Setting Aspirational, Resource and Management Action Targets Across the Glenelg Hopkins CMA

2\textsuperscript{nd} Milestone Report – Groundwater Modelling and Catchment Response

\begin{center}
\includegraphics[width=\textwidth]{landscape_1.jpg}
\includegraphics[width=\textwidth]{landscape_2.jpg}
\end{center}

\textbf{CSIRO Land and Water} Prepared by:
Chris Smitt, Peter Dahlhaus, Jim Cox, David Heislers and Darren Bennetts
Summary

Conceptual hydrogeological models and FLOWTUBE modelling scenarios are presented for four base level sub-catchments, which have been chosen as high asset risk, from 132 across the GHCMA region. The results are preliminary at this stage of the project.

In the Final Milestone Report (due in June 2004), scenarios will be presented for the no-change condition and the changed condition under modified land management for eight base level sub-catchments. These catchments will act as a basis for assessing salinity management across other sub-catchments with similar attributes. This will enable us to make an assessment as to whether the proposed management targets across the GHCMA will have the expected outcomes/impacts on the high-risk assets (i.e. protect them from salinisation). Salinity prioritisation within the GHCMA Salinity Plan was based on the work of Heislers and Brewin (2003). In some areas the paucity of data will resulted in more speculative scenarios. The change scenarios have been based on the adoption of appropriate management actions, rather than the actual likely adoption rates.

Resource condition targets were set according to the National Framework for Natural Resource Management (NRM) Standards and Targets. A difficulty in setting achievable resource condition targets for some areas is that salinity trends are not evident in the short monitoring record (or in some cases, no monitoring record). In other cases, where a trend is measurable, there is no knowledge of what is causing the trend. In these cases the targets will be set as a commitment to establishing a measurable target within a reasonably short timeframe.
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Introduction

Project aims

The general objective of this project is to set aspirational, resource condition and management action targets for salinity priority areas across the Glenelg-Hopkins Catchment Management Authority (GHCMA) region. This is to help determine if the stated outcomes of on ground works targets that have been set within the GHCMA Salinity Plan (GHCMA 2002) are realistic. The GHCMA is disaggregated into three drainage basins, Glenelg, Hopkins and Portland Coast. The region is disaggregated into 132 base level sub-catchments centred on small creeks or waterways (which for planning purposes are re-aggregated into 32 sub-catchments).

The first milestone report was “a review of the groundwater flow systems (GFSs) and analysis of available surface and groundwater data” (Smitt et al. 2003). The report collated and synthesised all relevant data including GFSs, did a “first pass” review and statistical analysis of stream electrical conductivity and saltload data, and showed how FLOWTUBE modelling can be incorporated to prioritise management actions.

This, the second milestone report, used the data collated in the first milestone report along with information in the report by Heislers and Brewin (2003) to reach consensus on base level sub-catchments with highest asset risk rating. A conceptual hydrogeological (groundwater flow) model was then conceptualised for each base level sub-catchment (and agreement reached at a workshop on 29th March 2004). The FLOWTUBE model was run where there was sufficient bore information to calibrate one or more “flowtubes” within part of a base level sub-catchment.

For the Final Milestone Report, realistic aspirational, resource condition and management action targets will be determined for the eight representative base level sub-catchments (Figure 1 with the aid of statistical trend analysis and FLOWTUBE modelling). To set realistic aspirational, resource condition and management action targets, it will be assumed that the results of the modelling applied to both the sub-catchment and adjacent sub-catchments where the same conceptual model applied, in those parts of the sub-catchment where the GFS was the same¹. This report presents the work in progress to-date and the project will be finalised by June 30th 2004 and results reported in Milestone 4.

¹ Unlike in the CCMA, planning in the GHCMA is done at the (surfacewater) sub-catchment scale which may include more than one GFS
Figure 1 Selected base level sub-catchments chosen to assess management strategies to reduce salinity

**Current condition and trends**

The Integrated Catchment Salinity Risk Prioritisation (ICSRP), which is a pre-cursor to the Geospatial Salinity Hazard and Asset Risk Prediction (GSHARP) process was used to identify the assets at risk in each sub-catchment (Heislers and Brewin, 2003).

Figure 2 shows the trends in electrical conductivity in streams across the region (Smitt et al. 2003).
Figure 2 Stream electrical conductivity trends across the GHCMA (Smitt et al. 2003).

**Salinity processes**

In the majority of cases, the processes causing the salinity within each target area are unproven and the proposed conceptual models are based on logical hydrogeological theory developed by local experts.

**Groundwater Modelling - Scenarios**

No-change scenarios will be predicted on the basis of the available trends, conceptual models, numerical modelling (FLOWTUBE), or mapped salinity as appropriate for each area. In some areas the paucity of data will result in more speculative scenarios. The change scenarios will be based on the adoption of appropriate management actions, rather than the actual likely adoption rates.

Table 1 summarises the base level sub-catchments within the GHCMA chosen for the modelling component of this study. The assets at risk, a brief summary of why the base level sub-catchment was chosen and its priority rankings are also shown.
Table 1 Identifies sub-catchments in the GHCMA with high asset risk ratings and high groundwater modelling priorities.

<table>
<thead>
<tr>
<th>Cat ID</th>
<th>Assets at risk</th>
<th>Summary</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>H3.3</td>
<td>Environment</td>
<td>Very large and complex catchment, which includes the well studied areas of Woorndo and Glenthompson. This is a priority area for modelling, with reference to previous undertaken throughout the area.</td>
<td>A1</td>
</tr>
<tr>
<td>H4.4</td>
<td>Infrastructure</td>
<td>Medium scale catchment with salinity associated with the boundary of GFS 13 and GFS 14 and GFS 1. An area where recharge control should be tested.</td>
<td>A2</td>
</tr>
<tr>
<td>G6.1</td>
<td>Environment</td>
<td>Large catchment with significant salinity all in GFS 10 (East Dundas). This includes the Red Barren salinity field site. High priority for modelling as it feeds Rocklands Reservoir.</td>
<td>A1</td>
</tr>
<tr>
<td>G10.1</td>
<td>Infrastructure</td>
<td>Very large catchment with significant areas of salinity associated with water bodies in GFS 1 and GFS 10</td>
<td>A1</td>
</tr>
<tr>
<td>G11.2</td>
<td>Infrastructure</td>
<td>Narrow catchment with significant areas of salinity associated with the catchment outlet in GFS 14</td>
<td>A2</td>
</tr>
<tr>
<td>H7.3</td>
<td>Environment</td>
<td>Large catchment with significant areas of salinity (mostly primary) associated with wetlands and lakes in GFS 2</td>
<td>A1</td>
</tr>
<tr>
<td>G11.6</td>
<td>Infrastructure</td>
<td>Long and narrow with significant areas of salinity associated with wetlands and lakes in GFS 14</td>
<td>A1</td>
</tr>
<tr>
<td>G12.1</td>
<td>Environment, Agriculture</td>
<td>A large catchment with significant valley floor salinity mapped in GFS 10, GFS 14 and GFS 17.</td>
<td>A2</td>
</tr>
</tbody>
</table>
**Asset Risk Assessment**

Each asset type (agricultural land, environmental, infrastructure) was assessed against the appropriate hazard criteria to produce a normalised assessment of the risk of salinity to assets in the sub-catchment (Heislers and Brewin 2003). The conceptual hydrogeological models were developed along transects which passed through these assets. Flowtubes were chosen so that the management changes which were used in the FLOWTUBE modelling had most impact on the protection of these assets.

**Resource Condition Targets**

The GHCMA region together with the neighbouring Corangamite CMA has been designated one of 21 priority regions in Australia in the National Action Plan for Salinity and Water Quality. The NAP and its Intergovernmental Agreement (IGA) require the GHCMA to comply with the National Framework for Natural Resource Management (NRM) Standards and Targets. The framework states a minimum set of regional targets to be developed for:

1. Land salinity
2. Soil condition
3. Native vegetation communities’ integrity
4. Inland aquatic ecosystems integrity (rivers and other wetlands)
5. Estuarine, coastal and marine habitats integrity
6. Nutrients in aquatic environments
7. Turbidity / suspended particulate matter in aquatic environments
8. Surface water salinity in freshwater aquatic environments
9. Significant native species and ecological communities
10. Ecologically significant invasive species

A difficulty in setting achievable resource condition targets for some areas is that salinity trends are not evident in the short monitoring record (or in some cases, no monitoring record). In other cases, where a trend is measurable, there is no knowledge of what is causing the trend. In these cases the targets have been set as a commitment to establishing a measurable target within a reasonably short timeframe.
The timeframe for the achievement of resource condition targets is 10 to 20 years, and they are intended to be pragmatic and achievable (GHCMA 2002).

Resource Condition Targets also often referred to as End of Valley Targets provide specific, time bound, measurable targets for the medium term (10 - 20 years). The National Framework for natural resource management standards and targets identifies a minimum set of eight matters for which targets must be set in the region. Three of these relate to salinity management.

- Area of land threatened by shallow or rising watertables,
- Surface water salinity; and
- Extent of critical assets identified and protected from salinity and degrading water quality.

Establishment of appropriate targets requires prediction of trends, an assessment of risk to assets and values and agreement on the acceptable level of risk. Insufficient data currently exists in the region to enable appropriate targets to be set for all matters except surface water salinity. High priority actions have been identified in the GHCMA Salinity Plan (GHCMA, 2003) to support development of appropriate targets in consultation with the community by December 2004.

Interim surface water salinity targets have been set for four catchment points by the GHCMA Salinity Plan, (GHCMA, 2003). Targets indicate the maximum stream salinity level desired for these rivers by 2012.

- Hopkins River at Wickliffe 13500 EC 90% of the time
- Hopkins River at Hopkins Falls 6000 EC 90% of the time
- Glenelg River at Sandford 3300 EC 90% of the time
- Wannon River at Henty 5840 EC 90% of the time

These targets will be reviewed (in Milestone 4) and may change dependant on our understanding of impact of the on-ground works in altering the resource condition. Information that will enable us make this assessment will come from modelling land use change and observing the groundwater response (e.g. the impact of trees or pastures on salinity). Extrapolation to broader catchment scale, and the extended timeframe over which actions may become effective or have an impact, add additional complexity.
1 Sub-Catchment H3.3 (Hopkins River/Mustons Creek)

1.1 Description

Base level sub-catchment H3.3 is very large and complex and includes two well-studied areas, Woorndoo and Glenthompson (Dixon, 1989, and Cox et al 1999). Because of the complexity, the results from the modelled area, based on the hydrogeological conceptual model, cannot be extrapolated to other areas in the sub-catchment. In the Final Report a number of conceptual models will be developed for the sub-catchment and FLOWTUBE run for transects within each. This is the only way all assets within the base level sub-catchment can be assessed as to how they will be affected by land management changes.

1.1.1 Salinity Action Plan Ranking:

H3.3 base level sub-catchment is Priority A1: salinity hazard, high/moderate value assets, groundwater system responds to recharge control activities. Options that may work and require modelling include: Recharge management, discharge management and engineering.

1.1.2 Problem GFS:

The problem GFS in this base level sub-catchment are (from, Dahlhaus et al, 2002):

GFS 1 – Local flow systems in Quaternary alluvium and coastal deposits,
GFS 4 – Local Flow Systems in Deeply Weathered Granitic Rocks,
GFS 5 – Local and Intermediate Deeply Weathered Palaeozoics,
GFS 8 – Local flow systems in the Woorndoo, and
GFS 14 – Regional and intermediate flow systems in Volcanic Plains basalt.

Figure 3 shows the locations of these GFS's within the base level sub-catchment.
Figure 3 Summary of sub-catchment H3.3
1.2 Asset Risk Assessment

Tables 2 to 4 identify the salinity hazard rankings, the asset risk ratings and the intended management options for base level sub-catchment H3.3, (source, Heislers and Brewin, 2003).

Table 2 Summarises salinity hazard rankings for sub-catchment H3.3

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of discharge</td>
<td>Moderate</td>
</tr>
<tr>
<td>Line discharge</td>
<td>Very Low</td>
</tr>
<tr>
<td>Water table &lt; 5 m</td>
<td>Moderate</td>
</tr>
<tr>
<td>TDS of groundwater</td>
<td>Moderate</td>
</tr>
<tr>
<td>Flow weighted salinity</td>
<td>Very Low</td>
</tr>
<tr>
<td>Land management Unit</td>
<td>Moderate</td>
</tr>
<tr>
<td>Bulk Score</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3 Summarises asset risk ratings for sub-catchment H3.3

<table>
<thead>
<tr>
<th>Asset</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>Very High</td>
</tr>
<tr>
<td>Rail</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Town</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Infrastructure Total</td>
<td>High</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Very High</td>
</tr>
<tr>
<td>Public Land</td>
<td>Low</td>
</tr>
<tr>
<td>VROT</td>
<td>Moderate</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Moderate</td>
</tr>
<tr>
<td>Environment Total</td>
<td>High</td>
</tr>
<tr>
<td>Average Risk</td>
<td>Very High</td>
</tr>
<tr>
<td>Water Quality Risk</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 4 Summarises the intended management for sub-catchment H3.3, (source, GHCMA SMP).

<table>
<thead>
<tr>
<th>Management option (type)</th>
<th>Management option (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recharge control</td>
<td>Yes</td>
</tr>
<tr>
<td>Discharge management</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1.3 Salinity processes

Figure 4 shows the area which was chosen from within the base level sub-catchment H3.3 to develop a conceptual hydrogeological model and determine how it responds to recharge management.
Figure 4 Area targeted for flowtube modelling within sub-catchment H3.3.

Figure 5 shows a simplified conceptual model of the hydrogeology in the targeted area of sub-catchment H3.3. This conceptual model has been based on a detailed study in the Woorndoo area, Stuart-Smith and Black, (1999) and Paine et al (2004), with further input from key professionals during a workshop held in Ballarat during March.
1.4 Groundwater modelling simulation and results

1.4.1 No Change Scenario

Figure 6 shows the stream EC trend from 1976 to 1986 for gauging station 236202 – Hopkins River at Wickliffe. This gauging station lies just to the north of the modelled area and should only be used as a general indicator of the stream EC trends within this catchment. Unfortunately, at this stage we were unable to obtain a record of stream EC beyond 1986, which prevents the prediction of future trends for this base level sub-catchment.
Figure 6 Stream EC for Hopkins River at Wickliffe

Figure 7 shows the stream EC trend from 1976 to 2002 for gauging station 236209 – Hopkins River at Hopkins Falls. This gauging station lies to the south of the modelled area and should only be used as a general indicator of the stream EC trends within this catchment. The statistics show that there is an EC trend of $29.6 \pm 23.7 \, \mu S/cm/yr$ which is statistically significant. Under a no change scenario, we may expect a similar trend to continue.

Figure 7 Stream EC for Hopkins River at Hopkins Falls
1.4.2  **Change Scenario**

Three basic scenarios have been simulated for the base level sub-catchment:

1. Reduce recharge rates by 90% in the top quarter of the catchment,
2. Reduce recharge rates by 90% in the middle third of the catchment, and
3. Reduce recharge rates by 90% over the entire catchment.

Figure 8 shows the simulated location of the water levels for continual recharge that has been reduced by 90% in the top quarter of the catchment. It should be noted that after 100 years there is no change in the water level, suggesting that the system has reached a new equilibrium.

![Figure 8](image)

Figure 8 Shows the effect of reducing the recharge by 90% over the top quarter of the catchment. Water levels are simulated for 5, 10, 20, 50 and 100 years into the future.

Figure 9 shows the simulated location of the water levels for continual recharge that has been reduced by 90% in the middle third of the catchment. In this scenario, no change is seen with water level reduction after 10 years.
Figure 9 Shows the effect of reducing the recharge by 90% over the middle third of the catchment. Water levels are simulated for 5, 10 and 20 years into the future.

This simulation clearly shows that reducing land use in this area via land use change has very little impact on future water levels throughout the catchment. This suggests that the majority of the water that discharges in the lower parts of the catchment is sourced from either the highland reaches or intermediate throughflow from neighbouring catchments (namely base level sub-catchments H3.4, H4.4 and H11.1).

The final simulation in this sub-catchment is presented in Figure 10. Here the location of the water levels for continual recharge that has been reduced by 90% over the entire catchment is shown. In this scenario, there is no change in the water level (i.e. a new equilibrium reached) after 150 years. This is indicative of an Intermediate Groundwater Flow System rather than a Local Flow System. Also it should be noted that this level of land use change significantly lowers through the catchment and after 20 years, discharge to the Woondoo Lakes ceases, causing them to potentially dry up, given no direct surface runoff.
1.5 Summary

Within this base level sub-catchment the assets most at risk are the roads, agricultural land and public land, therefore the modelling targeted the protection of these assets. It is evident from the FLOWTUBE modelling that recharge reduction significantly impacts water table elevation throughout the catchment and especially in the upland parts, and depending on the extent of the land management new equilibriums can be seen from between 50 to 150 years. This has significant implications on protecting assets such as infrastructure and agricultural land as the main issues here are shallow saline groundwaters. What is also evident is that if you reduce recharge in the top quarter of the catchment, you are not only reducing the water levels down gradient but you are effectively cutting off the supply of fresh water which mixes with the underlying saline groundwater that discharges into the lakes. Potentially, this means that if you were to undertake this management option not only would you decrease water levels in the upland reaches of the catchment but you may also cause the lakes where the groundwater discharges to become saltier. To overcome this problem engineering drains may be installed in to rapidly direct the water off the landscape and into these discharge lakes.

However, within this region there may exist a Victorian rare or threatened species (VROT) that require no significant changes to the hydrology of the landscape to keep their habitat. In such a scenario, reducing the water table elevations may cause a change in their habitat so it is necessary to keep this in mind when undertaking any management actions.

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*The actual VROT species threatened is not indicated in Heislers and Brewin (2003)*
2 Sub-Catchment G6.1 (Glenelg River/Grampians Headwater)

2.1 Description

Base level sub-catchment G6.1 is a very large and complex catchment that includes the documented studied areas by Brouwer and Fitzpatrick in 2002. This base level sub-catchment is considered a high priority for modelling as there are several important assets at risk including, infrastructure, public land, agriculture and environmental sites.

2.1.1 Salinity Action Plan Ranking:

G6.1 base level sub-catchment is Priority A1: salinity hazard, high/moderate value assets, groundwater system responds to recharge control activities. Options that may work and require modelling include: Recharge management, discharge management and engineering.

2.1.2 Problem GFS:

The problem GFS in this base level sub-catchment is:

GFS 10 – Local flow systems in the East Dundas

Figure 11 shows the location of this GFS within the base level sub-catchment.
Figure 11 Summary of sub-catchment G6.1
2.2 Asset Risk Assessment

Tables 5 to 7 identify the salinity hazard rankings, the asset risk ratings and the intended management options for sub-catchment G6.1 (source, Heislers and Brewin, 2003).

Table 5 Summarises salinity hazard rankings for sub-catchment G6.1,

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of discharge</td>
<td>Moderate</td>
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<tr>
<td>Line discharge</td>
<td>Moderate</td>
</tr>
<tr>
<td>Water table &lt; 5 m</td>
<td>High</td>
</tr>
<tr>
<td>TDS of groundwater</td>
<td>Moderate</td>
</tr>
<tr>
<td>Flow weighted salinity</td>
<td>High</td>
</tr>
<tr>
<td>Land management Unit</td>
<td>Very High</td>
</tr>
<tr>
<td>Bulk Score</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6 Summarises asset risk ratings for sub-catchment G6.1

<table>
<thead>
<tr>
<th>Asset at risk</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>Very High</td>
</tr>
<tr>
<td>Rail</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Town</td>
<td>Low</td>
</tr>
<tr>
<td>Infrastructure Total</td>
<td>Very High</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Very High</td>
</tr>
<tr>
<td>Public Land</td>
<td>Very High</td>
</tr>
<tr>
<td>VROT</td>
<td>High</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Environment Total</td>
<td>Very High</td>
</tr>
<tr>
<td>Average Risk</td>
<td>Very High</td>
</tr>
<tr>
<td>Water Quality Risk</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 7 Summarises the intended management for sub-catchment G6.1, (source, GHCMA SMP).

<table>
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<th>Management option (type)</th>
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</tr>
</tbody>
</table>

### 2.3 Salinity processes

Figure 12 shows the area, which was chosen from within the base level sub-catchment G6.1 to develop a conceptual hydrogeological model and determine how it responds to recharge management.
Figure 12 Area targeted for flowtube modelling within sub-catchment G6.1

Figure 13 and Figure 14 show conceptual models of the hydrogeology and salinity processes sub-catchment G6.1. These conceptual models have been based on a detailed study which encompasses the study area (Brouwer and Fitzpatrick, 2002a, 2002b)
Figure 13 Conceptual model of salinity process within sub-catchment G6.1.

Figure 14 Conceptual model of salinity process within sub-catchment G6.1.
2.4  Groundwater modelling simulations and trends

2.4.1  No Change Scenario

Figure 15 shows the stream EC trend from 1974 to 2002 for gauging station 238202 – Glenelg River at Sandford. This is the closest gauging station to this sub-catchment and it lies well downstream. It is for this reason that it should only be used as a general indicator of the stream EC trends within this catchment. The statistics show that there is an EC trend of \(-6.8 \pm 13.5\) µS/cm/yr however, this is not significant. Under a no change scenario, we would expect a similar trend.

![Smoothed EC - Glenelg River @ Sandford (238202)](image)

Figure 15 Stream EC for Glenelg River at Sandford

2.4.2  Change Scenario

Two basic scenarios have been simulated for the base level sub-catchment:

1. Reduce recharge rates by 90% in the top quarter of the catchment,

2. Reduce recharge rates by 90% over the entire catchment.

Figure 16 shows the simulated location of the water levels for continual recharge that has been reduced by 90% in the top quarter of the catchment. It should be noted that after 100 years there is no change in the water level, suggesting that the system has reached a new equilibrium.
Figure 16 Shows the effect of reducing the recharge by 90% over the top quarter of the catchment. Water levels are simulated for 5, 10, 20, 50 and 100 years into the future.

This simulation clearly shows that reducing recharge via land use in this area significantly impacts on future water levels in the upper two thirds of the catchment. This suggests that the majority of the water that discharges in the lower parts of the catchment is source from either the highland reaches or intermediate through-flow from neighbouring catchments (namely base level sub-catchments G5.4, G10.2 and/or G6.3). However, at the lower end the model was forced to merge into a constant head boundary and thus may not be entirely accurate at this end.

The final simulation in this sub-catchment is presented in Figure 17. Here the location of the water levels for continual recharge that has been reduced by 90% over the entire catchment is shown. In this scenario, there is no change in the water level (i.e. a new equilibrium reached) after 100 years. This is indicative of either an Intermediate Groundwater Flow System or a Local Flow System. Also it should be noted that this level of land use change significantly lowers the water table through the catchment. The responsiveness of the aquifer is quite rapid with rapid falls occurring in the first 10 to 20 years.
Figure 17 Shows the effect of reducing the recharge by 90% over the entire catchment. Water levels are simulated for 5, 10, 20 50, 100 and 150 years into the future.

2.5 Summary

This model behaves similarly to that of H3.3 with the exception being a quicker response to land use change. Within this base level sub-catchment the assets most at risk are the roads, agricultural land and public land, therefore the modelling targeted the protection of these assets. It is evident from the FLOWTUBE modelling that recharge reduction rapidly and significantly impacts water table elevation throughout the catchment and especially in the upland parts, and depending on the extent of the land management new equilibriums can be seen from between 50 to 100 years.

By reducing recharge in the upland reaches of the catchment, assets such as infrastructure and agricultural land, which are at risk by shallow saline groundwater, may be preserved. What is also evident (and as in the case of base level sub-catchment H3.3) is that if you reduce recharge in the top quarter of the catchment, you are not only reducing the water levels down gradient but you are effectively cutting off the supply of fresh water which mixes with the underlying saline groundwater that discharges into the Glenelg River. To overcome this problem engineering drains may be installed in to rapidly direct the water off the landscape and into the Glenelg River which would not only “freshen” up the immediate environment but would also help decrease stream EC levels down stream.
3.1 Description

Base level sub-catchment H4.4 is a medium to large catchment with salinity associated with the boundary of GFS 13 and GFS 14 and GFS 1. This base level sub-catchment is considered a high priority for modelling as there are several important assets at risk including, infrastructure, public and agricultural land. Despite this being a priority A2 base level sub-catchment (i.e. GFS not expected to respond to recharge management), recharge control should be tested on local areas where assets are at high risk.

3.1.1 Salinity Action Plan Ranking:

H4.4 base level sub-catchment is Priority A2: salinity hazard, high/moderate value assets, groundwater system does not responds to recharge control activities. Options that may work and require modelling include: Discharge management and engineering.

3.1.2 Problem GFS:

The problem GFS in this base level sub-catchment is:

- GFS 1 - Local flow systems in Quaternary alluvium and coastal deposits
- GFS 13 – Intermediate and Local Flow Systems in the Fractured Palaeozoics
- GFS 14 - Regional and intermediate flow systems in Volcanic Plains basalt

Figure 18 shows the location of these GFSs within the base level sub-catchment.
3.2 Asset Risk Assessment

Tables 8 to 10 identify the salinity hazard rankings, the asset risk ratings and the intended management options for sub-catchment H4.4 (source, Heislers and Brewin, 2003).

Table 8 Summarises salinity hazard rankings for sub-catchment H4.4

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of discharge</td>
<td>Low</td>
</tr>
<tr>
<td>Line discharge</td>
<td>Very Low</td>
</tr>
<tr>
<td>Water table &lt; 5 m</td>
<td>High</td>
</tr>
<tr>
<td>TDS of groundwater</td>
<td>Medium</td>
</tr>
<tr>
<td>Flow weighted salinity</td>
<td>Low</td>
</tr>
<tr>
<td>Land management Unit</td>
<td>Medium</td>
</tr>
<tr>
<td>Bulk Score</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 9 Summarises asset risk ratings for sub-catchment H4.4

<table>
<thead>
<tr>
<th>Asset at risk</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>Very High</td>
</tr>
<tr>
<td>Rail</td>
<td>Low</td>
</tr>
<tr>
<td>Town</td>
<td>Low</td>
</tr>
<tr>
<td>Infrastructure Total</td>
<td>Very High</td>
</tr>
<tr>
<td>Agricultural</td>
<td>High</td>
</tr>
<tr>
<td>Public Land</td>
<td>Medium</td>
</tr>
<tr>
<td>VROT</td>
<td>Low</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Medium</td>
</tr>
<tr>
<td>Environment Total</td>
<td>High</td>
</tr>
<tr>
<td>Average Risk</td>
<td>Very High</td>
</tr>
<tr>
<td>Water Quality Risk</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 10 Summarises the intended management for sub-catchment H4.4, (source, GHCMA SMP).

<table>
<thead>
<tr>
<th>Management option (type)</th>
<th>Management option (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recharge control</td>
<td>No</td>
</tr>
<tr>
<td>Discharge management</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### 3.3 Salinity processes

Figure 19 shows the area, which was chosen from within the base level sub-catchment H4.4 to develop a conceptual hydrogeological model and determine how it responds to recharge management.
Figure 19 Area targeted for flowtube modelling within sub-catchment H4.4

Figure 20 to Figure 22 shows conceptual models of the hydrogeology under several transects listed in Figure 19 for sub-catchment H4.4. These conceptual models have been developed by key professionals during a workshop held in Ballarat during March and from limited geological logs throughout the sub-catchment.

Figure 20 Conceptual model of salinity process within sub-catchment H4.4
3.4 Groundwater modelling simulations and results

3.4.1 No Change Scenario

Figure 23 shows the stream EC trend from 1976 to 1986 for gauging station 236202 – Hopkins River at Wickliffe. This gauging station lies to the south of the modelled area and should only be used as a general indicator of the stream EC trends within this catchment. Unfortunately, at this stage we were unable to obtain a record of stream EC beyond 1986, which prevents the prediction of future trends for this base level sub-catchment.
3.4.2 Change Scenario

Two basic scenarios have been simulated for the base level sub-catchment:

1. Reduce recharge rates by 90% in the top quarter of the catchment,
2. Reduce recharge rates by 90% over the entire catchment.

Figure 24 shows the simulated location of the water levels for continual recharge that has been reduced by 90% in the top quarter of the catchment. It should be noted that after 100 years there is no change in the water level, suggesting that the system has reached a new equilibrium.
Figure 24 Shows the effect of reducing the recharge by 90% over the top quarter of the catchment. Water levels are simulated for 5, 10, 20, 50 and 100 years into the future.

This simulation clearly shows that reducing recharge in this area via land use change has quite a significant impact on highland groundwater levels with the upper half of the catchment drying right out. However, there is low confidence on aquifer thickness within this base level sub-catchment as there were only 2 bore logs that contained aquifer depth data. Therefore, the depth to basement was kept constant at an elevation of 200 m.

The final simulation in this base level sub-catchment is presented in Figure 25. Here the location of the water levels for continual recharge that has been reduced by 90% over the entire catchment is shown.
Figure 25 Shows the effect of reducing the recharge by 90% over the middle third of the catchment. Water levels are simulated for 5, 10 and 20 years into the future.

In this scenario, there is no change in the water level (i.e. a new equilibrium reached) after 150 years. This simulation clearly shows that reducing recharge in this area via land use change has quite a significant impact on highland groundwater levels. However, there is very little difference between this scenario and that demonstrated in Figure 24 Shows the effect of reducing the recharge by 90% over the top quarter of the catchment. Water levels are simulated for 5, 10, 20, 50 and 100 years into the future. It should be noted that the responsiveness of the aquifer is indicative of a Local Flow System.

3.5 Summary

Within this base level sub-catchment the assets most at risk are infrastructure, (roads and rail), agricultural and public land, therefore the modelling targeted the protection of these assets. It is evident from the FLOWTUBE modelling that recharge reduction significantly impacts water table elevation along the steeper slopes of the transect and depending on the extent of the land management new equilibriums can be seen from between 100 to 150 years. In the flatter part of the transect, recharge reduction seems to have very little effect of groundwater elevations.

This has significant implications on protecting assets such as infrastructure and agricultural land in this area as the primary reason they are at risk is due to the presence of the shallow saline groundwater. This is a region where discharge management becomes a priority and should be investigated further.
4 Sub-Catchment H7.3 (Mid Mt Emu Creek)

4.1 Description

Base level sub-catchment H7.3 is a large catchment with significant areas of salinity (mostly primary) associated with wetlands and lakes in GFS 2. This base level sub-catchment is considered a high priority for modelling as there are several important assets at risk including, infrastructure, public land, agriculture and environmental sites.

4.1.1 Salinity Action Plan Ranking:

H7.3 base level sub-catchment is Priority A1: salinity hazard, high/moderate value assets, groundwater system responds to recharge control activities. Options that may work and require modelling include: Recharge management, discharge management and engineering.

4.1.2 Problem GFS:

The problem GFS in this base level sub-catchment is:

GFS 2 – Local and Intermediate Flow Systems in the Volcanic plains (later phase volcanics)

Figure 26 shows the location of this GFS within the base level sub-catchment.
4.2 Asset Risk Assessment

Tables 11 to 13 identify the salinity hazard rankings, the asset risk ratings and the intended management options for sub-catchment H7.3, (source, Heislers and Brewin, 2003).
Table 11 Summarises salinity hazard rankings for sub-catchment H7.3

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of discharge</td>
<td>High</td>
</tr>
<tr>
<td>Line discharge</td>
<td>Very High</td>
</tr>
<tr>
<td>Water table &lt; 5 m</td>
<td>Low</td>
</tr>
<tr>
<td>TDS of groundwater</td>
<td>Medium</td>
</tr>
<tr>
<td>Flow weighted salinity</td>
<td>High</td>
</tr>
<tr>
<td>Land management Unit</td>
<td>High</td>
</tr>
<tr>
<td>Bulk Score</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 12 Summarises asset risk ratings for sub-catchment H7.3

<table>
<thead>
<tr>
<th>Asset at risk</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>Medium</td>
</tr>
<tr>
<td>Rail</td>
<td>N/A</td>
</tr>
<tr>
<td>Town</td>
<td>N/A</td>
</tr>
<tr>
<td>Infrastructure Total</td>
<td>Low</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Very High</td>
</tr>
<tr>
<td>Public Land</td>
<td>High</td>
</tr>
<tr>
<td>VROT</td>
<td>Very High</td>
</tr>
<tr>
<td>Wetlands</td>
<td>N/A</td>
</tr>
<tr>
<td>Environment Total</td>
<td>Very High</td>
</tr>
<tr>
<td>Average Risk</td>
<td>Very High</td>
</tr>
<tr>
<td>Water Quality Risk</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Table 13 Summarises the intended management for sub-catchment H7.3, (source, GHCMA SMP).

<table>
<thead>
<tr>
<th>Management option (type)</th>
<th>Management option (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recharge control</td>
<td>N/A</td>
</tr>
<tr>
<td>Discharge management</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### 4.3 Salinity processes

Figure 27 shows the area, which was chosen from within the base level sub-catchment H4.4 to develop a conceptual hydrogeological model and determine how it responds to recharge management.

![Figure 27 Area targeted for flowtube modelling within sub-catchment H7.3](image-url)
Figure 28 shows a conceptual model of the hydrogeology under transect A – A‘ listed in Figure 28 for sub-catchment H7.3. This conceptual model has been developed by key professionals during a workshop held in Ballarat during March and from limited geological logs throughout the sub-catchment.

4.4 Groundwater modelling simulations and results

4.4.1 No Change Scenario

Figure 29 shows the stream EC trend from 1974 to 2002 for gauging station 236202 – Mt Emu Creek at Taroon. This is the closest gauging station to this sub-catchment and it lies well downstream. It is for this reason that it should only be used as a general indicator of the stream EC trends within this catchment. The statistics show that there is an EC trend of \[ 9.7 \pm 21.8 \, \mu\text{S/cm/yr} \] however, this is not significant. Under a no change scenario, we would expect a similar trend.
4.4.2 Change Scenario

FLOWTUBE modelling within this base level sub-catchment was unsuccessful due to the complex hydrogeology. FLOWTUBE could not calibrate against the observed water levels, as the interaction between GFS 2 and 14 seems to be too great. The role the volcanic vent plays also adds further complexity to the system. In essence, too much water was coming in, either via recharge in GFS 2 or through-flow from GFS 14. For the model to calibrate against the observed water levels, unrealistic hydraulic conductivity values of greater than 50 m/d were required and/or increasing the depth to bedrock to greater than 100m. Also the amount of water entering the top of the catchment had to be reduced to virtually 0 m/d, which is not unrealistic for upland local flow systems but in this case there is significant through-flow from neighbouring catchments.

4.5 Summary

A more complex groundwater flow model such as MODFLOW along with higher array of input data is required to accurately model future groundwater response to land use change in this area. However, based on the conceptual model it is expected that by reducing recharge within GFS 2, you will significantly lower the water table in the upland reaches with the danger of drying and/or salting up Lake Gellie.
5 References


