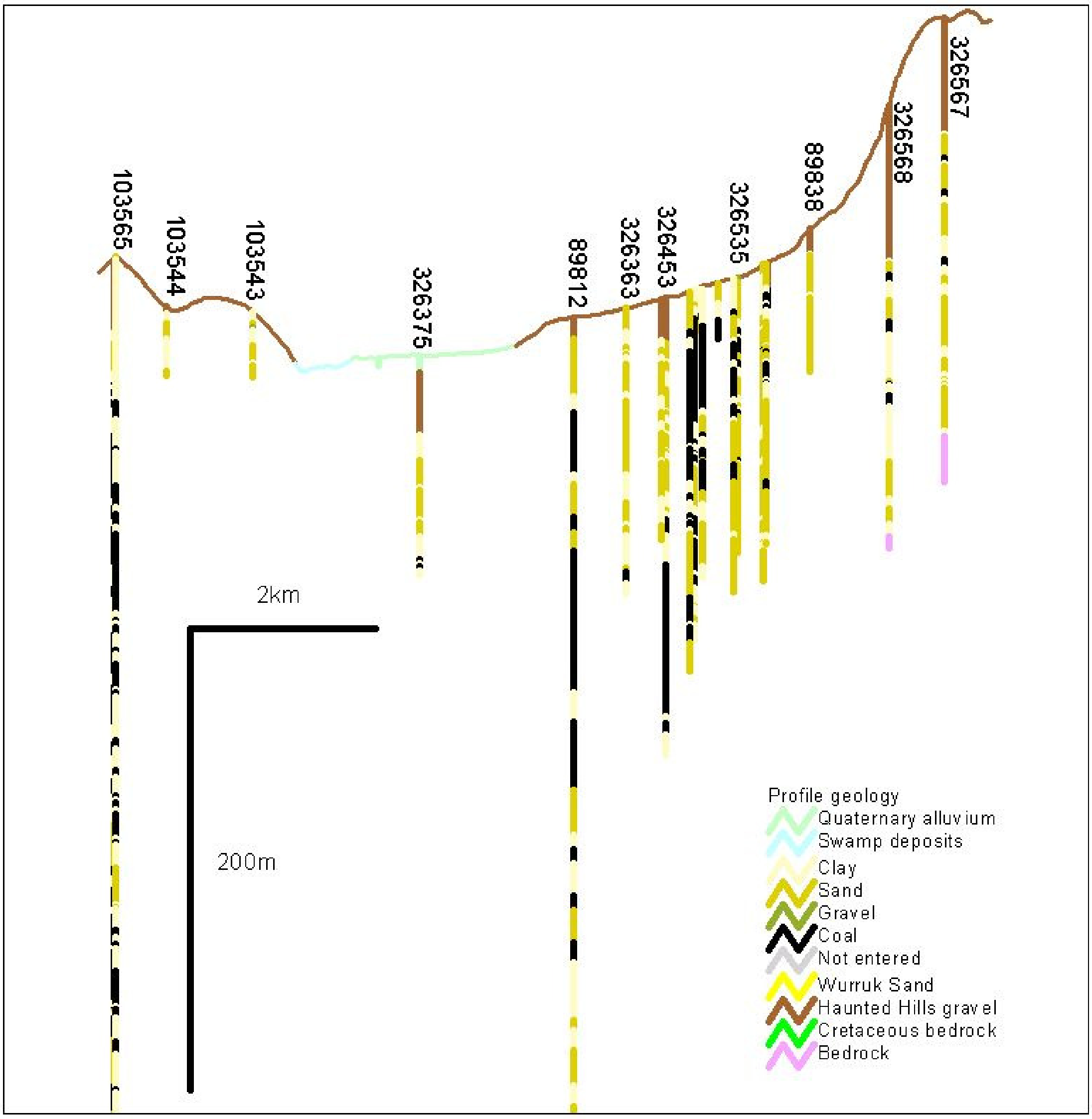

Figure 7. Geological cross section though the Rosedale site

The 'initial' model was designed and input to the program to replicate existing groundwater conditions, **Figure 8.** The model has been constructed in 4 sections that have been assigned aquifer parameters according to **Table 1**. The end of the "Flowtube" has been designated as a free flow boundary. The groundwater surface has been modelled as the hydraulic gradient up slope based on existing mining bore data and recent depth of groundwater investigation at the study site.

The aquifer thickness is difficult to assess given that mining lithology logs show a continuous layer of grey clays, sands and coal to beyond 100 metres below surface. To ascertain the depth to bottom of the aquifer, a number of aquifer thicknesses were trialled to replicate the current standing water level. As a consequence, the depth to the aquifer bottom (as indicated in Figure 14) is apparent only and may not be geologically defined.

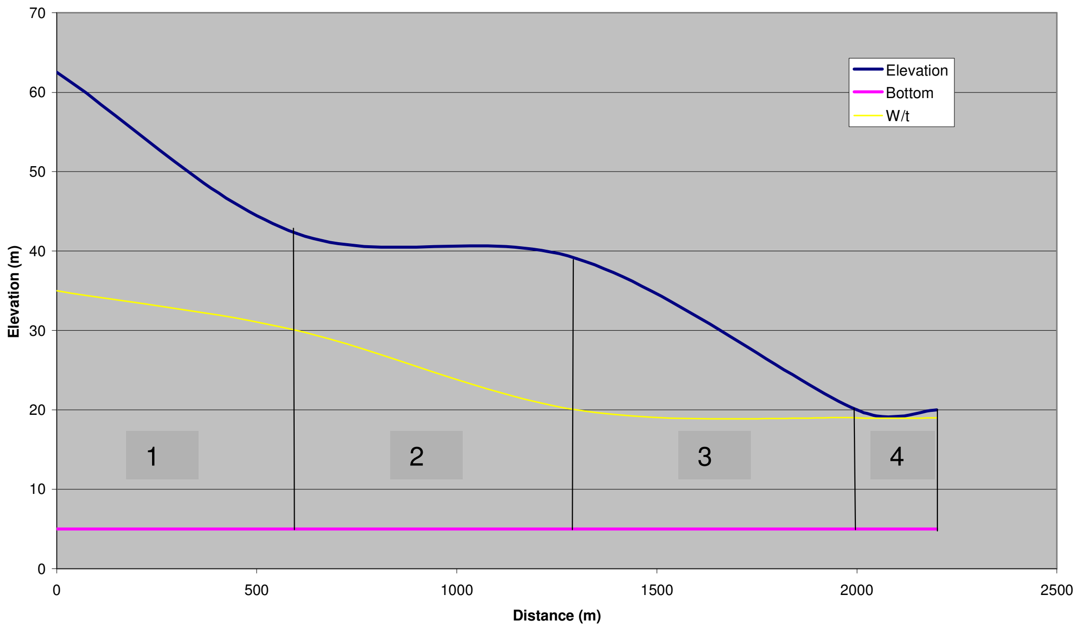

Figure 8. Initial groundwater conditions at the Rosedale site showing model design and current standing water level

Table 1. Rosedale modelled aquifer parameters

Section	Aquifer thickness (m)	Upper layer K* (m/day)	Lower layer K (m/day)	Mean specific yield %
1	50	0.1	0.5	0.03
2	35	0.1	0.5	0.03
3	25	0.05	0.5	0.03
4	15	0.05	0.5	0.03

*K = hydraulic conductivity

The recharge rates for each vegetation option used in the model runs are:

Annual Pasture	50mm/year
Perennial Pasture	5 mm/year
Trees	3 mm/year

The “do nothing” scenario has been modelled using a recharge value of 50mm/year under annual pasture across each section, excluding the discharge site. This has resulted in a minor increase of the standing water level below the discharge site, (see **Figure 9)**. The model was run for 10 years, 20 years and 50 years. A projected 2.3 metre rise of groundwater levels at the discharge site is apparent after 50 years. This equates to an expansion of the discharge zone of approximately 200m back upslope after 50 years. This indicates that if higher water use plants are not established over the area to reduce groundwater recharge, the saline area is expected to continue growing.

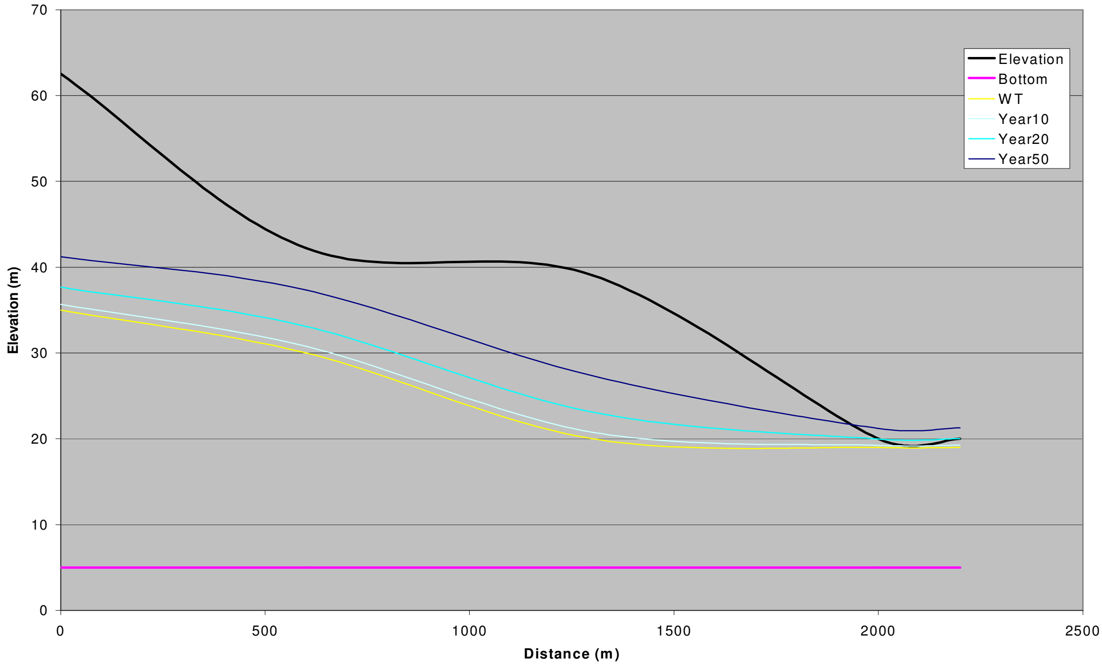

Figure 9. Rosedale site modelled groundwater behaviour under a "do nothing" scenario

To assess the effect of land management options that aim to reduce recharge, a number of scenarios were run based on a standardised volume of recharge beneath various vegetative options. The recharge values assigned to each scenario are based on previous modelling studies conducted by the designers of FLOWTUBE, and may or may not be appropriate for the West Gippsland area.

Figure 10 shows the FLOWTUBE output where replacement of annual pasture with perennial pasture over total length of the cross-section has been simulated. Using a recharge of 5mm/year, the model output suggests a lowering of the water level below the discharge site of approximately 5 metres could be achieved. It should be noted that the model assumes an instantaneous reduction of recharge of 90% at year 1 and does not allow for an establishment period to achieve maximum plant-water use.

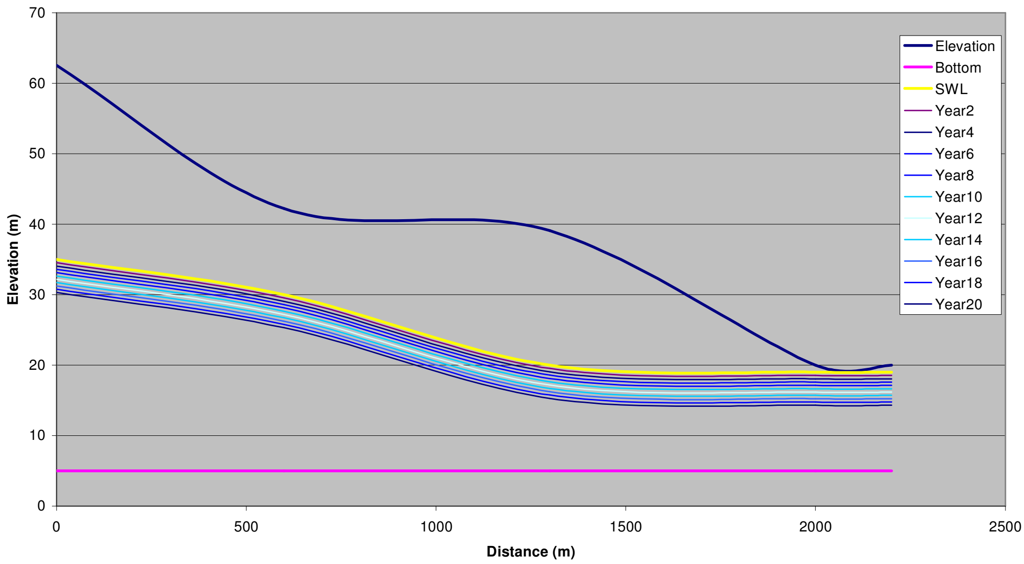

Figure 10. The Rosedale site modelled under perennial pasture with 5mm / year recharge

The model was also run as a simulation of a tree/perennial pasture scenario having 50% of the landscape planted to trees and 50% (50:50 mix) under perennial pasture. The trees are positioned in the upper landscape, in section 1 and 2 (see **Figure 11**) and assigned a recharge value of 3mm / year. Perennial pasture established on the slope leading to the discharge site was assigned a recharge value of 5mm / year.

The groundwater response for this scenario suggests a fall in water level under the ridge area over 6 metres could be achieved in 50 years. The corresponding fall in waterlevel beneath the discharge area is estimated to be nearly 5 metres after 50 years. A summary of the results of the model scenarios is provided in **table 2.**

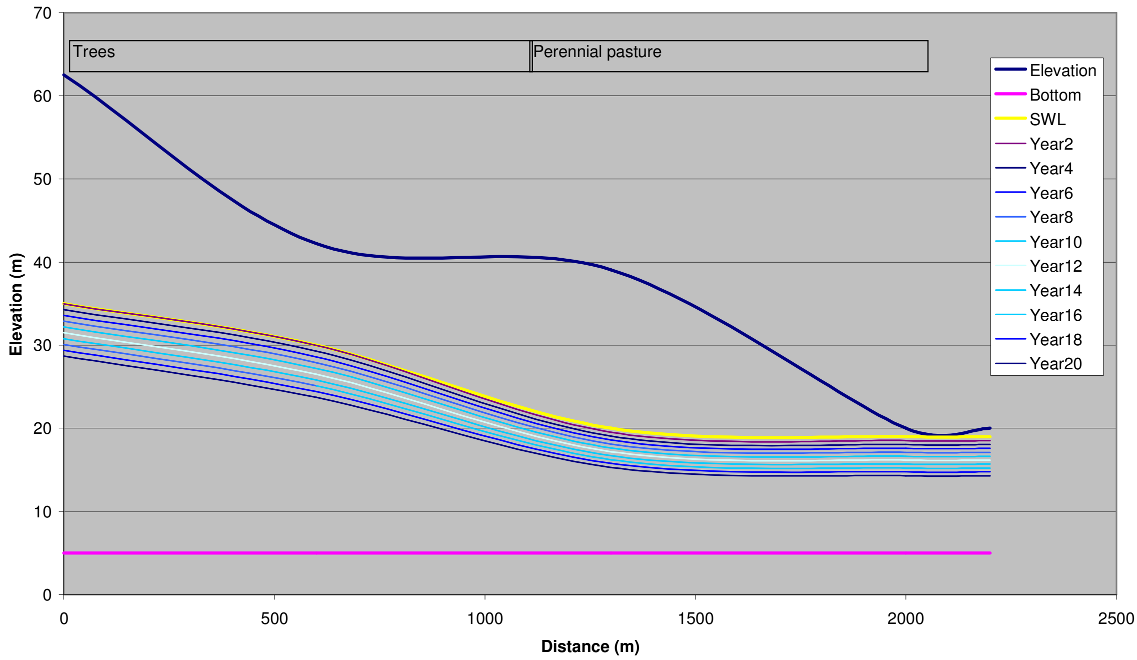

Figure 11. The Rosedale site modelled under 50% trees on the upper areas (3mm recharge) and 50% perennial pasture on lower areas (5mm recharge)

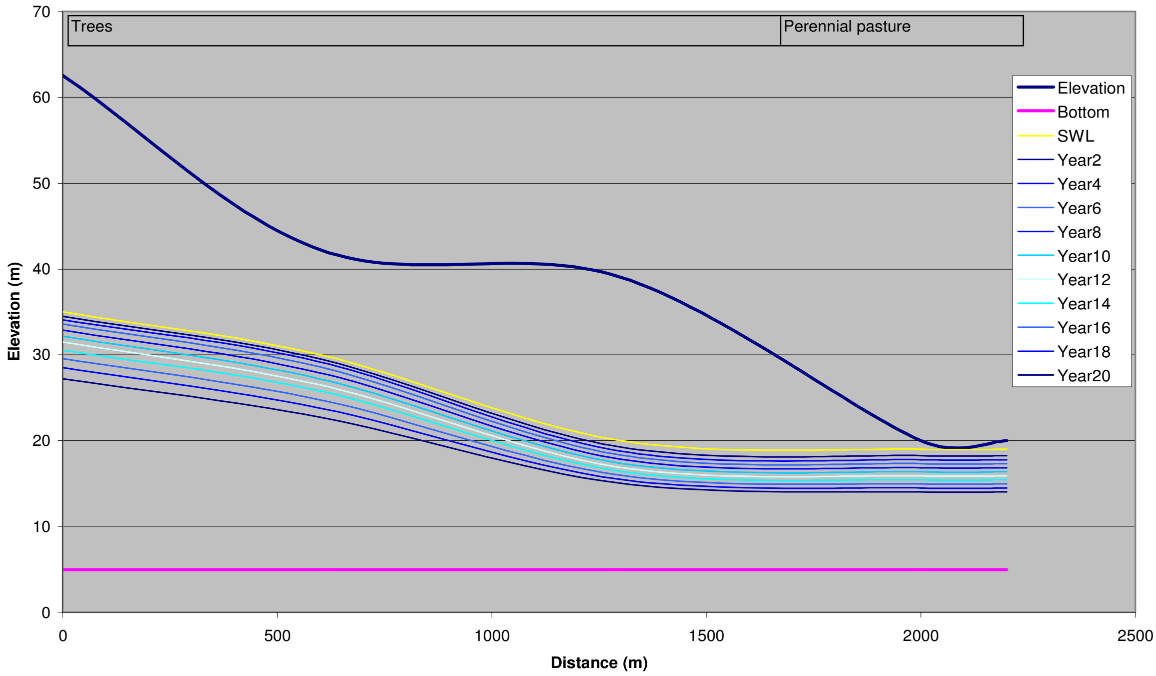

Figure 12. The Rosedale site modelled under 75% trees and 25% perennial pasture

Figure 12 is the result of a model run with 75% trees on the upper catchment and 25% perennial pasture on the lower section. The increased area under lower recharge trees suggests a further fall in standing water level below the trees could be achieved. However, the difference compared to the 50:50 mix is not large and the modelling indicates all scenarios will result in a useful overall reduction in watertable level within reasonable timeframes.

Table 2. Summary of Rosedale FLOWTUBE results.

Scenario	**Change in depth to groundwater from initial conditions (m)**								
Landscape position	**Ridge**			**Mid slope**			**Discharge zone**		
Time step (years)	**10**	**20**	**50**	**10**	**20**	**50**	**10**	**20**	**50**
"do nothing"	0.67	2.67	6.22	0.78	3.11	7.35	0.26	1.02	2.3
Time step (years)	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**
All perennial pasture	-2.35	-3.29	-4.75	-2.34	-3.28	-4.74	-2.33	-3.27	-4.73
50% tree 50% perennial	-2.81	-4.19	-6.29	-2.35	-3.29	-4.79	-2.36	-3.37	-4.81
75% tree 25% perennial	-2.84	-4.45	-7.77	-2.62	-3.56	-4.97	-2.63	-3.57	-4.99

2.6. Discussion of Rosedale FLOWTUBE results

FLOWTUBE modelling of the Rosedale site was conducted on the northern extent of the study area because depth to groundwater data is not available for the southern extent. Depth to groundwater investigation was attempted on the southern extent but intersection of groundwater was not achieved due to technical constraints (below depth of soil corer capability). Depth to groundwater could not be measured beyond 7m from natural surface on the southern extent. Depth to groundwater was measured at three sites on the northern extent and used together with the discharge zone to represent the current groundwater conditions for the FLOWTUBE model. Groundwater levels in lower parts of the landscape around the township are within 3 metres of natural surface.

The groundwater discharge at Rosedale is driven by two converging hydraulic gradients from topographic ridges to the north and south. The FLOWTUBE model was constructed to simulate flow from the north ridge. Under the do nothing scenario, the model suggests an increase in discharge area adjacent to the township is likely (assuming occurrence of mean recharge during simulation periods). The consequences of such discharge area enlargement would require action given the close proximity of urban development. The modelling suggests an expansion of the discharge zone back upslope of approximately 200 metres in 50 years time. However, the exact expression of salinity discharge will be controlled by topography and watertable intersection.

Various vegetative salinity mitigation options were tested under the model to estimate their impact on groundwater levels over time. The establishment of perennial pastures over a 20 year period appeared to be the best option. The 50% or 75% tree establishment combined with perennial pasture did not provide a significant improvement in the ability to lower groundwater levels at the discharge site compared to perennial pastures only.

Given that the crest of the south ridge is already forested, it has been surmised that perennial pasture on the south alluvial plain would also be the preferred option. Sub-surface lithology encountered during investigation was similar to the northern extent, although higher up the slope the geology may become sandier and less consolidated. This would provide greater hydraulic conductivity for groundwater recharge and therefore may provide greater opportunity for recharge reduction through the establishment of deep rooted perennial pasture.