CSIRO LAND and WATER

Victorian Volcanic Plains Scoping Study

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Final Report

Client Report for Corangamite Catchment Management Authority

October 2003
Executive Summary

This Scoping Study proposes a framework for an integrated, large-scale collaborative Research, Investigation and Communication program to better target National Action Plan for Salinity and Water Quality funding and to attract co-investment of research (not just National Action Plan for Salinity and Water Quality funding) within south-west Victoria. It was envisaged at the outset, that the program would align, and if necessary, enhance existing research projects as well as develop new projects to fill knowledge gaps and have a clear geographical focus. The Scoping Study will be distributed to the Corangamite, Glenelg-Hopkins and Port Phillip Catchment Management Authorities for consideration. Thus, the program needed synergies across the three Catchment Management Authorities.

Corangamite Catchment Management Authority commissioned Jim Cox (CSIRO Land and Water), Peter Dahlhaus (Dahlhaus Environmental Geology Pty Ltd & University of Ballarat) and Richard MacEwan (Victorian Department of Primary Industries) to produce this Scoping Study. The Scoping Study proposes that a program of research projects be developed to address salinity and water quality issues on the Victorian Volcanic Plains (VVP). The VVP span the three Catchment Management Authority regions. In economic, social and environmental terms, the VVP are of paramount importance to south-west Victoria as they encompass the majority of the region’s high-value assets. These include:

- **Agricultural assets** such as the horticultural industry around Werribee, the cropping industry around Ballarat, the dairy industry around Warrnambool and the wool-growing industry around Hamilton;

- **Environmental assets**, such as the wetlands of international importance in the Geelong and Colac regions, which are listed under the Ramsar convention and Chinese and Japanese migratory bird agreements. In addition, hundreds of significant wetlands, lakes, flora remnants and faunal habitats are registered across the VVP, which has recently been listed as one of the nation’s regions which are rich in biodiversity but under immediate threat;

- **Water quality assets**, including the urban water-supply catchments for the major provincial cities of Ballarat and Geelong;

- **Infrastructure assets**, including the major cities of Geelong, Ballarat, Werribee, Warrnambool, Portland, Hamilton and Colac. The area includes major transport corridors, power, gas and water transmission lines, and communication infrastructure; and

- **Cultural and heritage assets**, including the Lake Condah and Lake Connewarre aboriginal heritage sites, and the European historic sites of Portland, Geelong and Port Fairy.

The National Land and Water Audit predicts that within the Corangamite and Glenelg Hopkins Catchment Management Authority regions over 40% of the dryland agricultural land, most of which are on the VVP, are at risk of becoming saline by 2050. The impact of the associated loss of production due to salinity is estimated to cost the region approximately $90 million per annum by 2050. The Catchment Management Authorities largest Groundwater Flow System occurs below the VVP yet very little is known about its hydrological response to land use and climate change. The Scoping Study therefore has developed a research, investigation and communication framework, under the National Action Plan for Salinity and Water Quality principles, which will guide National Action Plan investment in land management change to ensure that the Audit’s prediction does not eventuate. The Scoping Study also includes a framework for ensuring the VVP research program is implemented. A Project Coordinator is required to consolidate, facilitate and communicate the research to the various groups and stakeholders as well as negotiate co-investment. Thus the Scoping Study does not limit itself to issues requiring only National Action Plan for Salinity and Water Quality funding but includes examples of national resource management research issues that require co-investment from other sources such as the National Heritage Trust, Research and Development Corporations and industry.
There is potential for the Catchment Management Authorities to collaborate in a range of projects that provide environmental and economic benefits to the agricultural industries utilising the VVP. While there are many issues within particular industries where Catchment Management Authorities could add value, there are two generic issues across the region where the Catchment Management Authorities could have significant input and provide improved economic and environmental outcomes under the National Action Plan for Salinity and Water Quality framework i.e. environmental impacts of the current agricultural industries and new environmentally and economically sustainable production systems.

To predict the future impacts of salinity under various land management scenarios the processes leading to salinity on the VVP must be clearly understood. The first set of proposed projects within the Scoping Study therefore increase our knowledge of the hydrology of the VVP. The second stage of research and investigation project priorities identified within the Scoping Study cut across water quality, biodiversity, cultural as well as salinity issues for both indigenous and non-indigenous communities on the VVP. The list of projects is not exhaustive and do not all qualify for National Action Plan for Salinity and Water Quality funding but are designed to stimulate and encourage cooperation between researchers and co-investors. The outcomes from this work must then be packaged within a communication plan easily accessible and understandable to land owners to ensure widespread adoption. Only then will this research and investigation lead to the development of environmentally sustainable farming practices (sustainable agriculture and biodiversity health) on the VVP.

In order to be effectual, the proposed VVP study must:

- have joint ownership, being funded through the three Catchment Management Authorities by National Action Plan for Salinity and Water Quality, National Heritage Trust and National Landcare Program, State funding, as well as co-investment by research partners;
- encourage and support research collaboration, bringing together and supporting projects with researchers and students from CSIRO, Department of Primary Industries, Victorian Universities, and CRCs (e.g. Hydrology and Landscape Environment and Mineral Exploration) but will not be restricted to these partners;
- have a reference committee which peer reviews projects for inclusion in the program, ensures co-investment is maximised, ensures deliverables are met and of high scientific merit and facilitates a communication plan for the deliverables; and
- be the platform for non National Action Plan for Salinity and Water Quality research and thus attract co-investment from the production oriented research providers (i.e. Land and Water Australia, Bureau of Rural Sciences, Grains Research and Development Corporation, Meat and Livestock Australia etc.).

The study will be promoted through the Catchment Management Authorities and federal and state research organisations websites as well as in the media to maximise its impact and co-investment. Once established, the study is expected to cost in excess of $2M per year with half these cost coming from National Action Plan for Salinity and Water Quality. This level of funding must be secured for the study to be successful.

To get the program started, projects to be funded in 2003/2004 by the Catchment Management Authorities will include those which address the Groundwater Flow Systems concept to increase our knowledge of the hydrology of the VVP. Other projects funded by the Catchment Management Authorities within their 2003/2004 investment plan will be assessed by the reference committee as to whether it forms part of the VVP Study and is therefore subject to the same rigour as other projects which fall under this umbrella.

Thus, endorsement of the proposed framework will lead to a substantial platform for collaborative research, investigation and communication that can serve the development and implementation of land management solutions for the VVP, that take account of:

- hydrology;
• climate change scenarios;
• conservation;
• land use change;
• farming systems;
• environmental management systems;
• indigenous issues; and
• socio-economic context.
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List of Acronyms
AROT; VROT Australian rare or threatened; Victorian rare or threatened (species)
CCMA Corangamite Catchment Management Authority
CRC Cooperative Research Centre
CSIRO Commonwealth Scientific and Industrial Research Organisation
DEM Digital elevation model
DPI Department of Primary Industries
DRDC Dairy Research and Development Corporation
DSE Department of Sustainability and Environment
EVC Ecological Vegetation Class
GFS Groundwater flow system
GHCMCA Glenelg Hopkins Catchment Management Authority
GMA Groundwater management area
GRDC Grains Research and Development Corporation
NAP National Action Plan
NAPSWQ National Action Plan for Salinity and Water Quality
NHT National Heritage Trust
NLWRA National Land and Water Resources Audit
NRE Department of Natural Resources and Environment
ORL Our Rural Landscapes
PAV Permissible annual volume
PIRV Primary Industries Research Victoria
PPCMA Port Phillip and Western Port Catchment Management Authority
RCIP Regional Catchment Investment Plan
RCS Regional Catchment Strategy
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIP</td>
<td>Regional Investment Panel</td>
</tr>
<tr>
<td>SAP</td>
<td>Salinity Action Plan</td>
</tr>
<tr>
<td>SRW</td>
<td>Southern Rural Water</td>
</tr>
<tr>
<td>VVP</td>
<td>Victorian Volcanic Plains</td>
</tr>
</tbody>
</table>
The “Victorian Volcanic Plains” (VVP) refers to a loosely defined area of south-west Victoria stretching from Melbourne in the east to the South Australian border in the west. It is commonly referred to as the “Western District Plains”, the “Western Plains” or the “Volcanic Plains”. The VVP region referred to in this document is generally coincident with the West Victorian Volcanic Plains geomorphic unit (Hills, 1940; Jenkin, 1988) and the Victorian Volcanic Plains (VVP) Bioregion (NLWRA, 2001a). A more defined boundary will ultimately emerge as priorities are set and the research develops.

In economic, social and environmental terms, the VVP are of paramount importance to south-west Victoria as they encompass the majority of the region’s high-value assets. These include:

- **Agricultural assets** such as the horticultural industry around Werribee, the cropping industry around Ballarat, the dairy industry around Warrnambool and the wool-growing industry around Hamilton.

- **Environmental assets**, such as the wetlands of international importance in the Geelong and Colac regions, which are listed under the Ramsar convention and Chinese and Japanese migratory bird agreements. In addition, hundreds of significant wetlands, lakes, flora remnants and faunal habitats are registered across the plains.

- **Water quality assets**, including the urban water-supply catchments for the major provincial cities of Ballarat and Geelong.

- **Infrastructure assets**, including the major cities of Geelong, Ballarat, Werribee, Warrnambool, Portland, Hamilton and Colac. The area includes major transport corridors, power, gas and water transmission lines, and communication infrastructure.

- **Cultural and heritage assets**, including the Lake Condah and Lake Connewarre aboriginal heritage sites, and the European historic sites of Portland, Geelong and Port Fairy.

The threat to the viability of the VVP has been graphically illustrated by the National Land and Water Resources Audit (NLWRA, 2001b). The Audit predicts that over 40% of the dryland agricultural land in the Corangamite, Glenelg Hopkins, and Port Phillip and Western Port CMA regions could be affected by shallow watertables within 50 years, the majority of which would be across the VVP (Figure 1.1; Tables 1.1, 1.2 & 1.3). The impact of the associated loss of production due to salinity is estimated to cost the region approximately $90 million per annum by 2050 (Figure 1.2, Tables 1.1, 1.2 & 1.3).

In terms of environmental assets, the situation is dire. The recent audit of Australia’s terrestrial biodiversity (NLWRA, 2002a) ranked the VVP in the highest stress class. This has resulted in the VVP being included in the national list of “biodiversity hotspots” which will result in priority funding as part of the government’s $2.7 billion Natural Heritage Trust. Greater than 95% of all native vegetation in the VVP has been cleared, 15% of Ecological Vegetation Classes (EVC) and floristic communities were probably extinct and 78% are threatened. Only 1% of the Plains Grassland and Grassy Woodland that once covered three-quarters of the region remains, and much of this is degraded. Sixty-five taxa are listed as nationally threatened (i.e. AROTS) and 173 are listed as threatened in Victoria (i.e. VROTS). These include 15 mammals, 61 birds, 4 reptiles, 1 frog, 8 fish, 2 invertebrates and 93 plants. Twelve are listed as extinct.

The wetlands and lakes are arguably the highest ranked assets of the VVP. Nine lakes are international assets, being listed as wetlands of international importance under the Ramsar Convention. An additional 26 wetlands are listed in the Directory of Important Wetlands in Australia (EA, 2001). Over 75% of the shallow freshwater wetlands have been modified or destroyed, and...
some of the most important lakes are being altered by drainage and manipulations of water flows resulting in permanent damage to their environmental quality (Williams, 1992).

The conservation of biodiversity in the wetlands is believed to be linked to the quality of refugia at various scales from global to regional. Refugia are areas of opportunity to which species move during periods when non-conducive conditions prevail (Craig Allen & Tim Corlett, pers. comm.). For example, refugia around Lake Corangamite may be the groundwater springs along the southern fringe of the lake (eg. McVeans Springs), or the smaller wetlands in the Stony Rises. Many of these groundwater dependent wetlands and springs are vital to the health of the larger ecosystems and the Western District lakes have also been recognised as important Australian groundwater dependent ecosystems with a high threat (Clifton & Evans, 2001).

![Figure 1.1 NLWRA predictions of threat to agricultural land](image-url)
Potential gross margin foregone for all agricultural commodities due to shallow water tables and salinity

Figure 1.2 NLWRA predictions of the cost of salinity to agriculture
## Table 1.1 NLWRA predictions for the Corangamite CMA

<table>
<thead>
<tr>
<th>Area of land (kha) in each watertable class (excluding forest, urban and irrigation areas)</th>
<th>Coastal</th>
<th>&lt;2m</th>
<th>2-5m</th>
<th>5-10m</th>
<th>&gt;10m</th>
<th>% &lt;2m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of land (kha)</td>
<td>9.9</td>
<td>51.2</td>
<td>333.3</td>
<td>545.0</td>
<td>91.5</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

| Area and percentage of CCMA in each salinity risk category for upper and lower limit trend values |
|---|---|---|---|---|---|
| No risk | Low risk | Moderate risk | High risk |
| Area (kha) | % | Area (kha) | % | Area (kha) | % | Area (kha) | % |
| Lower limit values | 91.4 | 8.9% | 554.9 | 53.8% | 384.6 | 37.3% | 0.0 | 0.0% |
| Upper limit values | 52.9 | 5.1% | 97.2 | 9.4% | 557.8 | 54.1% | 323.0 | 31.3% |

| Areas of land and proportion of dryland agricultural land predicted to have shallow water tables in 1998, 2020 and 2050 |
|---|---|---|---|
| Area (kha) | % | Pastures & crops ($M/y) | Total ($M/y) | Road (km) | Rail (km) | Towns |
| 1998 | 51.2 | 5.0% | 2.81 | 2.81 | 456 | 26 | 1 |
| 2020 lower limit | 50.9 | 4.9% | 2.85 | 2.85 | 457 | 25 | 0 |
| 2050 lower limit | 54.7 | 5.3% | 3.04 | 3.04 | 480 | 26 | 0 |
| 2020 upper limit | 213.3 | 20.7% | 9.64 | 9.64 | 1386 | 93 | 6 |
| 2050 upper limit | 499.1 | 48.5% | 24.10 | 29.40 | 4008 | 205 | 16 |

| Total length of stream and perimeter of surface water body and number of surface water bodies predicted to be located in areas with shallow watertables |
|---|---|---|---|---|
| Length (km) | Number | Flora | Fauna | RAMSAR |
| 1998 | 1045 | 658 | 3.1 | 5.6 | 1306 | 476 | 15.5% |
| 2020 lower limit | 1047 | 647 | 3.2 | 5.4 | 177 | 460 | 14.9% |
| 2050 lower limit | 1096 | 652 | 3.3 | 5.4 | 177 | 463 | 15.0% |
| 2020 upper limit | 2629 | 1222 | 9.0 | 20.6 | 31005 | 866 | 28.1% |
| 2050 upper limit | 5447 | 1546 | 20.6 | 30.3 | 32020 | 1256 | 40.8% |

| Percentages of threatened flora and fauna records in areas predicted to have shallow watertables |
|---|---|---|---|---|
| Length (km) | Number | Flora | Fauna | RAMSAR |
| 1998 | 1045 | 658 | 3.1 | 5.6 | 1306 | 476 | 15.5% |
| 2020 lower limit | 1047 | 647 | 3.2 | 5.4 | 177 | 460 | 14.9% |
| 2050 lower limit | 1096 | 652 | 3.3 | 5.4 | 177 | 463 | 15.0% |
| 2020 upper limit | 2629 | 1222 | 9.0 | 20.6 | 31005 | 866 | 28.1% |
| 2050 upper limit | 5447 | 1546 | 20.6 | 30.3 | 32020 | 1256 | 40.8% |

| Potential area of RAMSAR wetlands, number of natural wetlands and percentage of regional and state natural wetlands in areas predicted to have shallow watertables |
|---|---|---|---|
| Length (km) | Number | Flora | Fauna | RAMSAR |
| 1998 | 1045 | 658 | 3.1 | 5.6 | 1306 | 476 | 15.5% |
| 2020 lower limit | 1047 | 647 | 3.2 | 5.4 | 177 | 460 | 14.9% |
| 2050 lower limit | 1096 | 652 | 3.3 | 5.4 | 177 | 463 | 15.0% |
| 2020 upper limit | 2629 | 1222 | 9.0 | 20.6 | 31005 | 866 | 28.1% |
| 2050 upper limit | 5447 | 1546 | 20.6 | 30.3 | 32020 | 1256 | 40.8% |
## Area of land predicted to currently be in each depth to watertable class and percentage of GHCMA region with shallow water table

<table>
<thead>
<tr>
<th>Area of land (kha) in each watertable class (excluding forest, urban and irrigation areas)</th>
<th>Coastal</th>
<th>&lt;2m</th>
<th>2-5m</th>
<th>5-10m</th>
<th>&gt;10m</th>
<th>% &lt;2m</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.4</td>
<td>144.5</td>
<td>697.8</td>
<td>1051.5</td>
<td>280.7</td>
<td>6.6</td>
<td></td>
</tr>
</tbody>
</table>

## Area and percentage of GHCMA in each salinity risk category for upper and lower limit trend values

<table>
<thead>
<tr>
<th>No risk</th>
<th>Low risk</th>
<th>Moderate risk</th>
<th>High risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (kha)</td>
<td>%</td>
<td>Area (kha)</td>
<td>%</td>
</tr>
<tr>
<td>Lower limit values</td>
<td>280.0</td>
<td>12.8</td>
<td>1058.5</td>
</tr>
<tr>
<td>Upper limit values</td>
<td>91.6</td>
<td>4.2</td>
<td>140.6</td>
</tr>
</tbody>
</table>

## Areas of land and proportion of dryland agricultural land predicted to have shallow water tables in 1998, 2020 and 2050

<table>
<thead>
<tr>
<th>Area (kha)</th>
<th>%</th>
<th>Pastures &amp; crops ($M/y)</th>
<th>Total ($M/y)</th>
<th>Road (km)</th>
<th>Rail (km)</th>
<th>Towns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>144.5</td>
<td>6.6</td>
<td>7.19</td>
<td>7.19</td>
<td>738</td>
<td>34</td>
</tr>
<tr>
<td>2020 lower limit</td>
<td>144.1</td>
<td>6.6</td>
<td>6.77</td>
<td>6.77</td>
<td>738</td>
<td>31</td>
</tr>
<tr>
<td>2050 lower limit</td>
<td>145.2</td>
<td>6.7</td>
<td>6.84</td>
<td>6.84</td>
<td>745</td>
<td>31</td>
</tr>
<tr>
<td>2020 upper limit</td>
<td>429.6</td>
<td>19.7</td>
<td>18.64</td>
<td>18.64</td>
<td>2153</td>
<td>73</td>
</tr>
<tr>
<td>2050 upper limit</td>
<td>947.2</td>
<td>43.4</td>
<td>42.26</td>
<td>42.26</td>
<td>5027</td>
<td>174</td>
</tr>
</tbody>
</table>

## Potential gross margin foregone for pastures and crops and all agricultural commodities due to shallow water tables and salinity

| Potential length of road and rail network and number of towns (populations <10,000 occurring in areas with shallow water tables) |
|---|---|---|---|---|
| Area (kha) | % | Pastures & crops ($M/y) | Total ($M/y) | Road (km) | Rail (km) | Towns |
| 1998 | 144.5 | 6.6 | 7.19 | 7.19 | 738 | 34 | 0 |
| 2020 lower limit | 144.1 | 6.6 | 6.77 | 6.77 | 738 | 31 | 0 |
| 2050 lower limit | 145.2 | 6.7 | 6.84 | 6.84 | 745 | 31 | 0 |
| 2020 upper limit | 429.6 | 19.7 | 18.64 | 18.64 | 2153 | 73 | 3 |
| 2050 upper limit | 947.2 | 43.4 | 42.26 | 42.26 | 5027 | 174 | 10 |

## Total length of stream and perimeter of surface water body and number of surface water bodies predicted to be located in areas with shallow watertables

<p>| Percentages of threatened flora and fauna records in areas predicted to have shallow watertables |
|---|---|---|---|
| Total area of RAMSAR wetlands, number of natural wetlands and percentage of regional and state natural wetlands in areas predicted to have shallow watertables |</p>
<table>
<thead>
<tr>
<th>Length (km)</th>
<th>Number</th>
<th>Flora</th>
<th>Fauna</th>
<th>RAMSAR</th>
<th>Natural</th>
<th>%</th>
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<tbody>
<tr>
<td>1998</td>
<td>2382</td>
<td>692</td>
<td>3.7</td>
<td>5.6</td>
<td>176</td>
<td>831</td>
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<tr>
<td>2020 lower limit</td>
<td>2428</td>
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<td>2050 lower limit</td>
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<td>2020 upper limit</td>
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<td>21.8</td>
<td>31.1</td>
<td>483</td>
<td>2479</td>
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**Table 1.2 NLWRA predictions for Glenelg Hopkins CMA**
### Area of land predicted to currently be in each depth to watertable class and percentage of PPCMA region with shallow water table

<table>
<thead>
<tr>
<th>Area of land (kha) in each watertable class (excluding forest, urban and irrigation areas)</th>
<th>Coastal</th>
<th>&lt;2m</th>
<th>2-5m</th>
<th>5-10m</th>
<th>&gt;10m</th>
<th>% &lt;2m</th>
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<tbody>
<tr>
<td></td>
<td>20.1</td>
<td>8.5</td>
<td>205.6</td>
<td>399.9</td>
<td>157.8</td>
<td>1.19</td>
</tr>
</tbody>
</table>

### Area and percentage of PPCMA in each salinity risk category for upper and lower limit trend values

<table>
<thead>
<tr>
<th>No risk</th>
<th>Low risk</th>
<th>Moderate risk</th>
<th>High risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (kha)</td>
<td>%</td>
<td>Area (kha)</td>
<td>%</td>
</tr>
<tr>
<td>Lower limit values</td>
<td>116.9</td>
<td>14.8</td>
<td>460.7</td>
</tr>
<tr>
<td>Upper limit values</td>
<td>5.5</td>
<td>0.7</td>
<td>428.2</td>
</tr>
</tbody>
</table>

### Areas of land and proportion of dryland agricultural land predicted to have shallow water tables in 1998, 2020 and 2050

<table>
<thead>
<tr>
<th>Area (kha)</th>
<th>%</th>
<th>Pastures &amp; crops ($M/y)</th>
<th>Total ($M/y)</th>
<th>Road (km)</th>
<th>Rail (km)</th>
<th>Towns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>8.5</td>
<td>1.1</td>
<td>0.33</td>
<td>0.33</td>
<td>107</td>
<td>1</td>
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<tr>
<td>2020 lower limit</td>
<td>7.0</td>
<td>1.1</td>
<td>0.26</td>
<td>0.26</td>
<td>88</td>
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<tr>
<td>2050 lower limit</td>
<td>7.0</td>
<td>1.1</td>
<td>0.26</td>
<td>0.26</td>
<td>89</td>
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<tr>
<td>2020 upper limit</td>
<td>43.2</td>
<td>5.1</td>
<td>1.84</td>
<td>3.62</td>
<td>357</td>
<td>14</td>
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<tr>
<td>2050 upper limit</td>
<td>134.1</td>
<td>16.9</td>
<td>5.87</td>
<td>17.76</td>
<td>1257</td>
<td>79</td>
</tr>
</tbody>
</table>

### Total length of stream and perimeter of surface water body and number of surface water bodies predicted to be located in areas with shallow watertables

<table>
<thead>
<tr>
<th>Length (km)</th>
<th>Number</th>
<th>Flora</th>
<th>Fauna</th>
<th>RAMSAR</th>
<th>Natural</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>169</td>
<td>50</td>
<td>0.8</td>
<td>3.3</td>
<td>644</td>
<td>59</td>
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<tr>
<td>2020 lower limit</td>
<td>163</td>
<td>39</td>
<td>0.8</td>
<td>1.8</td>
<td>4112</td>
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<td>2050 lower limit</td>
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<td>4089</td>
<td>48</td>
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<tr>
<td>2020 upper limit</td>
<td>829</td>
<td>164</td>
<td>3.8</td>
<td>7.5</td>
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<td>121</td>
</tr>
<tr>
<td>2050 upper limit</td>
<td>2120</td>
<td>320</td>
<td>8.2</td>
<td>12.9</td>
<td>6883</td>
<td>282</td>
</tr>
</tbody>
</table>

Table 1.3 NLWRA predictions for Port Phillip and Western Port CMA
The health of waterways and rivers throughout the VVP is poor, with a majority of stream lengths being rated in poor or very poor condition. An assessment of Australia’s catchments, rivers and estuaries rated the Werribee River, Moorabool River, Barwon River, Lake Corangamite and Hopkins River catchments as being in the poorest condition and the highest landscape stress in the South East Drainage Division (NLWRA, 2002b). The vast majority of area of all of these catchments lies within the VVP (as defined in this study).

The health of waterways impacts water quality assets, particularly urban and irrigation water quality. In the Moorabool River, increasing salinity is an urgent threat to the urban water supply for both the City of Ballarat and the City of Greater Geelong (Dahlhaus, 2003b). The salinity trends in the Moorabool River system have been dramatically increasing over the past 26 years. The linear trend in EC measured at the Batesford gauging station (# 232202) from November 1976 to October 2001 is $18.7 \pm 7.0 \mu S/cm/yr$ EC. The non-linear trend (Figure 1.3) shows the dramatic rise from 1170 $\mu S/cm$ to 1940 $\mu S/cm$ over that period. The average salt load was calculated as 37 tonnes/day (Dahlhaus, Smitt & Cox, in prep.).

![MOORABOOL RIVER @ BATESFORD (# 232202)](chart)

**Figure 1.3 Salinity trend in the Moorabool River at Batesford 1976 to 2001**

(Source: Dahlhaus, Smitt & Cox, in prep.)

Salinity is carried from the landscape in the region’s streams and rivers. Over the past twenty five years the average salt load in the Barwon River has been 280 tonnes of salt per day, or a little over 100,000 tonnes per year. The majority of this salt is gained as the Barwon River traverses the VVP north of Winchelsea, as groundwater flowing from the extensive basalt aquifers to the west enters the river as baseflow (Coram, 1996, Gill, 1988, Lamson, 1990, Roderick, 1988, SKM, 1997).

As an asset, groundwater quality and quantity is equally important to many parts of the VVP as surface water. Finding the right balance between the competing beneficial uses of groundwater assets in the areas around Bungaree, Warrion, Werribee and Condah is a current and contentious issue. Assigning a Permissible Annual Volume (PAV) of extraction for the Groundwater Management Areas (GMA) requires a much greater understanding of the hydrogeology for the entire VVP, and some argue that many of the PAVs are already unsustainable.

Groundwater contamination, especially by nitrate, is common in most cropping and dairy farming areas where the groundwater is at shallow depths. In the Lake Corangamite region nutrient contamination of the groundwater has been recorded at most springs, with nitrate at McVeans Springs increasing from 0.13 mg/L in 1906 to 16 mg/l in 1994 (Bayne, 1998).
Infrastructure assets on the VVP are threatened by both shallow watertables and salinity. In the National Salinity Audit (NLWRA, 2001b), 891 kilometres of road, 61 kilometres of railways and one town (<10,000 population) are currently threatened by shallow watertables in the region (Tables 1.1, 1.2 & 1.3). It is predicted that these figures could rise to 10292 kilometres of road, 458 kilometres of railways and 34 towns by 2050, in the worse case scenario. The majority of these threats lie within the VVP, as the area with the shallowest watertables.

Other examples of threats to infrastructure assets can be found in the target areas of the draft Corangamite region Salinity Action Plan (SAP) (Nicholson et al., 2003). Thirty-one kilometres of sealed road, 25 kilometres of unsealed road and 71 kilometres of tracks intersected mapped salinity discharge areas in the VVP (Dahlhaus, 2003b). This represented an estimated cost of around $200,000 per annum in maintenance (Tucker et al., 2003). Also identified were threats to utility assets such as electricity, water, gas and phone infrastructure across many regions of the VVP (Dahlhaus, 2003a, Heislers & Brewin, 2003).

The threat to cultural and heritage assets is more difficult to quantify, as the details on the locations of the majority of Aboriginal heritage sites are unavailable in the public domain. However, it is known that tribes of the Wathaurong, Gulidjan, Djargurdwurung, Giraiwurung and Gunditjmara language groups occupied the VVP region (Clark, 1990, Horton, 2000). An account of the life of the convict William Buckley who escaped from a settlement at Sorrento in 1803 and lived in the region with the Wathaurong community (probably the Wada wurrung balug clan) for 32 years, records the VVP as being a rich and diverse source of food (Flannery, 2002). With the European colonisation of Western Victoria, the VVP were an early target for squatters as the relative abundance of grass and fewer trees made pastoralism attractive. Historic homesteads and other artefacts of historical significance are abundant across this landscape.

1.1 Administrative responsibilities

The VVP extend across major portions of three Catchment Management Authority regions – Port Phillip and Western Port (PPCMA), Corangamite (CCMA) and Glenelg Hopkins (GHCMA), and into the southern portion of North Central CMA region (NCCMA) (Figure 1.4). The CMAs provide the strategic direction for natural resource management throughout the VVP region via the development of their Regional Catchment Strategies (RCS). The CMA boards and implementation committees ensure strong community representation at this strategic level. Responsibilities of the CMAs include waterway health and management, floodplain and rural drainage management, coordination of dryland salinity management under the Catchment and Land Protection Act (1994). They also ensure the coordination of Natural Heritage Trust (NHT), National Action Plan (NAP) for Salinity and Water Quality and regional catchment grant processes.

The combined CCMA and the GHCMA area has been designated a single NAP priority region whilst the NCCMA area is an additional NAP region. The NAP aims to:

- Prevent, stabilise and reverse trends in dryland salinity affecting the sustainability of production, the conservation of biological diversity and the viability of our infrastructure.
- Improve water quality and secure reliable allocations for human uses, industry and the environment.

The municipalities, water authorities and infrastructure managers will be engaged in this project as part of the set of stakeholders who will benefit from its deliverables. The ultimate outcome of the project is best-practice land and water use.
The Department of Sustainability & Environment (DSE) and the Department of Primary Industries (DPI) (both formerly within the Department of Natural Resources & Environment) are responsible for different aspects of environmental management. DSE is largely responsible for strategic direction of public and crown land management, forestry and fire management on public land, flora and fauna management, environmental flow, water monitoring and greenhouse issues.

The Department of Primary Industries (DPI) maintains a focus on activities such as mining and extraction industries, agriculture and fisheries programs. Key roles of the Department Primary Industries (DPI) are the delivery of extension services (salinity, soil conservation, pest management, agriculture and vegetation) via the Catchment and Agriculture Services business, and research via the science platforms within Primary Industries Research Victoria (PIRVic) the research and development division in DPI.

Parks Victoria manages Victoria’s parks and conservation reserve network, including the international assets such as the Ramsar lakes and wetlands. The Environment Protection and Biodiversity Conservation Act 1999, which operates in conjunction with a range of other State legislation affects the management of the region’s environmental assets, including the management and protection of primary saline wetlands for their biodiversity values.

Southern Rural Water (SRW) is the agency responsible for management of water allocations to private and industrial users, streamflow management plans, waterway determinations and groundwater allocation and monitoring. It is a key organisation that plays a critical role in balancing

Figure 1.4 CMAs in the VVP research region

1.1.1 The Department of Sustainability & Environment (DSE) and the Department of Primary Industries (DPI) (both formerly within the Department of Natural Resources & Environment)

The Department of Sustainability & Environment (DSE) is largely responsible for strategic direction of public and crown land management, forestry and fire management on public land, flora and fauna management, environmental flow, water monitoring and greenhouse issues.

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1.1.2 Parks Victoria

Parks Victoria manages Victoria’s parks and conservation reserve network, including the international assets such as the Ramsar lakes and wetlands. The Environment Protection and Biodiversity Conservation Act 1999, which operates in conjunction with a range of other State legislation affects the management of the region’s environmental assets, including the management and protection of primary saline wetlands for their biodiversity values.

1.1.3 Southern Rural Water

Southern Rural Water (SRW) is the agency responsible for management of water allocations to private and industrial users, streamflow management plans, waterway determinations and groundwater allocation and monitoring. It is a key organisation that plays a critical role in balancing
the use of freshwater surface and groundwater resources with longer-term downstream impacts within river systems.

1.1.4 Urban Water Authorities - Water Supply Catchments

The region’s urban water authorities include Western Water, Barwon Water, Central Highlands Water, Grampians Water, South West Water, Glenelg Water and Portland Coast Water. These organisations have undertaken much of the planning and development in improving water quality supplies, and managing or reducing the salinity and nutrient impacts within water supply catchments. These authorities are also the referral agent for statutory planning within proclaimed water supply catchments.

1.1.5 Local Government

Local governments oversee strategic planning and deliver statutory planning responsibilities (under the DSE) and as such they play an active role in directing preferential land use change within the VVP region. There are approximately 15 municipalities (Figure 1.5) with jurisdiction over parts of the VVP. Land-use management is critical to the management of salinity and water quality. Local government is increasingly taking a lead role in the development of resource management strategies within their boundaries and effective salinity and water quality management will require support from this key level of government.

![Figure 1.5 Municipalities in the VVP research region](image)

1.1.6 Infrastructure and utility asset managers

Salinity and shallow groundwater can have a major impact on the life expectancy of regional infrastructure and utilities. VicRoads manage the major freeway and highway infrastructure within the region, whereas local government manages the local municipal roads. Other managers of
widespread regional infrastructure include VicTrack (railways) Powercor (electricity), Telstra (telecommunications) and gas suppliers. In a region that is highly populated, the impacts of salinity on infrastructure could be very significant.

### 1.1.7 Landholders and Industry Groups

Through the CMAs, areas of common interest between meat, wool, grain, dairy, forestry and natural resource organisations are being identified and mechanisms proposed to enhance joint work on those common areas will be developed. Groups such as DPI (research, extension, policy), Best Wool 2010, Sustainable Grazing Systems, Southern Farming Systems, West Vic Dairy, Victorian Farmers Federation, various consultants and landcare groups have many common links with salinity and water quality management on the VVP. Many of these groups have common goals that relate to increased production as well as improved sustainability (water, soil, nutrient use). In the context of the VVP project, developing partnerships with these industry and landholders will be critical to enhancing the uptake of improved land use practices across the region.

### 1.1.8 Natural Resource and Environment Organisations

Organisations such as local landcare groups and networks, Greening Australia, Trust for Nature, Australian Conservation Volunteers, Coast Action Groups, Field Naturalists, local environment and friends groups, Fishcare and Victorian Field and Game Association, Australian Plants, lake committees plus many more are working tirelessly to improve the state of their local environments. Many of these groups have developed their local plans and strategies and are keen to access support to implement their plans. Developing partnerships and harnessing this network of knowledge, skills and enthusiasm will need to be a key objective of the VVP research program.

### 1.1.9 Aboriginal/Indigenous Community

The protection and management of archaeological sites is a key issue for the indigenous community. Many of the indigenous heritage sites in the VVP region are surface water bodies, which have suffered by manipulation of both surface and groundwater hydrology. The VVP project recognises the need for consultation and cooperation with local cultural heritage organisations to ensure appropriate implementation measures are used in and near all significant sites.
2 Landscape elements

The VVP research region extends across south west Victoria from Port Phillip Bay to Portland, and has been delineated on the geomorphological characteristics of the landscape, being the landforms associated with the Newer Volcanics geological formation (Figure 2.1). The area is over 2.4 million hectares in size and includes the highland volcanic rocks as they are physically and hydrologically connected to the plains volcanic rocks area, although they are generally narrower and thicker valley flows.

![Figure 2.1 VVP research project study area](image)

2.1 Geology

The majority of the VVP landscape is composed of older and recent phases of the Newer Volcanics formation. The eruptive activity that formed the Newer Volcanics formation spanned the Late Neogene and Quaternary Periods, from the Early Pliocene to the Holocene epochs. The earliest flows are dated to 4.6 Ma\(^3\), with a peak of activity at around 2.4 Ma and the youngest around 7 ka\(^4\) (Joyce, 1988). In a stratigraphic context, they unconformably overlie the variety of rocks exposed in the pre-volcanic landscape. These include Palaeozoic igneous, sedimentary and metamorphic rocks, Mesozoic sedimentary rocks, and Cainozoic sedimentary rocks (Edwards et al., 1996). Extensive breaks in the eruptive history allowed weathering and soil formation on some of the basalts, which have been subsequently covered by later lava flows. Engineering geological investigations west of Melbourne has revealed that the basalts create a complex arrangement of the individual flows in three-dimensional space (Dahiau & O'Rourke, 1992). The relative ages of the flows have been mapped on the basis of their stratigraphic relationships (Yates, 1954), weathering and regolith characteristics (Gibbons & Gill, 1964), geochemical composition and mineralogy (Price et al., 1988), and palaeomagnetism (Taylor et al., 1996).

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\(^3\) Millions of years before present
\(^4\) Thousands of years before present
The Newer Volcanics are subdivided into two major groupings. The majority of the basalts that dominate the plains comprise a thin (generally <50 m) veneer of tholeiitic or chemically transitional composition. These are generally considered older, and are sometimes referred to as the Earlier Newer Volcanics (Joyce, 1988). The less extensive volcanics which form the eruption points (scoria cones, maars, tuff rings, and lava shields) are dominantly alkalic composition (Price et al., 1988) and considered younger (Later Newer Volcanics).

**Figure 2.2** Extent of the Newer Volcanics Formation

### 2.2 Geomorphology

The VVP research area extends across two of Victoria’s geomorphological divisions; viz: the Western Uplands and the Western Plains (Jenkin, 1988).

#### 2.2.1 Western Uplands

The Victorian Western Uplands extend west of the Kilmore Gap (a geocol) to the western edge of the Dundas Tableland. They have been divided into the dissected uplands, sometimes referred to as the Midlands (Hills, 1940; Jenkin, 1988), the strike ridges and valleys of the Grampians; and the tablelands, including the Dundas, Merino and Stavely Tablelands.

The VVP research area falls within the dissected uplands unit, which is characterised by a variety of interwoven landforms preserved by substantial uplift during the Palaeogene and late Neogene (Taylor et al., 1996). The uplift appears to be greater in the eastern parts of the VVP research area.

Undulating hills and broad valleys characterise the landscapes formed on the Palaeozoic sedimentary rocks and granite plutons. Remnants of an Early Cainozoic palaeoplain occur as caps of Palaeogene gravels sporadically distributed at various elevations east of Ararat. A remnant of the sands deposited during the Pliocene marine regression fringes the southern Palaeozoic rocks.
as a dissected tableland and extends across the Stavely Tableland and Dundas Tableland as strand lines (Bennett & Paine, pers. comm.).

The recently formed volcanic landscapes in the Western Uplands contrast with the older Cainozoic landscapes. The basalts of the Plio-Pleistocene eruptions of the Newer Volcanics fill many of the large ancient valleys to form elongate planar VVP are usually fringed by streams of the displaced drainage. The eruption points form prominent lava cones, composite cones and low shield volcanoes. The prominent volcanic cones of Mt Buninyong (745 m), Mt Warrenheip (741 m), and Tipperary Hill (743 m) are now the highest elevations of the VVP research region.

The soils on both the sedimentary rocks and the granites are regarded as agriculturally ‘poor’ compared to the soils of the Newer Volcanics, which exhibit gradational clayey chocolate soils and kraznozems on the younger rocks to coarsely structured duplex soils on the older rocks. The combination of kraznozem soils and a substantial groundwater resource for irrigation makes the volcanic landscapes in the Bungaree area one of the most valuable agricultural assets in Victoria.

2.2.2 Western Plains

The vast majority of the VVP research area lies within the Victorian Western Plains, comprising undulating plains formed on both volcanic and sedimentary rocks. The landscapes of this physiographic unit are formed on some of the youngest rocks in Australia.

2.2.3 Volcanic plains

The volcanic plains were built up by sporadic volcanic eruptions over a period of about 5 million years. The eruptions resulted in lobes of lava flowing from the eruption points, which overlap to form a variable thickness of basalt, interleaved with sporadic pyroclastic deposits of scoria and tuff. At times, lengthy breaks between eruptions allowed soils to form on the upper surface of the basalt flows which were subsequently covered by later eruptions, forming discontinuous buried palaeosoil horizons of variable thickness.

Drainage across the volcanic plains is generally poorly developed. The uplift of the Otway Ranges and the disruption of drainage by the volcanic eruptions resulted in the formation of a shallow basin in the central Corangamite CMA region, where the majority of lakes, including Lake Corangamite, are situated. The fluctuating lake levels during the Pleistocene resulted in lunette formation, especially prominent in the Beeac-Eurack district.

Lava from the volcanic eruptions was often very fluid and flowed to the lowest point on the landscape, often resulting in blocked drainage systems. The Wannon, Glenelg, Curdies and Barwon Rivers were probably the most affected and their present day courses have been strongly influenced by the eruptive history of the region.

The most obvious features – scoria cones, lava cones, composite (scoria-lava) cones, and maars – indicate the places of last eruptive activity. Mount Napier (439 metres) Mount Anakie (398 metres) and Mt Elephant (393 metres) form the highest cones. Some of the maars and craters contain lakes, such as Lake Purrumbete, Lake Bullen Merri and Lake Gnotuk.

The stony rises represent the most recent volcanic activity, the most prominent of which are the Harman Valley basalt flows from Mount Napier (32 ka) and the platform from which the Mount Porndon (289 metres) scoria cones rise (59 ka), placing them among the youngest landforms in Australia (Stone et al., 1997). The stony rises are characterised by rocky and undulating landscapes, comprising stony mounds with little or no soil and no surface drainage development. Older stony rise landscapes, have some soil development, some small ephemeral lakes, swamps and wetlands which have formed in the depressions, but no significant surface drainage systems. As the stony rise landscapes develop through geological time, they evolve into plains with poorly developed drainage.
The plains of the Newer Volcanic basalts that formed in the Late Pliocene and during the Pleistocene are generally characterised by thinner regolith development and poorly developed drainage. In these landscapes, flow boundaries are obvious, and corestones (‘floaters’) are often seen at the surface. Shallow drainage lines have developed, often along the boundaries of lava flows. Discontinuous drainage lines may end at ephemeral wetlands and swamps.

The earlier Pliocene volcanic landscapes are represented by plains with well developed drainage. These areas are characterised by very planar landscapes with thicker soil development, sometimes referred to as the Hamilton regolith unit (Ollier & Joyce, 1986).

Lakes and swamps, both permanent and ephemeral dominate parts of the volcanic plains landscapes. Hydrologically, the lakes vary from hypersaline groundwater discharge lakes (eg. Lake Beeac) to groundwater throughflow lakes with surface water input (eg. Lake Murdeduke) (Coram et al., 1998).

### 2.2.4 Sedimentary plains

The sedimentary plains mainly comprise the marine sands deposited by the retreating Pliocene sea and the exposed underlying Gellibrand Marls and Port Campbell Limestone. The sand plains also appear in ‘windows’ within the volcanic plains, where they were not covered by lava from the Newer Volcanic eruptions.

The sand plains outcrop along the southern edge of the VVP, from Barwon Heads to Warrnambool. Along the western edge of the VVP, from Portland to Dartmoor, the sands are underlain by karstic limestone. The sands are the most extensive stratigraphic unit underlying the VVP region.

### 2.3 Soils

Soils and landform mapping in the GHCMA and CCMA regions has been recently revised at a scale of 1:100,000 (Baxter & Robinson 2001, Robinson et al. 2003). PPCMA and NCCMA regions have earlier mapping at scales from 1:25,000 to 1:250,000). In spite of some common geological parent material (volcanic plains) the soils of the region have wide and varied properties. These differences result from the form of the parent material (ash, scoria, viscous basalt flows), age of the land surface (time period for weathering), relative relief or position in the landscape, and rainfall. The last two factors, relief and rainfall, largely control the hydrological weathering environment in which the soils have formed.

Soils associated with slopes and low hills of the volcanic cones are well-structured and well-drained non-cracking clay soils, which generate zero to very little runoff with excess water largely contributing to local recharge. These soils are largely used for irrigated horticulture as they also are in areas with easy access to fresh groundwater.

Soils associated with maars, paleo-lakes, and depressions within the stony rises are dominated by heavy, cracking-clays, the surfaces of some having self-mulching properties. These soils are poorly drained and relatively impermeable when saturated, although, when dry, deep cracks may connect to fractured basaltic rock and therefore provide a pathway to groundwater. These soils have higher levels of salinity than others in the region, largely because of their topographic position (low in the landscape) and they are also sodic.

More generally, soils of the plains have texture contrast soils with fine sandy loam to clay loam surface textures and medium or heavy clay subsoils. The relatively flat (undulating plain) landform disguises a highly variable (gilgai) subsoil, which is usually sodic and dispersive and may also contain large amounts of free calcium carbonate. Sodicity and carbonate content appear to increase from west to east, with soils in the eastern portion of the VVP having large amounts of calcium carbonate in the subsoil. This feature is probably related to a climatic gradient across the plain. The fine sand, which dominates the topsoil has not originated from the basalt but has been
transported from sedimentary plain material or from quartz rich sources (granite and palaeozoic sediments) in the surrounding uplands. Fine buckshot is often a feature in these soils. These soils have complex hydrological properties and are very prone to waterlogging.

Soils of the sedimentary plains occur where basalt coverage has been incomplete. These are also texture contrast soils but with lighter surface textures (loamy sand to sandy loam) than those on the volcanic plain. Topsoils are shallow and have sharp or abrupt boundaries to sodic clay subsoils. The overall soil profiles are generally shallow overlying an iron-cemented remnant of the coastal sand plain. Topsoil and shallow subsoil may often have large quantities of coarse iron rich gravel.

### 2.4 Climate

The VVP generally receive between 500 and 700 mm of rainfall per annum (Dahlhaus, 2002). Rainfall is generally higher in winter and spring, although for much of the area, it is relatively evenly distributed between the seasons. The average annual precipitation generally decreases from southwest to northeast across the region. The area east of the Brisbane Ranges (Rowsley Fault) and Lovely Banks Monocline lies within a rain shadow and receives less than 500 mm (eg. Melton, 490 mm; Balliang East, 474 mm). The variation in average annual rainfall ranges from 840 mm at Portland, 720 mm at Colac, 680 mm at Hamilton, 630 mm at Skipton, and 530 mm at Cressy.

Rainfall and evapotranspiration for the VVP has an effect on water budgets and land-use management options. Research on the effect of climate change on the hydrologic budgets of Lakes Keilambete, Gnotuk and Bullenmerri suggests that the precipitation to evaporation ratio has changed over the past 100 years to a drier state (Jones, 1995). In fact, palaeoclimate changes have been associated with changes to lake levels and salinities over the past 16,000 years and beyond (Bowler & Hamada, 1971). Climate change (past, current and predicted climate change) has a dramatic influence on groundwater levels, the expansion or contraction of salinity, and salinity of wetlands and surface water bodies. Climate change may also have drastic impact on land-use changes.

### 2.5 Surface hydrology

#### 2.5.1 Rivers and Creeks

The vast majority of the VVP lie within the South East Drainage Division of Australia. The river basins include (from east to west) Yarra River, Maribyrnong River, Werribee River, Moorabool River, Barwon River, Lake Corangamite, Hopkins River, Glenelg River and the Portland Coast (Figure 2.3). By comparison to the adjacent geomorphic units, the drainage of the VVP is discontinuous and sparsely distributed. Very few of the streams and rivers originate on the plains, as most have their headwaters in the Western Uplands or Southern Uplands.

Waterways of the VVP are generally rated as being in poor health. Within the Corangamite CMA, 51% of waterways are rated as moderate to poor health, with riparian zones extensively cleared. The waterways of the Hopkins Basin have the highest proportion of stream reaches in the poor to very poor rating in Victoria. Issues affecting waterway health include erosion, sedimentation, lack of vegetation cover on stream banks, native vegetation removal, grazing stock in waterways, increasing salinisation, eutrophication, pollution, changes to hydrology and irrigation, diversion and drainage schemes (Ross et al., 2002).

The observations and experiences of the early settlers are important in establishing the extent of changes to the surface hydrology. One of the earliest accounts was that of Mathew Flinders who described the walk across the Werribee Plains to the You Yangs on the morning of May 1st 1802, as “Our way was over a low plain, where the water appeared frequently to lodge; it was covered with small-bladed grass, but almost destitute of wood, and the soil was clayey and shallow.” (Flannery, 2000). Another account in 1839 described the VVP then as “…wind-swept with wire-like grass and tussocks…no trees…in winter the land was soft and boggy and too poor and risky for sheep. It was possible to walk from Darlington to Geelong without stepping on grass.” (McArthur,
quoted in (CPA, 1957). These accounts testify to the frequent waterlogging and generally poor drainage of many areas of the VVP. Many of the early agricultural works were focused on improving drainage, which has subsequently modified the hydrology.

![River basins of the VVP](image)

**Figure 2.3 River basins of the VVP**

<table>
<thead>
<tr>
<th>River basin</th>
<th>Index of Stream Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>Maribyrnong</td>
<td>16</td>
</tr>
<tr>
<td>Werribee</td>
<td>1</td>
</tr>
<tr>
<td>Moorabool</td>
<td>0</td>
</tr>
<tr>
<td>Barwon</td>
<td>0</td>
</tr>
<tr>
<td>Corangamite</td>
<td>0</td>
</tr>
<tr>
<td>Hopkins</td>
<td>0</td>
</tr>
<tr>
<td>Glenelg</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 2.1: Physical condition of streams for each river basin (Ross et al., 2002).

### 2.5.2 Lakes and wetlands

There is a high density of lakes and wetlands on the VVP. The GHCMA region has 44% of the total Victorian wetlands. In the Corangamite CMA, there are over 1400 wetlands, covering more than 65,000 ha. It is estimated that more than 3,000 wetlands (covering 17,000 ha) have been drained or grazed.

The wetlands of the VVP are among Australia’s greatest environmental assets. Nine lakes in the VVP are included in the Ramsar convention of wetlands of international importance. They are

- Lake Beeac
- Lake Bookar
- Lake Colongulac
Lake Corangamite
Lake Cundare
Lake Gnarpurt
Lake Milangil
Lake Murdeduke
Lake Terangpom

These lakes are visited by tens of thousands of birds including 19 bird species listed under the Japan Australia Migratory Birds Agreement (JAMBA), 19 species listed under the China Australia Migratory Birds Agreement (CAMBA) and 16 species listed under the Bonn Convention. Changes in the water regimes, increased salinity, pollution, pest plants and animals, grazing by domestic stock, recreational pressures and erosion are major risks associated with the Ramsar listed Western District Lakes (Parks Victoria, 2002).

The Environment Protection and Biodiversity Conservation Act 1999, which came into effect in July 2000, requires that any action that has, will have, or is likely to have a significant impact on a matter of National Environmental Significance (NES) is required to undergo an assessment and approvals process. Management of the Ramsar lakes and a further 26 wetlands and groups of wetlands listed in the Directory of Important Wetlands in Australia (EA, 2001) are matters of NES, since they are wetlands of national and international significance.

The abundant wetlands on the VVP result from the geomorphological and hydrogeological evolution of the landscapes. Some of the volcanic eruption points formed as a result of magma contacting a watertable resulting in the formation of a broad explosive crater with a low rim, termed a maar. The maars often form lakes or wetlands, such as Lake Purrumbete and Lake Keilambete. Other wetlands have formed where lava flows blocked the drainage (eg. Lake Condah), in the craters of volcanic cones (eg. Lake Bullenmerri); in depressions between the boundaries of lava flows (eg. Lake Corangamite; Blackam 1999); or in sag depressions in the surface of lava flows; and in the depressions of the stony rises.

A high percentage of the wetlands located on the VVP are saline to hypersaline and have saline groundwater inflow. Monitoring of some of the wetlands has shown that even though many experience extreme ranges of salinity, they have reasonable health and support a wide variety of macro invertebrate species (Harding, 2002). The majority of wetlands are located on private land with only a minimum number having active conservation measures in place such as protective fencing and habitat plantings.

The hydrology and hydrochemistry of groundwater-surface water interactions around several shallow lakes in the VVP has been studied by few researchers (eg. Coram, 1996). The lakes occur in surface depressions on the shallow unconfined Newer Volcanics groundwater aquifer and are thought to be the expression of the water table. The lakes have similar timing and magnitude of lake level fluctuation and major ion composition. The latter results from evaporative concentration and precipitation of cyclic salts contributed to lakes by groundwater and surface water inflows. Variations between the total dissolved salt content of lake waters reflect the importance of discharge from the lake to the down gradient groundwater system. The proportion of inflowing salts (from groundwater and surface water) determined by the hydraulic conductivity of the aquifer down gradient of the lakes.

2.6 Hydrogeology and Groundwater Flow Systems

Hydrogeological research on the VVP has been sporadic since the early 1970s. Over the past 30 years, it has been the groundwater interaction with the lakes and surface water bodies that has been the greatest focus of research (e.g. Mann et al. 1992; Nolan et al. 1990). Initially this work was related the introduction of groundwater legislation in 1969 (Groundwater Act, 1969) and
focused on understanding the resource (eg. Thompson, 1971). Later projects were undertaken to review the role of groundwater in salinity (eg. Gill, 1988); groundwater-lake interactions (eg. Coram, 1986; Dickinson, 1995); and groundwater movement (eg. Blackam, 1999). Current research is focused on attempts to discriminate aquifers within the VVP (eg. Bennett, in prep.).

Groundwater Flow Systems (GFS) have been delineated for both the CCMA and the GHCMA following three-day workshops with hydrogeological experts in each region (Dahlhaus et al., 2002a, 2002b). A report from the recently held GFS workshop to delineate the flow systems for the PPCMA region is pending. The GFS projects are part of a larger national initiative in catchment characterisation, intended to assist in the management of salinity. The GFS for the VVP are assumed Regional systems covered by thin, discontinuous Local systems (Quaternary alluvium & later volcanic phases). In the Corangamite CMA region, the Highlands volcanic flows have been delineated as Intermediate systems on the basis of their limited spatial distribution as valley flows.

An important unanswered question is whether the assumed Intermediate and Regional flow systems are correct. Because of the emplacement history of the volcanics (ie. sporadic eruptions made up of individual flows) it seems logical that the GFS could be disaggregated into more useful spatial entities for groundwater management. If a full three-dimensional hydrostratigraphic model was developed and proven, it would provide a sound basis for the management of groundwater resources and salinity. Knowing the spatial geometry of aquifers and the groundwater flow-paths through the VVP would allow for more targeted investment of salinity funding. Also important is an understanding of the role that the varied soils in the VVP play as the interface between rainfall, runoff and recharge. Brief description of the soils and their general hydrological properties has been given but there is very little known quantitatively concerning the water holding and water transmitting properties of the region's soils. The 1:100,000 soil-landform mapping provides a basis for sampling the region, in the context of a disaggregated GFS, in order to study and quantify hydrological differences between major soil types.

Figure 2.4 Groundwater flow systems on the VVP

![Groundwater Flow Systems](image-url)
2.7 Land Use

Humans have inhabited the VVP region for at least 35,000 years (Mulvaney & Kamminga, 1999) although little is known of the early inhabitants. Accounts from the region's indigenous inhabitants, the Wathaurong, Gulidjan, Djargurdwurung, Giraiwurung and Gunditjmara Aboriginal communities, who occupied the area when white settlers first explored the region around the turn of the 19th century (Clark, 1990, Horton, 2000), suggest that the VVP were capable of supporting a significant population. The grassy plains, rivers and wetlands provided an ample supply and variety of food. In particular, shellfish were gathered from the coast, fish and eels were hunted and trapped in significant quantities in the rivers, lakes and estuaries, land mammals and reptiles were hunted on the plains and birds (especially water birds) were taken from the lakes and estuaries (Flannery, 2002, Marshall & Webb, 1997).

The open and fertile VVP were quickly colonised by European squatters and settlers in the late 1830's and 1840's. Very little land was retained in public ownership and about 95% of the land is now in private ownership (Ross et al., 2002). Agriculture brought significant changes in land use, especially the removal of grassland and woodlands for crops and introduced pastures. Sheep and cattle grazing on sown pasture, dairying and cropping are the major agricultural industries. Although the majority of land on the VVP is devoted to agricultural production centred on grazing, there is a significant and expanding forestry industry, particularly blue gums (Eucalyptus globulus), in the high rainfall parts, which will undoubtedly modify the water balance in these areas.

Cropping on the VVP in the past has either failed or resulted in poor yields due to management difficulties such as weed control and waterlogging. Crop failure due to waterlogging was considered beyond the control of the grower and thus cropping was therefore seen as an opportunity enterprise when conditions were seemingly right. However, cropping in areas previously thought to be too wet is now possible with the adoption of raised bed cropping practices. The change from pastures to raised bed cropping systems may modify the runoff and nutrient regimes and it is therefore expected that disposal of drainage waters will become an issue both from a quantity and quality viewpoint.

Dairy production on the VVP is increasing between Hamilton and Warrnambool. Smaller scale land uses include viticulture and horticulture, which are heavily dependent on groundwater reserves for summer irrigation.

Nature conservation reserves occupy just 1.3% of the total VVP bioregion. It is considered the bioregion most poorly represented by conservation reserves in Victoria (Ross et al., 2002). The larger conservation reserves include Mt Eccles National Park, Mt Napier National Park, Organ Pipes National Park, Lower Glenelg National Park, Cobra Killuc Flora Reserve, Lake Goldsmith Wildlife Reserve, and the Inverleigh Flora and Fauna Reserve. Elsewhere, scattered wildlife reserves, bushland reserves and flora reserves of varying size constitute the public land categories where nature conservation forms at least part of the management objectives. Many of these areas are associated with permanent or semi-permanent wetlands.

Urban land use is intensive in parts of the VVP region. Major centres include (from east to west) the western suburbs of Melbourne, Werribee, Melton, Geelong, Ballarat, Colac, Camperdown, Cobden, Terang, Mortlake, Warrnambool, Port Fairy, Hamilton, Heywood and Portland. The western suburbs of Melbourne have been rapidly encroaching on the VVP, within an arc from Kalkallo to Sunbury, Melton and Werribee. New subdivisions such as Caroline Springs blanket the VVP with intensive urbanisation, resulting in hydrologic change far greater than that of any other land-use. Resulting problems include engineering hazards such as shallow rock and reactive soils to increased groundwater pollution and modified groundwater recharge (Dahlhaus, 1988).

2.8 Native Vegetation

The VVP has 115 Ecological Vegetation Classes (EVC's) listed (Ross et al., 2002), including mosaics and complexes of EVCs have been identified as occurring on the Victorian Volcanic Plain,
either by direct observation or ecological modelling. The most widespread vegetation types are open tussock grasslands, grassy woodlands, herb-rich woodlands and swamp scrub. Descriptions of the relevant EVC’s are given in the West Victoria Comprehensive Regional Assessment Biodiversity Assessment (RFA Steering Committee, 2000).

The national audit of terrestrial biodiversity (NLWRA, 2002a) estimates that over 95% of all native vegetation has been cleared in the VVP. The most endangered are the Plains Grassland and Grassy Woodland, of which less than 1% remains intact. Only three EVCs retain greater than 5% of their former extent - Lowland Forest (93%), Herb-rich Foothill Forest (19%) and Stony Rises Herb-rich Woodland (18%).
3 Salinity on the VVP

The vast majority of the mapped salinity in south-west Victoria occurs on the VVP. There are about 27,000 hectares of salt affected land in the GHCMA and about 21,000 hectares affected in the CCMA region. It is estimated that a substantial proportion (eg. 52% of the CCMA region) of the mapped salinity is primary in origin (Dahlhaus et al., 2003). Geomorphic evidence (eg. lunettes) and historical evidence (eg. early recorded history) substantiate the primary salinity assumption, although delineating between primary and secondary is difficult. It is uncertain as to what changes to the salinity processes have been initiated (if any) since widespread land-use change and whether land use change has had a greater or lesser impact than climate variability.

The salinity risk rating (Figure 3.1), which is based on rising groundwater predictions for the region, identifies the VVP as at high risk. Groundwater levels in 1998 (Figure 3.2) have been modelled using bore data and the AUSLIG DEM (approximately 300 metre by 300 metre resolution). Worst-case predictions for groundwater levels in 2020 (Figure 3.3) and 2050 (Figure 3.4) have then been calculated using a linear rise model measured from selected hydrographs. Based on the evidence of bore hydrographs (Dahlhaus et al., in prep), the assumption that groundwater levels on the VVP are rising (linearly) is most probably only correct for a small part of the region and thus the true area at risk of salinity from rising saline groundwaters (as opposed to other causes) is unclear. It is important to define the true processes causing salinity as the remedial actions will be different and their effectiveness will vary.

![Salinity risk rating for the VVP region](source: NLWRA website. Source data from (SKM, 2000))
Figure 3.2 Modelled depth to 1998 watertable
(source: NLWRA website. Source data from (SKM, 2000))

Figure 3.3 Modelled predicted depth to 2020 watertable
Figure 3.4 Modelled predicted depth to 2050 watertable

(source: NLWRA website. Source data from (SKM, 2000)
Previous research and current projects

Over the past 50 years, Government departments, universities and consultants have undertaken many investigations (as distinct from research), which have contributed significantly to the repository of knowledge about the natural resource management of the VVP. However, a comprehensive inventory of the previous research on the biophysical environment of the VVP region has not been found (and may not exist).

The vast majority of the previous investigations, consultancies and applied research projects have been commissioned studies related to a specific issue. Among the previous research projects are a number of recurring themes, viz:

- The hydrology of the lakes and wetlands (especially around Lake Corangamite)
- Management of the drainage and diversion schemes
- Groundwater resource investigations
- Stream water quality, nutrient management and salinity management
- Impacts of land-use on water quality (especially potato crops and dairying)

Known projects that have mainly been funded through NAP over the last few years and which relate to the VVP region is listed in Table 4.1. The list is not complete, as there are probably many projects “hidden” in universities and research agencies, which have not been brought to the attention of the authors of this report. Also there may be several research projects on the VVP over the last few years that have been funded by the Research and Development Corporations.

<table>
<thead>
<tr>
<th>CMA region</th>
<th>Project</th>
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<tbody>
<tr>
<td>Corangamite</td>
<td>Groundwater Flow Systems</td>
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<td>Subcatchment salinity risk prioritisation</td>
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<td>Groundwater monitoring and research database</td>
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<td></td>
<td>Groundwater monitoring guidelines and review</td>
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<td>Salinity research and investigation inventory</td>
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<td>Water quality monitoring review</td>
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<td>Land resource assessment of the Corangamite region</td>
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<td>High resolution digital elevation model (LIDAR)</td>
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<td>Assembly of digital orthophotomosaic</td>
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<td></td>
<td>Enhanced soil health program</td>
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<td>Biodiversity mapping</td>
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<td>Wetlands inventory</td>
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<td>Environment resource inventory</td>
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<td>Communication, engagement and social change benchmarking</td>
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<td></td>
<td>Moorabool River catchment project</td>
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<td>Review of Corangamite drainage and diversion schemes</td>
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<td>Catchment Characterisation for salinity risk assessment</td>
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<td>Demographics and characteristics of the Corangamite people</td>
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<td>Engagement Strategy for the Corangamite Catchment Management Authority</td>
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<td></td>
<td>Corangamite communities – their values, beliefs, attitudes and behaviour in managing natural resources.</td>
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<td></td>
<td>Communications Strategy – Corangamite CMA region.</td>
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Table 4.1 Current or recently completed research and investigation projects

<table>
<thead>
<tr>
<th>Area</th>
<th>Projects and Activities</th>
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<tr>
<td>Glenelg Hopkins</td>
<td>Groundwater Flow Systems</td>
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<td></td>
<td>Subcatchment salinity risk prioritisation (Glenelg Hopkins)</td>
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<tr>
<td></td>
<td>Directory of research and investigation in southwest Victoria</td>
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<td></td>
<td>Land resource assessment of the Glenelg-Hopkins Region</td>
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<td></td>
<td>Land and Water-use Change study</td>
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<tr>
<td>Port Phillip</td>
<td>Groundwater Flow Systems</td>
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<td>North Central</td>
<td>Groundwater Flow Systems</td>
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<td>Basalt plains salinity risk study</td>
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<td></td>
<td>Upper Loddon &amp; Campaspe Groundwater Management Area reviews</td>
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<td></td>
<td>Update of salinity management priority setting</td>
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4.1 The need for unified research

In the past projects have been undertaken in specific places in the landscape and investigated specific biophysical parameters for a specific outcome. The projects have been typically reductionist science, within a single discipline and often enclosed within a Government department, research organization, authority or university. This has resulted in the development of a fragmented knowledge-base on the various landscape elements with little interaction between the disciplines.

The situation over the past 20 years has been exacerbated by the fragmentation of the data and information repositories within Government departments. The data and knowledge collected by groups within the Soil Conservation Authority, the Geological Survey of Victoria, Melbourne and Metropolitan Board of Works, State Rivers and Water Supply Commission, State Electricity Commission, Land Conservation Council, Ministry for Planning and Environment, Crown Lands and Survey (to name just a few), has been relegated to archives. Much of this information is extremely valuable, especially for comparisons with the current catchment condition and to establish trends.

The review of previous and current projects has identified a need for:

1. The establishment of a knowledge network for the VVP that will provide a clearing-house of scientific information, both past and present. Ideally, the knowledge network would have two components: a repository for research reports, theses, papers, maps, GIS data and files, and an efficient distribution mechanism for this information. The Victorian Resources Online (VRO) website currently provides part of this service and may be an option for the VVP knowledge network.

2. Data management and access frameworks and data infrastructure within DPI/DSE are in place and could be utilised via:
   - water warehouse
• corporate data stores
• NAP information management framework
• Regional Data Net

There could also be opportunities through the future VEMIS project (Victorian Environmental Monitoring Information System), an initiative stemming from Peter Sutherland’s office.

3. A collaborative approach between all agencies engaged in research in the VVP region. To maximise the research investment, researchers in current projects need to access the data and findings of researchers in other disciplines across the VVP.

4. Cross-disciplinary research projects, which can combine the accumulated knowledge of different disciplines for VVP-wide projects.
5 Project Development

This section is a list of possible research projects that would greatly advance our understanding of the processes causing salinity on the VVP. All projects qualify for NAP funding. The list is far from exhaustive but gives a clear indication of what the research needs are on the VVP and tries to fill a few of the major knowledge gaps. The set of proposed projects specifically increases our knowledge of the hydrology of the VVP. Salt sources and drivers are identified. Groundwater flow systems are accurately identified. Soil hydrology and land management is addressed. The reliance of significant wetlands on groundwater and/or surface water resources will be determined. This is all necessary to allow us to more accurately predict the scale and timing of the impacts of salinity on surface water, groundwater, wetlands and streams under various land management scenarios. Additionally a project outline for appropriate social research in the VVP is included. Further research project ideas, not restricted to projects qualifying for NAPSWQ funding but collated from DPI research staff have been submitted on proformas, which are included as an appendix (Appendix B). These have been submitted in confidence that their origin will be respected and that any development of the ideas will not occur without appropriate discussion.

The projects encourage and support research collaboration, bringing together and supporting projects with researchers and students from CSIRO, Department of Primary Industries, Victorian Universities, and CRCs (e.g. Catchment Hydrology, and Landscape Environment and Mineral Exploration) but are not be restricted to these partners. Existing work and the networks of collaborators each partner brings, greatly expands the linkages available to the proposed work.

There are specific linkages to existing projects that have national scope, and are at the cutting edge of research in Australia. These include:

- Catchment Classification Project through CSIRO Land & Water, a continuation of the GFS work delineating and modelling flow systems, with links to the state water and environment departments in Queensland, NSW, ACT, Victoria and South Australia,
- Healthy Country, a CSIRO Flagship Program with a national program of developing sustainable whole-system solutions, with links to individual projects linked with Catchment Management Authorities and Boards throughout the eastern states,
- NAP funded projects in South Australia involving CSIRO Land & Water and CRC LEME, working on the use of environmental tracers for identifying salt sources and pathways, and associated travel or response times,
- Floodplain, riparian vegetation health and in-stream ecosystem behaviour, performed primarily in SA and WA, with work focussed on river and groundwater interactions in the lower reaches of the Murray River, and the effect of engineering measures on streams and groundwater aquifers on coastal rivers in WA, involving the state water authorities.

In addition there are clear links to many current State government projects currently being undertaken by DSE and DPI, especially through Primary Industries Research Victoria (PIRV) division. These include:

- Our Rural Landscape (ORL) a $50 million project under the Victorians. Bright Ideas. Brilliant Future. Initiative. The ORL project aims at increasing the profitability of sustainable food production systems, and improving the amenity, biodiversity and quality of life across rural and regional communities.
- Werribee plains – A vision for sustainable growth, aims at sustainable agriculture, industrial and urban development on the Werribee Plains sub-region of the VVP.
- Core research projects being conducted by DSE and DPI focussed on hydrology, nutrient management, hydrology and water-use efficiency.
- NAP funded state-wide projects involving various government agencies to develop tools such as the Catchment Assessment Tool and others.
Links to other research agencies (eg. universities) and industry groups (eg. Meat and Livestock Australia, Dairy (DRDC), Grains (GRDC), Southern Farming Systems, etc.) have also been explored.

The set of projects outlined encompasses a range of issues on the VVP. It is preferred by some research partners that new work be cohesive and substantial, so that they may make a more positive contribution in terms of in-kind support, rather than simply accepting what might be viewed as “small consultancies.” Picking and choosing pieces from the proposed work will lessen the return of the project as a whole, leave gaps in understanding the VVP as a system, and reduce the appeal to larger partners and potential collaborators.

The set of projects also includes an example of a research and investigation project on the VVP that does not seek NAP funding but rather attempts to bring in other funding into the VVP. The project looks at the impacts of flooding Lake Condah, which involves cultural as well as salinity issues for both indigenous and non-indigenous communities on the VVP. Other projects funded by the Catchment Management Authorities within their 2003/2004 investment plan can be assessed by a reference committee as to whether they form part of the VVP study and therefore subject to a rigorous review.

The outcomes from all research work must be packaged within a communication plan, which is easily accessible and understandable to land owners, to ensure widespread adoption (this is discussed in the following section). Only then will this package of research and investigation lead to the development of environmentally sustainable farming practices on the VVP.

5.1 Project 1. Development of a 3D model of the hydrostratigraphy of the VVP

We still do not have a good spatial view of the materials, thicknesses and stratigraphic variability below the VVP. Yet this will determine where salt is stored or mobilised. At the surface, the basalt flows vary greatly in morphology and soil development. Many wetlands coincide with depressions in the plains that reflect the fact that the basalt is a thin veneer over an older underlying uneven landscape. The volcanic landscapes extend into the Victorian Central Highlands (Ballarat, Ararat) but this area is generally not regarded as part of the “plains” landscapes. However this area will be included in this research project as changes in the hydrology of this area will affect the hydrology of the plains. The recent volcanic flows were the second phase of volcanism. Numerous volcanic cones are testament of the level of volcanic activity in the last 100,000 years. The stony rises that are prominent in the volcanic landscape are the result of this activity. There are essentially intact lavas that have undergone only minimal weathering.

The Newer Volcanics need to be modelled in three dimensions over the entire plains area, as would the extent of interbasaltic palaeosols (aquicludes) and underlying structures, to determine the relative importance of their influence on the hydrogeology and thus salinity of the VVP. Pliocene sands underlie an extensive area of the VVP and would influence recharge and discharge, particularly where they are thick and continuous.

Project Title: VVP Project 1. A 3D model of the hydrogeology of the VVP

Potential Collaborators:

- Ballarat University (Peter Dahlhaus)
- LaTrobe University (John Webb & Daren Bennetts)
- CSIRO Land & Water (Jim Cox)
- CRC LEME (John Wilford)
- DPI (David Heislers (CLPR), David Taylor (GSV))

Outcomes / justification:
This project will re-interpret the hydrostratigraphy of the VVP. The aim of the project is to delineate the aquifer geometry and boundaries of groundwater "units" to improve the level of confidence in scenario modelling of groundwater and salinity management actions. This will greatly help both the management of groundwater resources (eg. greater confidence in calculating Permissible Annual Volumes) and salinity (eg. greater confidence in Flowtube modelling).

The National Salinity Audit used the Catchment Characterisation approach, to assess the risk of salinity from rising watertables across Australia. The Audit identified the VVP area of Victoria as an area of high risk from rising saline watertables. The Catchment Characterisation approach is only reliable if there is a good understanding of the thicknesses of the underlying structures below the newer volcanics as this will influence the hydrogeology and thus salinity of the plains. The National Salinity Audit lumped the VVP into a regional GFS (and thus the hydrology of whole region is supposed to respond similarly to land use changes).

Methods

The project aims to improve our understanding of the hydrostratigraphy of the VVP in order to better understand the hydrogeology. This will be done by:

1. re-interpreting bore logs across the VVP;
2. reviewing all geophysical data including radar, low resolution gravity, total magnetic intensity and radiometrics;
3. field based reconnaissance in selected high priority regions; and
4. development of a 3D model of the VVP hydrogeology

Aquifer geometry determined by piecing together bore hole data and perhaps targeted drilling. It includes the sub-basaltic units and pre-existing topography before the basalts; Aquifer properties and interaction determined by geochemistry techniques including radiometrics and isotopes, flow net analysis, understanding residence time of groundwaters, interaction between aquifers (recharge vs discharge and pressures); Targeted geophysics; Geochemistry of groundwaters and streams

There is a substantial amount of data owned by Federal and State research agencies, Universities and the CMAs that must be obtained and synthesised – the project depends on this data being made available:

Estimated budget: $300,000 over two years

The budget will cover salaries, overhead and operating costs of key scientists from several organisations as well as student projects.

5.2 Project 2. Delineation of Groundwater Flow Systems

The National Salinity Audit lumped the VVP into a regional Groundwater Flow System (GFS) and thus the whole region is supposed to respond similarly to land use changes. Thus, an initial assessment of the GFS across the VVP has recently been completed. This report questioned the whole region being lumped together and suggested the ‘rising watertable theory’ probably doesn’t hold for some of the most agriculturally important landscapes within the VVP. Much of the GFS categorisation was based on limited data and best guess estimates. Thus the true impacts of land management changes on salinity and water quality in each of the groundwater flow systems is often "best guess".

This project will extend the GFS approach and fill in the major knowledge gaps that have been identified across the VVP. This is the only way, which will allow the impacts of land management change to be more reliably predicted.
**Project Title:** VVP Project 2. Groundwater flow systems – the first stage in assessing how catchment hydrology responds to land use change.

**Potential Collaborators:**
- CSIRO Land & Water (Jim Cox, Glen Walker, Chris Smitt)
- Ballarat University (Peter Dahlhaus)
- DPI (David Heislers, Richard MacEwan (PIRV))

**Outcomes / justification:**

This project will extend the GFS approach and fill in the major knowledge gaps that have been identified across the VVP. This is the only way, which will allow the impacts of land management change to be more reliably predicted.

The National Salinity Audit used the Catchment Characterisation approach, to assess the risk of salinity from rising watertables across Australia. The Audit identified the VVP area of Victoria as an area of high risk from rising saline watertables.

The Catchment Characterisation approach is only reliable if there is a good understanding of a regions groundwater flow systems (GFS). The National Salinity Audit lumped the VVP into a regional GFS (and thus the whole region is supposed to respond similarly to land use changes). Thus, an initial assessment of the groundwater flow systems (GFS) across the VVP has recently been completed. This report questioned the whole region being lumped together and suggested the ‘rising watetable theory’ probably doesn’t hold for some of the most agriculturally important landscapes within the VVP. Much of the GFS categorisation was based on limited data and best guess estimates. Thus the true impacts of land management changes on salinity and water quality in each of the groundwater flow systems is often “best guess”.

**Methods**

The project aims to improve our understanding of the hydrological processes across the VVP in order to delineate where local, intermediate and regional GFS dominate the salinity processes by:

1. re-examining all research that has already been done (e.g. interpreting groundwater levels and trends and salt trends in groundwater and surface water using geo-statistical techniques);
2. identifying knowledge gaps in the hydrogeology of the VVP and the processes leading to salinity and its management;
3. field based reconnaissance in selected high priority regions and a targeted research and investigation program developed and initiated (this will include PhD level to complex collaborative projects by senior qualified research scientists from various organisations);
4. development of a 3D model of the VVP hydrogeology; and
5. groundwater modelling of land use impacts

**Aquifer geometry** determined by piecing together bore hole data and targeted drilling (Project 1), **Aquifer properties and interaction** determined by geochemistry techniques including radiometrics and isotopes, flow net analysis, understanding residence time of groundwaters, interaction between aquifers (recharge vs discharge and pressures); **Sources of salt and mobilisation processes** determined; Improvement to groundwater flow models for each region; **Surface-groundwater interactions with wetlands and lakes** as well as streams and drainage lines understood; **Technique development** to determine chemistry of surface waters and mixing of waters; **Targeted geophysics; Geochemistry** of groundwaters and streams; and **Modelling** the...
impacts of different land management activities and thus the feasibility of different management options within a region.

**Estimated budget:** $200,000 over one year (funding currently being considered in Corangamite CMA)

The budget will cover salaries, overhead and operating costs of key scientists from several organisations as well as PhD students and some casual labour costs.

### 5.3 Project 3. Linking soil hydrology and land management to groundwater and surface water impacts

Soil is the hydrological interface between rainfall, runoff, recharge, groundwater storage and streamflow. Soil data provided by previous soil-landform surveys provides, amongst other land use planning benefits, the necessary classification of the landscape for modelling land use change and impact on environmental assets, in particular hydrological impact. Hydrological modelling is fundamental for understanding and quantifying impacts on water yield and water quality, groundwater and salinisation processes but often lacks sufficient quantification of soil hydraulic properties to allow confident estimates of recharge. Runoff and recharge originating from agricultural land transports pollutants including nutrients, chemicals and sediment to ground and surface water but there is little quantitative data to assist in understanding, modelling and managing the processes in different soils and farming systems.

This is a highly complex area because of the variety of soils and the choices available in managing farming systems. This project serves to build links between related projects already funded or submitted for funding and to provide a systematic framework for gathering necessary hydraulic data.

Links to existing or new projects would include:

- **CCMA and Southern Farming Systems (SFS) integration of raised bed cropping with catchment hydrology (Col Hacking / Cam Nicholson) which is proposed for funding under NAP.**

- **Runoff and nutrient losses from high rainfall cropping (raised beds and flat) proposed by GRDC for continuance of Tim Johnston’s (DPI) research currently based at Rowan Peel’s concept farm property.**

- **Research on the offsite impact of grazing systems proposed by David Nash (DPI) for GRDC and GHCMA support (this project will link to the projects described above).**

Additional or integrating work would entail:

**Sub-project 3.1 Characterisation of the catchments selected for the CCMA/SFS project.**

The project as it stands is largely concerned with engagement and extension and has insufficient scope for collection of appropriate data to allow modelling or monitoring, and therefore validation, of the land management impact for this work. Value can therefore be added to this project in order to benefit the broader scientific goals for the VVP. The 1:100,000 soil-landform information for GHCMA and CCMA provides an inventory of regional soils but has insufficient spatial resolution to apply to sub catchment modelling. More detailed mapping of soils, in particular for their hydraulic properties and nutrient retention, will be required. The SFS 3D conceptual model should be used to provide the groundwater context for the proposed study sites.

**Indicative budget:** $100,000 one year

**Sub-project 3.2 Disaggregation of VVP soil-landforms into hydrological units**
Disaggregation (or aggregation depending on functional differences) of the soil-landforms of the VVP into appropriate hydrological units based on soil, surface hydrology and groundwater context. This activity will provide the spatial base for characterising soil hydrology for modelling plant water use, runoff, erosion, and recharge across the whole of the VVP.

**Indicative budget:** $100,000

**Sub-project 3.3 Reference site characterisation**

Reference sites will be selected based on the output of sub-project 3.2. Collection of reference data for regolith characteristics, soil morphology, hydraulic properties, and nutrient retention (e.g. P absorption) will support modelling such as that applied in SWAT (Soil Water Assessment Tool) and CAT (Catchment Assessment Tool). There are beneficial links between reference site characterisation and the ‘delineation of groundwater flow systems’ fieldwork program, so coordination between hydro-geological and hydro-pedological site selection and field work is advocated. This activity will provide reliable field data for modelling hydrology across the VVP.

**Indicative budget:** Per reference site, $7,000 (soils data) and $1,000-10,000 (deeper material, depending on thickness, drilling costs, and need for piezometry or chemistry).

**Sub-project 3.4 Soil-water-nutrient interactions in the VVP**

Research into soil-nutrient-water interactions for major agricultural soils in the high rainfall zone will provide the process understanding needed to develop management within farming systems to minimise nutrient losses to waterways whilst being able to maintain intensively productive agriculture. The project will entail setting up of an intensive research site at which soil properties and nutrient dynamics in soil water and runoff can be appropriately measured. Research will have ‘satellite’ sites on the VVP where collaboration with landholders on farm and sub-catchment studies will extend and support the more intensive process research based at the primary research site. This will include Tim Johnston’s cropping project and David Nash’s offsite impacts of grazing systems project and will link to the CCMA/SFS raised bed farming and catchment hydrology project.

**Indicative budget:** Total budget for this research is estimated to be $900,000 per year for 3-5 years. Some funding commitment has been indicated for this: $250,000 from GRDC, $250,000 from DPI, $200,000 discussed with GHCMA (David Nash October 03). An additional $200,000 CMA or other contribution to be sought.

### 5.4 Project 4. Identifying the sources of salt and mobilization processes

Identifying the sources of salt and mobilization processes is important for effective management of surface and ground water resources. A great deal of mythology surrounds the various hypotheses concerning salt sources to various catchments, including dissolution of salt deposits, weathering of soils and rocks, mixing with trapped seawater in marine sedimentary formations, or acquisition and evapo-concentration of salts deposited by rainfall and dryfall.

A proven way to evaluate the relative importance of these mechanisms is to use the chemical and isotopic compositions of rainfall, ground water and surface water as natural ‘tracers’ of solute and water sources. Many saline groundwaters and streams have very similar chemical composition to sea water, and are invariably dominated by sodium (Na⁺) and chloride (Cl⁻) (>85% by mass). Therefore, it is not unreasonable to expect that mixing between rainfall and with trapped seawater is the reason for the observed chemical compositions. However, because the ocean has a characteristic ratio of heavy to light hydrogen (²H/¹H) and oxygen (¹⁸O/¹⁶O), and we can measure these ratios very precisely relative to a known standard in any water sample, the amount of trapped seawater contributing to any water sample can be estimated. In general, this contribution has been found to be negligible even in trapped porewaters of the marine clay formations of the Murray basin. Dissolution of salt minerals within the soil or in rocks also produces Br/Cl⁻ ratios that are much lower than marine or aerosol values because of the inability of evaporite minerals to take in
the large Br\(^{-}\) atom in the mineral lattice. Again, most continental waters in Australia have Br\(^{-}/Cl^{-}\) ratios similar to, or slightly higher than marine values.

The contribution of weathering of rock forming minerals to salinity has been thought to be important in a number of localities. However, because rocks contain virtually little or no Cl\(^{-}\) that is easily accessible, and most 'salinity' in streams and groundwaters is dominated by Cl\(^{-}\) it is hard to explain the high salinity, though weathering may contribute some of the minor ions such as Ca\(^{2+}\), Mg\(^{2+}\) and HCO\(_3\)\(^{-}\) through carbonate mineral dissolution. The issue of acid sulfate soils weathering and its impact on salinisation processes can be tested by evaluating the SO\(_4^{2-}/Cl^{-}\) ratios as well as isotopic signatures (\(\delta^{34}S\)) of dissolved sulfate. Even where there are numerous examples of disseminated reduced sulfur minerals in the weathering profiles, SO\(_4^{2-}/Cl^{-}\) ratios of saline seeps show that this process is of local importance, often only affecting surficial or perched systems that are 'fresh' rather than saline.

Although rainfall contains very low concentrations of salt (primarily of marine origin), it contributes most of the salt load and salinity is controlled by the extent of evapotranspiration (ET) in the soil zone. Once the soil water moves well below the zone where it is affected by ET (below the root zone) it ultimately recharges the groundwater, maintaining the marine like aerosol signature. It also retains the isotopic composition of rainfall which is much more depleted in \(^{2}H\) and \(^{18}O\) relative to seawater and is largely unaffected during transit through the soil zone.

**Project Title:** VVP Project 4. Identifying the sources of salt and mobilization processes.

**Potential Collaborators:**

- CSIRO Land & Water (Andrew Herczeg)
- Deakin University (John Sherwood)
- LaTrobe University (John Webb)
- CRC LEME (John Wilford)
- Monash University (Ian Cartwright)

**Outcomes / justification:**

This project will determine the likely sources of salt in the VVP landscapes and their relative importance in contributing to present-day salinity of both land and water. It is of vital importance to understanding the salinisation of urban water supplies (particularly the Moorabool River) by tracing the provenance of the salt and establishing the links between cause and effect. This in turn will provide confidence in the recommended management actions, especially where they are likely to be “trade-offs” (eg. restricting allocations of groundwater to improve the quality of urban water supply). The knowledge outcomes delivered by this project are also essential to managing primary salinity assets, especially the Ramsar wetlands. Isotopic tracing can determine the sources of salt and relative importance of managing surface water as compared to the groundwater inflows to a particular water body.

**Methods**

The project aims to improve our understanding of the sources of salt across the VVP:

1. re-examining all research that has already been done (e.g. interpreting groundwater levels and trends and salt trends in groundwater and surface water using geo-statistical techniques);
2. identifying knowledge gaps in the hydrogeology of the VVP and the processes leading to salinity and its management;
3. field based reconnaissance in selected high priority regions and a targeted research and investigation program developed and initiated (this will include PhD level to complex collaborative projects by senior qualified research scientists from various organisations);

4. development of a 3D model of the VVP hydrogeology; and

5. groundwater modelling of land use impacts.

Aquifer properties and interaction determined by geochemistry techniques and understanding residence time of groundwaters, interaction between aquifers (recharge vs discharge and pressures); Sources of salt and mobilisation processes determined; Technique development to determine water chemistry mixing; and Geochemistry (salt profiles and saline water sources)

**Estimated budget:** $100,000 over one year (2004 - 05).

Agencies supporting this research may include CSIRO Land and Water, CRC LEME, CRC Catchment Hydrology and Universities. It is envisaged that the agencies would contribute additional funding or in-kind contributions. The budget will cover salaries, overhead and operating costs of key scientists from several organisations as well as PhD students and some casual labour costs

### 5.5 Project 5. Groundwater dependent ecosystems - Salinity of wetlands

The wetlands and lakes are arguably the highest ranked assets of the VVP. Nine lakes are international assets, being listed as wetlands of international importance under the Ramsar Convention. An additional 26 wetlands are listed in the Directory of Important Wetlands in Australia (EA, 2001). Over 75% of the shallow freshwater wetlands have been modified or destroyed, and some of the most important lakes are being altered by drainage and manipulations of water flows resulting in permanent damage to their environmental quality (Williams, 1995).

The conservation of biodiversity in the wetlands is believed to be linked to the quality of refugia at various scales from global to regional. Refugia are areas of opportunity to which species move during periods when non-conducive conditions prevail (Craig Allen & Tim Corlett, *pers. comm.*). For example, refugia around Lake Corangamite may be the groundwater springs along the southern fringe of the lake (eg. McVeans Springs), or the smaller wetlands in the Stony Rises. Many of these groundwater dependent wetlands and springs are vital to the health of the larger ecosystems and the Western District lakes have also been recognised as important Australian groundwater dependent ecosystems with a high threat (Clifton & Evans, 2001).

In locations where a large number of wetlands are currently salinised either as natural occurrences or through rising watertables thought needs to be given as to what can reasonably be achieved to address salinity issues. The situation is complicated when water quality is often highly variable throughout the year and between years. Some wetlands range from brackish to hypersaline. Recharge sources for springs and seeps are often ill defined so the ability to target and control groundwater inflows is problematical. Salinity control for wetlands that are currently salt affected may be limited to protection of the vegetation communities already present including valuable salt marshes that provide breeding sites for many water birds. For wetlands that are currently fresh a greater emphasis on catchment works to reduce the possibility of further salinity occurring would be more appropriate.

It is therefore necessary to identify the processes, which cause salinity in a selection of highly significant wetlands on the VVP and understand their reliance on the transient nature of seasonal recharge and discharge.

**Project Title:** VVP Project 5. Groundwater dependent ecosystems - Salinity of wetlands.

**Potential Collaborators:**
Outcomes / justification:

This project will determine the dependence of a selection of significant wetlands on the VVP on groundwater flows. For groundwater dependent ecosystems, threats to the quantity and quality of groundwater contributing to the wetlands and/or their refugia sites is needs to be ascertained for the continued management and maintenance of their environmental health.

Methods

The project therefore aims to improve our understanding wetland recharge and discharge, and salinity issues in selected high priority areas surrounding wetlands within the VVP by:

1. re-examining work that has already been done (e.g. delineation of surface water and groundwater dependent ecosystems;
2. identifying knowledge wetland hydrology;
3. setting up a targeted research and investigation program;
4. quantifying spatial and temporal changes in the dependence of ecosystems of surface waters opposed to groundwaters;
5. development of a conceptual model of surface water/groundwater dependence of priority wetland;
6. development of fact sheets/notes to guide land managers; and
7. development of drainage policy or recommendations for policy.

Installing field trails in some of areas to examine the dependence of selected wetlands on surface water/groundwater dependence (this may include examining existing data from wells and piezometers, installing new piezometers, flow net analysis, understand residence time of surface waters; groundwater-surface water interactions determined; Geochemical techniques used to determine surface water contributions to wetlands and streams; Temporal and spatial volumes of surface water measured in selected catchments and/or predicted from modelling exercises

Estimated budget: $250,000 over two years (commencing in 2004 - 05).

Some of the potential collaborators would be expected to contribute funding to this project. The budget will cover salaries, overhead and operating costs of key scientists from several organisations as well as students and some casual labour costs.

5.6 Project 6. Identifying the sources of saline water using environmental tracers

For remediation purposes, it is necessary to identify the sources of saline groundwater on the VVP. A number of water sources can contribute saline water to drainage lines, wetlands, rivers etc. These include surface runoff, inter-flow, as well as phreatic and confined aquifers. The relative proportion of these sources can also vary over time in response to rainfall and land management practice. A proven way to evaluate the relative importance of these sources is to take advantage of differences in the chemical and isotopic compositions of the various potential end-members, and by measuring these parameters in water, an estimate of relative fractions of water contributing to this can be obtained (Cook and Herczeg (1999) Environmental tracers in subsurface hydrology. Kluwer
A.P., Boston].

Often surface waters and inter-flow can have much lower salinity than the groundwater and often this parameter alone can be used provided that there are only two end-members contributing to drains having low and high salinity respectively. However, often there are a number of other sources as mentioned above, and therefore other tracers need to be used to untangle multiple sources. Sometime, there are subtle differences in the chemical composition of the different sources. For example, surface waters can have high Ca²⁺, HCO₃⁻ relative to chloride compared with subsurface waters. Therefore, using these ratios (e.g., HCO₃⁻/Cl⁻) can be enough to distinguish irrigation return flow from ambient groundwater, even if their salinities are similar. Sometimes, sulphate concentrations in groundwater are different from near surface inter-flow and the two can be distinguished on that basis. The use of ionic ratios as tracers also can take advantage of different mineralogy of different aquifers which impart their own characteristic chemical signature which is different from surface water, which has an atmospheric aerosol signature. In most instances, determining the suitability and characteristic chemical signatures from different water end-members needs to be done on an empirical basis. In other words, doing a reconnaissance study to evaluate if there are different chemical characteristics of the water systems in a given catchment.

There are also a host of naturally occurring stable isotopes that complement chemical tracers. The most commonly used are the stable isotopes of water (¹⁸O/¹⁶O and ²H/¹H expressed as δ¹⁸O and δ²H) which are direct tracers of the water molecules. A number of processes control variation of the isotopes, namely rainfall intensity and evaporation which can impart very different isotopic signatures for surface waters and interflow as compared with groundwater. For example, surface waters reflect the isotopic composition of recent rainfall, or can have been subjected to evaporation and have distinctly different isotope ratios to groundwaters which tend to reflect the long term mean isotopic composition of rainfall for the region.

There are various other isotopic tracers that can be applied to such problems of water sourcing and depends on the problem being addressed and the type of aquifer and surface water in a given setting. δ³⁴S of dissolved sulphate or δ¹³C of dissolved inorganic carbon, ⁶⁷Sr/⁶⁶Sr are also used in some circumstances. In general, the more chemical and isotope systems that are measured, the greater the degree of confidence in the estimates of water contributions to a given circumstance, of course this involves extra cost as the more ‘esoteric’ isotope systems involve greater expense. The approach using these methods can involve significantly labour and analytically intensive studies if the sources of water change on a seasonal basis. Some end-member compositions can vary rapidly (e.g., surface waters and inter-flow) and need to be sampled regularly along with drainage water.

Project Title: VVP Project 6. Identifying the sources of saline water using environmental tracers.

Potential Collaborators:

- CSIRO Land & Water (Andrew Herczeg)
- Deakin University (John Sherwood)
- LaTrobe University (John Webb)
- Monash University (Ian Cartwright)
- Melbourne University (Tammie Weaver)

Outcomes / justification:

This project will determine the sources of saline water in selected high priority drainage lines, streams and wetlands to help determine best management practices to ensure land use change (involving removing and disposal of excess surface water) will not adversely affect the quantity and quality of water resources (e.g. for the maintenance of public water supplies, wetland and ecosystem dependence on water resources, flushing of salt from rootzones, etc).

Methods
The project aims to improve our understanding of the sources of saline water on the VVP, recharge and discharge relationships, and salinity issues in selected high priority areas on the VVP by:

1. re-examining any work that has been done;
2. setting up a targeted sampling program;
3. laboratory analysis of environmental isotopes;
4. assessment of the spatial and temporal distribution of water quality (salinity perspective only);
5. development of a conceptual model of the sources of saline water across the VVP.

Re-examine any water quality data that exists for the VVP; Field sampling program developed; Specialised analysis of water (this is costly); Interpretation of data and production of risk map.

**Estimated budget:** $190,000 over two years (commencing in 2004 - 05)

Some of the potential collaborators would be expected to contribute funding to this project. The budget will cover salaries, overhead and operating costs of key scientists from several organisations as well as students and some casual labour costs.

### 5.7 Project 7. Lake Condah

This research project has been submitted by CSIRO Land and Water for funding by Land and Water Australia under its recent call. The project was initiated by the Lake Condah Trust on the VVP. This project seeks to define a sound scientific research program to underpin elements of the Strategy (eg re-flooding of Lake Condah and surrounding wetland system) and assist to gain the support of the local community members and stakeholder groups. Implementation of the research program (Stage 2 not considered here) will assist in the development of proposed land management plans and utilisation of native foods of the region.

CSIRO staff and senior Lake Condah representatives have collaboratively developed this proposal. Minister Ruddock launched the project in February 2002. The projects vision was endorsed; the CEO of Winda Mara Aboriginal Corporation and the Manager of Portland Aluminium are joint project chairs. A Lake Condah Leadership Group (40 organisations and individuals including Portland Aluminium, Glenelg Hopkins Catchment Management Authority, AFFA, Environment Australia, Indigenous Land Corporation, ATSIC, RMIT University, Deakin University, Glenelg Shire Council) formulated a project master plan and organisational structure. Minister Kemp indicated support for national heritage listing when Commonwealth legislation is passed. Preliminary discussions have been held with farmers, local business people and prominent community members.

**Project Title:** Scientific Support Program for Lake Condah Indigenous Regional Sustainability Strategy

**Potential Collaborators:**

- CSIRO Land & Water (Robert Molloy, Lesley Geldenhuys)
- Lake Condah Aboriginal Mission

**Outcomes / justification:**

Despite its high rainfall and naturally fertile lands, the region surrounding the Lake Condah Aboriginal Mission in south-western Victoria (Heywood) is in economic decline typical of one third of Australia’s regions (NIER SoR Report, 1998). The National Action Plan for Salinity and Water Quality recognises the region as being at high risk of salinity impact in the foreseeable future – current land management practices and land uses require review. The Lake Condah Sustainable
Development Strategy (the Strategy) is proposed to provide social and economic stability to the region’s indigenous and non-indigenous communities.

The project objectives are:

- To develop a scientific support program that assists the Lake Condah Trust in their Sustainable Development Project leading to local capacity building, increased social infrastructure, and ongoing employment for local people;
- To facilitate exchange of knowledge between Indigenous people, regional land managers and scientists;
- To reach a shared vision of research needs and priorities to underpin the key initiatives of the Lake Condah Trust’s sustainable development project;
- To develop a working example of a scientific support program for regional sustainability projects that incorporate indigenous cultural values

Methods

A small team of CSIRO researchers and the Executive Officer of the Lake Condah Trust would work collaboratively over a six-month period to assess the current status of knowledge and define research requirements and priorities to support the Trust’s key initiatives. It is anticipated that research areas will include the socio-economic implications of re-flooding Lake Condah and associated wetlands (i.e. consideration of indigenous water property rights and competing demands of downstream uses/users). The hydrological and ecological implications of this initiative on local surface and groundwater systems (and the ecosystems they currently support) would also be considered. The Trust has expressed an interest in capitalising on the region’s native food resources including eels and bush tucker; research would be required to identify opportunities and constraints for cultivation of these natural resources. We would also investigate and nominate a number of economic and cultural change scenarios anticipated to flow from implementation of the Strategy. These scenarios would be flagged for future detailed modelling to underpin development decision-making. Concurrently, the Lake Condah Trust would initiate a community information program where scientific expertise will be utilised to increase broad Strategy support and confidence in the merit of the proposed activities. There is strong backing for the project by the community and Alcoa Foundation, ILC and the NHT have approved funds for key initial stages. The legal Trust (in formation) will hold funds with the management being under the direction of an Executive Group of the Lake Condah Sustainable Development Project.

Estimated budget: $160,000

The budget includes a CSIRO contribution of funds to this project.

5.8 Project 8. Rural Sociology of the Basalt Plains

Knowledge of the social context for land management in the Basalt Plains is a pre-requisite for designing solutions to contemporary land degradation problems, and is a necessary partner to knowledge of the biophysical system and processes. Choices concerning land use and land management depend on a number of socio-economic factors. The current demographics of the Basalt Plains need to be analysed, and the likely future demographics modelled, in order to anticipate the likely nature of land use changes and the receptivity of land managers to messages concerning improved management practices. The population of the region is a mix of farming families and rural (lifestyle) dwellers and the use of the land may be either productive (as in primary production through agriculture) or consumptive (as in a rural living choice or ‘hobby’ farm).

The Basalt Plains is an unusual area in Victoria. With its relative lack of topographic variety and tree cover, much of the area has a lower amenity value than, say, the slopes of the Great Dividing Range. The resultant lower land values make it attractive for commercial farming. Against this, the
proximity of much of the plains to large towns and cities, which provide services and employment opportunities) makes the area attractive for lifestyle farmers. Understanding the balance of these forces is crucial to planning for improved resource management on the plains. Although demographic analysis would show the balance of different classes of residents, in-depth qualitative research is needed to determine the range of resource management attitudes among residents of the plains. A quantitative survey could then be undertaken to quantify how widely the different views are held.

A further complexity is variation in the duration of land tenure. Some parts of the plains have been tightly held, with some families occupying large holdings for several generations. Other parts, particularly those that have been more closely settled, have seen turnover in land ownership. The duration of land tenure may well have a significant effect on resource management attitudes and behaviours, but this has not been studied. An understanding of this effect would best be obtained through in-depth, qualitative research. This is a suitable project for a PhD student.

Development of solution. From the results of the different phases of research, an extension program could be devised that incorporated messages appropriate to the different classes of residents. This would maximise the success of communications to residents about resource management.

Existing knowledge

Several recent surveys are partially relevant:

- Rural land managers’ attitudes, behaviour and involvement in rabbit control, 2001
- A market profile of landholders in the Corangamite catchment, 1999
- Facilitating the adoption of landcare management practices among landholders in the Corangamite catchment, 1999
- Farm family values in the Mortlake riding, 2000
- Report on the effect of prosecution under the CaLP Act on changing behaviours in the South West Region of the Department of Natural Resources and Environment, 2001
- Identifying landcare group support needs: a survey of landcare groups in south west Victoria, 1999

These surveys provide information on some aspects of rural social issues on the Basalt Plains, but suffer from several limitations:

- Low response rates mean that their samples may not be representative
- Their samples cover only part of the Basalt Plains, or also cover areas outside the Basalt Plains
- They cover certain environmental attitudes and behaviours but do not, taken together, constitute a social profile of the Basalt Plains.

Current research related to this issue

None of DPI’s current social research is specifically relevant to the Basalt Plains, but we have the capability to conduct such research (a recent example of our demographic research is Barr et al. 2002).
Knowledge needed to advance understanding / solution of this issue
Data needs. To produce a social profile of the Basalt Plains, the following data from Australian Bureau of Statistics (ABS) would be needed:

- Census of Population and Housing. Age, migration, income, occupation and industry by Statistical Local Areas in the Basalt Plains, for 2001 and selected earlier censuses.
- Farm census. Farm type, size and production by Statistical Local Areas in the Basalt Plains, for 2001 census.

Research proposed
1. Social profile

Objective: Describe the social profile of the Basalt Plains

Method: Purchase data from ABS

Estimated budget: Data, $5,000 Analysis, reporting and project management, $45,000. One year

2. Qualitative phase

Objective: Identify the range of perspectives and views on resource management of the Basalt Plains

Method: Building on the social profile, conduct focus groups with identified segments and in-depth interviews with individuals.

Estimated budget: $55,000 one year (follows on from social profile research)

3. Survey

Objective: Quantify how widely the views on resource management of the Basalt Plains are held

Method: Quantitative survey or plains residents

Estimated budget: Say $80,000, one year (follows on from previous work)

4. Tenure effect

Objective: Determine the effect of the duration of land tenure on resource management attitudes and behaviours of farmers

Method: Partnership with university for a PhD student

Estimated budget: PhD scholarship, $25,000 per year (if student can obtain a scholarship elsewhere then top-up funds only would be required). Field expenses $10,000 per year. One to three years.

R&D agencies with capability to deliver this research
For rural demographic research: DPI (CLPR rural social research unit). Contacts: Neil Barr, phone 5430 4439 or neil.barr@nre.vic.gov.au; Roger Wilkinson, phone 5430 4391 or roger.wilkinson@nre.vic.gov.au

For PhD student supervision: University of Melbourne or other universities.
6 Implementation and communication plan

Achieving integrated research on the VVP requires the agreement and cooperation of both the research agencies and the natural resource management authorities. Essential components of integrated research will be an agreed implementation structure and communication plan.

The implementation of integrated research on the VVP should be guided by the following core values:

- Respect the work that is currently being undertaken and acknowledge the intellectual investment that each research group has already made to the VVP research
- Understand and accept that each group have research interests and priorities that may have been developed in relation to their strategic directions and investment stakeholders
- Where possible, endeavour to work with existing research groups to enhance their research to provide mutual benefits and target identified priorities
- New research should build on previous research to avoid repetition of studies
- Publish research in the literature commonly available within each discipline
- Where possible, ensure that the research has application to a broad range of stakeholders

In practice, integrated research is more likely to occur within a research discipline than across research disciplines. For example, current hydrological research may often include hydrogeology, vegetation water-use and soil hydrology, but rarely includes environmental history, indigenous studies or palaeoclimate research. Yet these disciplines have much to offer the understanding of hydrological processes by providing an historical context to the present hydrological observations (e.g. Bowler & Hamada, 1971, Jones, 1995, Nathan, 1998).

Cross disciplinary research can be encouraged through an effective communication plan, which would publicise the findings of all research disciplines, as well as inform the stakeholders, asset managers and catchment managers of the research implications.

6.1 Implementation structure

An implementation structure for the VVP research project is proposed which relies on a Project Coordinator to consolidate, facilitate, and communicate the research to the various groups and stakeholders. It is envisaged that the Project Coordinator would initially be a fractional appointment, possibly within the Department of Primary Industries Research Division. The position would ideally be a senior (Level 4) position to ensure that the person had the necessary skills and experience to negotiate cooperative arrangements between the various research and investment groups. The CCMA has indicated that they would coordinate a submission for funding the Project Coordinator in the first year of the VVP project (P. Codd, pers. comm.).

The recommended role of the Project Coordinator would include:

- Coordinate the establishment of a knowledge bank of VVP research and facilitate its use.
- Coordinate the establishment of a technical panel to assist in the review of VVP research projects.
- Coordinate the technical review of projects that are submitted through the CMAs and DPI for funding (e.g. NAP and NHT) to ensure that they align with the regional priorities and comply with the core values listed above.
- Work closely with the investment managers of the CMAs, DPI and DSE to facilitate substantial research projects with outcomes that address the Federal, State and Regional priorities for the VVP.
• Encourage funding bodies outside of the CMAs and DPI (eg. GRDC, DRDC) to submit their research proposals for inclusion in the overall VVP project process.

Where funding for a specific project is being sought through a CMA (eg. NHT or NAP funds), the research proposal would normally be developed in conjunction with the appropriate Implementation Committee (IC) to ensure that the outcome has a practical application in line with the priorities of the RCS. Once the IC has ratified the project it would be submitted to the CMA Board and/or the Regional Investment Panel/Group (RIP) for consideration for inclusion in the CMA’s Regional Catchment Investment Plan (RCIP). For research projects related to the VVP, it is recommended that they also be submitted to the VVP Project Coordinator so that the CMA Board and/or RIP are informed of their technical merit and any opportunities for integrated research and co-investment. For example, in cases where similar projects have been submitted in neighbouring CMAs, the Chairs of the RIPs may wish to meet and explore the opportunities for joint investment.

The resultant outcome of the VVP research will ultimately be applied in both policies and management strategies that would be delivered by agencies that have legal authority or administer an Act, such as CMAs, municipalities, water authorities, DPI, DSE, EPA, etc. Therefore priority should be given to projects that result in specific management procedures for the best management for the VVP with a process for continuous improvement/uptake. Examples might include research that results in a change to the statutory planning procedures, such as amendments to the septic tank standard or planning regulations for floodplains. This would ensure that the VVP research is translated into actual environmental change, rather than a pile of reports the recommendations of which are not enacted. Recommendations must translate into action, even if that requires projects to include writing policy and guiding it into law.

6.2 Communication plan

The findings of VVP research projects need to be made available to all VVP research groups and the outcomes and implications widely disseminated to the stakeholders. Traditionally, the outcomes of research projects are reported in a document to those who commissioned the project, reported in a thesis, or published in the literature. The reported documents are not always made available, particularly where the research has been commissioned by a client. More recently, research reports and theses are being disseminated through the facilities of the internet.

To facilitate the dissemination of VVP research outcomes, it is recommended that the Project Coordinator establish a knowledge bank or repository of VVP research, which would be freely available to all stakeholders. Ideally, the knowledge bank would be accessible through the DPI Victorian Resources Online (VRO) website and/or the CSIRO and/or LWA’s websites.

Although sharing of research data and ideas is desirable, it is often restricted by the research groups who regard their intellectual property as a valuable asset, which provides them with an advantage in the competition for funds. However, where possible, data sets collected for specific projects (eg. CCMA bore database, LIDAR, etc.) should be made available for non-commercial research.
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Appendix A  Agricultural research on the VVP - industry overview, current research, priorities and opportunities

A Contribution to the Scoping Study from Geoff Saul, DPI Hamilton and others (see acknowledgements)

Background

This contribution to the Scoping Study was provided by Geoff Saul and others. It provides an overview of industries on the VVP, current research by the Victorian Department of Primary Industries, their priorities and perceived research opportunities both under NAP and other funding sources.

Summary

The VVP of southwest Victoria have the most reliable temperate rainfall in Australia and relatively fertile soils. The region can accommodate a wide range of agricultural enterprises, from intensive dairy production to broad-scale grazing and cropping. In recent years, poor financial returns from wool sheep and beef cattle have seen a change in the industry balance with an increase in cropping, forestry, meat sheep and dairying at the expense of wool sheep. It is likely that the traditional beef cattle and wool industries will continue to decline and be replaced by cropping and dairying, even if returns for wool sheep increase. However, the sheep industry will remain as a major industry (40% of land, filling the "spaces" between other industries or land deemed unsuitable for alternative industries. Thus the sheep industry may well occupy marginal and more fragile areas of the catchments and so have a very significant impact on the environment.

State government departments DPI and DSE, often in collaboration with Rural Industry Research Corporations, provide funding for agricultural R&D. Priority for state funding depends on the beneficiaries from the R&D with high priority for projects that benefit the wider community and full cost recovery expected when projects only provide private benefits. RIRC priorities are set in conjunction with farming bodies and federal government agencies. In recent years, both state and federal agencies have expressed an increased priority for R&D that provides enhanced environmental outcomes.

There is potential for the CCMA to collaborate in a range of projects that provide environmental and economic benefits to the agricultural industries utilising the VVP. While there are many issues within particular industries where CCMA could add value, there are two generic issues across the region where the CCMA could have significant input and provide improved economic and environmental outcomes.

Environmental impacts of the current agricultural industries

Clearly there is a relationship between agricultural industries and the immediate and wider environment. However, there is relatively little factual information available about the actual impact of different industries (or different production systems within industries) on the environment ("environmental footprint"). For example, it is often assumed (by media, urban communities) that high input grazing systems are more damaging to the environment than lower input, less intensive systems. However, limited studies to date suggest that high input systems store more carbon in the soil and produce less greenhouse gas than low input systems. But high input systems may be detrimental to water quality.
Given the importance of grazing and cropping to the region, it is vital that these environmental impacts are quantified so that current practises and trade-offs between different management systems can be evaluated. The CCMA could work with agricultural industries to identify sites and projects where additional measurements or assessment could be made to quantify environmental impacts of current practises. An example is the Long Term Phosphate Experiment at Hamilton where good information is available about plant and animal production but limited data about soil health and water quality.

**New environmentally and economically sustainable production systems**

All agricultural industries are looking to develop new production systems that will allow farmers to improve their terms of trade. Some examples are raised bed cropping, bull beef and high input grazing systems. There is an opportunity to work with these industries to ensure that new systems are both economically and environmentally sustainable. As an example, all of the grazing industries (dairy, meat, wool) are looking at new pasture systems to double pasture production per ha but the effect on the local and regional environment is unclear? This type of work could also link with the cross-industry funding opportunities such as Our Rural Landscapes.

Specific opportunities within industries to improve environmental and biodiversity outcomes include;

- Integration of trees and agricultural industries,
- Improved persistence of key pasture species,
- Development of sustainable cropping systems for the HRZ,
- Environmentally sustainable use of dairy effluent,
- Water use efficiency of existing and new crop and pasture options for temperate regions
- Combining biodiversity and production outcomes on farms
- Developing an environmentally friendly lamb industry in the south-west

Collaboration with agricultural industries to develop joint projects can be facilitated via the Key Project managers for the different industries listed in Appendix 1. Also, the Science Key Client managers for each CMA can bring together the requirements of the CMA’s and research providers in DPI. Key contacts in the RIRC’s are also listed and they provide an opportunity for development of collaborative projects to link environmental and production R&D.

In south-western Victoria, key research providers include DPI at the Pastoral and Veterinary Institute, State Chemistry Laboratory, Centre for Land Protection, Dairy Research group at Warrnambool and crop agronomists at Ballarat and Hamilton. DPI research staff have a strong history of collaboration with intrastate, interstate and overseas research groups. Of particular significance to this report are links to other DPI institutes across Victoria, Melbourne, Deakin and La Trobe and RMIT Universities and CRC’s, and CSIRO units in Victoria and interstate.
Land use and industry changes on the VVP

Agricultural statistics for the southwest statistical region are shown in Table 1. A report on land use change in the region (Petheram et al. 2000) has also been used. While neither of these data sets exactly covers the VVP, the results give a reasonable representation of the agricultural industries in the region.

The agricultural industries in south-western Victoria have a value of around $1.5B per year (Table 1). While Hamilton is commonly referred to as the "Wool Capital" the value of crops grown in the region actually exceeds the value of wool.

Table 1 Gross value of agricultural production Victoria and South-west region - 1999-00

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Total Victoria $M</th>
<th>Southwest $M</th>
<th>% in Southwest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>1570</td>
<td>511</td>
<td>32%</td>
</tr>
<tr>
<td>Meat</td>
<td>1750</td>
<td>406</td>
<td>23%</td>
</tr>
<tr>
<td>Crops</td>
<td>3000</td>
<td>163</td>
<td>5%</td>
</tr>
<tr>
<td>Wool(^1)</td>
<td>410</td>
<td>148</td>
<td>36%</td>
</tr>
<tr>
<td>Other</td>
<td>475</td>
<td>19</td>
<td>4%</td>
</tr>
</tbody>
</table>

\(^1\) Wool prices in 1999-00 of $4.00/kg were amongst the lowest on record. The long-term average and current prices are c $6.00/kg. Assuming average prices means wool worth around $220M/year is produced in south-west Victoria.

Figure 1 shows land use change in south-west Victoria over a 10 year period (Petheram et al. 2000). The area devoted to wool production decreased while cropping and timber production both increased dramatically. Dairying also increased while beef cattle showed little change in land use. A decline in traditional cow/calf operations may have been masked by the development of the fledgling bull beef industry based around surplus dairy calves. The Petheram report also suggests a decline in the area of land used for lamb production but this appears at odds with industry knowledge and lamb sales in the region in recent years. Data from the Hamilton Sale Yards shows that lamb sales increased from 497,000 in 1999-00 to over 600,000 in 2002-03 suggesting a marked growth in the lamb industry. The sheep currently uses about 40% and beef cattle about 20% of the land in the south-west.

Figure 2 shows a more detailed breakdown of the change in land use within south-west Victoria. While there has been a reduction in the area used by sheep across all sub-regions, the increase in dairying and timber is specific to the higher rainfall areas while cropping has expanded in the drier part of the region. Beef production has expanded in some areas and decreased in other areas, supporting the view that the 100,000 plus bulls now being reared and grown out in the region affect the overall picture. The split between wool and prime lamb production is relatively flexible as many ewe flocks are mated to either a prime lamb or wool sire opportunistically. In the Farm Monitor Project (Beattie and Hamilton 2001), a third of the "lamb producers" were merino flocks mated to prime lamb sires. It is probably reasonable to take the overall view that the area used for sheep production in south-west Victoria has declined significantly and may never recover.

During the late 90’s, there was a large expansion in the area planted to blue gums but higher returns from the grazing industries and lower expectations on returns from wood chips have caused a plateau in the industry. Reliable industry sources suggest that many of the current plantings may revert to pasture after the fist rotation due to low yield from trees planted on inappropriate soils. While the expansion of plantations have attracted considerable press, it is interesting to note that the total area is less than half the expansion of cropping in the region which has largely gone unnoticed.
Table 2 shows the average and range in gross margins for wool, prime lambs and beef production based on results from the last 15 years of the Monitor Farm Program (Beattie and Hamilton 2001). The data highlights the high variability of these grazing industries, and the low profitability of the beef industry. The wool industry has endured the lowest prices on record over the last 10 years but has still outperformed the beef industry.

**Figure 1 Land use change in south-west Victoria** (after Petheram et al. 2000)

![Figure 1](image1)

**Figure 2 Change in land use within Statistical Local Areas**

![Figure 2](image2)

**Table 2 Gross margins for major industries in south-western Victoria 1985-2001 (current value)**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Average GM (^1) $/DSE</th>
<th>Average GM $/Ha</th>
<th>Range GM $/DSE</th>
<th>Range GM $/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>17.32</td>
<td>187</td>
<td>10.09 - 33.63</td>
<td>102 - 399</td>
</tr>
<tr>
<td>Prime lambs</td>
<td>20.10</td>
<td>259</td>
<td>12.47 - 32.80</td>
<td>183 - 415</td>
</tr>
</tbody>
</table>

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\(^1\) Gross margins in current dollars
It is not appropriate to directly compare gross margins between cropping and grazing enterprises due to different overhead and fixed costs of these enterprises. Also, care must be taken when comparing within grazing or cropping enterprises, as they may not be able to be undertaken on a particular farm due to rainfall, soil or other restrictions.

Figure for 1998-99 and only 78 farmers,

Range for 1998–2001 but low number of farmers

Figure 3 Wool production in Victoria 1996-97 kg/parish

Industry overviews and R&D opportunities

1.0 Sheep industry

The sheep industry has fluctuated between periods of specialisation for meat or wool production and periods when dual-purpose or co-production is more common. The wool and lamb industries tend to marginalise farmers who mix both forms of sheep production but the ability to quickly move between an emphasis on meat and/or wool is a strong attraction to some farmers. High prices for meat are encouraging many merino breeders to include selection for meat traits in their sire lines. A simulation study by Thompson et al. (2002) indicated that a meat wool flock is more profitable than either a wool or meat flock.

The lamb industry has traditionally been centred on the higher rainfall (>700mm) areas of the region with wool in the lower rainfall regions. During the 90's, many woolgrowers started to mate merinos for lamb production, either selling store lambs to finishers or
developing specialised finishing systems, agistment on Wimmera stubbles, feedlots or
legume pastures. These trends are likely to continue in the future.

While research funding and is split between wool and meat, there are many common
issues between the two parts of the sheep industry.

1.1 Wool

The Victorian wool industry has changed markedly over the last 10 years with a 300%
increase in fine wool production at the expense of coarser wool, a reduction of 2 micron in
average fibre diameter. Victoria produces over 20% of Australia's wool, with over 33%
produced in southern Victoria. A de-regulated market since the early 90's plus an
increased emphasis on environmental responsibility has seen farmers keen to embrace
new production systems that increase economic and environmental outcomes. The
Triple P program, developed at PVI has been a major catalyst for change. An analysis by
Trompf (2002) has shown that farmers who participated in this program had $50/hahigher
net income, 50% higher return on assets and 25% higher DSE/labour unit than GPP non
participants.

Barr et al. (2002) studied the demographics of the wool industry from 1986-96 and found
that;
- Farmers running wool sheep over the last 15 years, buffered their incomes by
  obtaining off-farm work (worth $20,000)
- The average age of Victorian wool-growers is increasing with few young woolgrowers
  entering the industry and older woolgrowers remaining in the industry. This trend is
due more to industry and cultural trends (young people don't want to work with sheep)
than to short term market trends. An increase in wool price will not see a significant
increase in new people to the industry.
- Baby boomers (born 1946-51) make up the largest cohort of sheep farmers. As this
  group retire, there will be significant opportunities for other people, new industries or
  farm aggregation to occur.
- In central Victoria, wool production appears to have a relatively stable (low profitable)
  future, as there are few alternative land uses. In southwest Victoria, there is a wider
  range of other land uses available.

1.2 Lamb

Until the early 80's, prime lamb production was mainly in north-east Victoria with lambs in
the southwest mainly in the very high rainfall areas around Colac and Portland-Heywood
regions. However, the decline of wool prices during the 90's and high lamb prices over
the last 5 years have seen specialist lamb producers expand in the 600-750 mm rainfall
areas, being pushed out of the higher rainfall regions by dairying. Anecdotal evidence is
that the prime lamb industry is attracting new younger entrants to the industry and that
many traditional woolgrowers are mating at least part of their flock for lamb production.

It is likely that cropping and dairying will continue to put pressure on sheep numbers in the
region. Sheep farmers will either need to increase profitability by adoption of best practice
techniques for wool, meat, or a combination of wool/meat production. Details of current
projects, priorities and potential funding opportunities are shown under the meat industry.

1.3 Wool R&D Purchasers, current projects and future priorities

1.3.1 Department of Primary Industry (DPI)
DPI is a significant funder of R,D&E in the wool industry with considerable work being undertaken in western Victorian when the majority of sheep are run. Investment in R&D is determined by an assessment on who are the main beneficiaries of the work. When the community is the main beneficiary, this is a high priority for government funding. Where the benefits will flow mainly to the industry as a whole, DPI will fund high priority work in conjunction with relevant industry or other bodies. Where the benefit from R&D will mainly flow to the private sector, DPI will only perform the work as full cost recovery from the beneficiary.

David Marland (based at DPI Ararat), manages the wool strategy through two Key Projects as indicated in Appendix 1. Over the next 5 years, priorities for the Victorian wool program of interest to natural resource managers include;

- Acquisition of skills by producers to manage their land within in catchments to meet government, community and industry expectations.
- Implementation of wool production systems by producers that minimise environmental risk
- Development of better management skills to enhance productivity and profitability.
- Profitable wool production from technologies that improve land use efficiency

1.3.2 **Australian Wool Innovation Ltd (AWI)**
Following a major restructure of the wool industry in 2000, AWI elected an new board and appointed new managers for R,D&E. Recently, Dr Len Stephens (formerly from MLA) was appointed CEO. Program managers are shown in Appendix 1.

AWI has a Sustainable Production Systems program that focuses on re-engineering farm production systems to make them more profitable and sustainable. The aim of the program is to reduce the cost of wool production by 10-20% through:

- Developing products and farming systems that increase income and lower production costs, including 10 new feed/nutritive systems by 2007.
- Reducing the environmental footprint of wool production systems, while developing tools for simultaneous increase of profit and sustainability

AWI are co-funding several DPI projects including NAPLIP, Triple P and Bestwool 2010, and the extension program, Bestwool 2010. AWI are also co-funders of the Land Water and Wool initiative managed by Land and Water Australia and are looking to collaborate with other RIRC's in future projects such as Sustainable Grazing Systems. AWI are very keen to work with local funding agencies such as CMA's.

It is anticipated that AWI will develop further programs of R&D in natural resources and pasture utilisation over the next 1-2 years.

1.3.3 **Glenelg Hopkins Catchment Management Authority**
Glenelg Hopkins CMA has accessed funding from NAP to co-fund work on "Pastures for Steep Hills", and "Environmentally Responsible Wool Production" as shown below.

1.4 **Current wool research projects**

Current R&D underway in natural resource management or pasture use managed by DPI includes;

- **National Annual Pasture Legume Improvement Program** -
  - Developing improved legume species for wool growing regions of Australia, especially species for niche areas such as waterlogged or saline regions. Pedro Evans based at PVI Hamilton leads the High-Rainfall component of the program, with work in Vic, SA, Tas and WA. with funding from DPI and AWI.
Land Water and Wool

- This program is a joint investment by AWI and Land and Water Australia with support by MLA and DPI and is developing more sustainable wool production systems across Australia. Dr Malcolm McCaskill at PVI Hamilton leads the research component of the program in Victoria, Sustainable Grazing of Saline Land where species and management options are being developed for saline discharge areas. On-farm demonstrations of grazing systems on saline land are being established across Victoria, facilitated by Trevor Pollard (PVI Hamilton).

- A second component Profitable and Sustainable Wool Production is lead through the Seymour DPI office and is working with farmers in 4 regions of Victoria to encourage the adoption of more sustainable farming practises. Darren Keating at DPI Hamilton leads the work in south-west Victoria.

Triple P

- A continuation of the program developed at PVI to encourage farmers to adopt more profitable grazing systems based on higher high fertility and improved pasture management. The program is managed by the RIST centre at Hamilton with funding from AWI and the Office of Training and Tertiary Education

Pastures for Steep Hills

- This new project is working in the hill country around Ararat to develop sustainable grazing systems for these tough environments. Lead by Dr Zhongnan Nie at PVI Hamilton, the project is funded by DPI and the Glenelg Hopkins CMA.

Environmentally Responsible Wool Production

- Paul Quigley at PVI Hamilton is leading research into efficient use to fertilisers that balances pasture production with care for the environment. The Long-term Phosphate Experiment is a key site with on-farm sites across Victoria. The project is funded by DPI and Glenelg Hopkins CMA.

1.5 R&D priorities

Saul (2001) reviewed the results from a number of surveys of farmers needs and developed the following priorities for pasture-based R&D projects in the wool industry.

Development of new sustainable sheep production systems

- Wool producers in the HRZ have adopted productive pasture systems (higher fertiliser rates, higher stocking rates) to increase profitability but are now looking for the next step to remain competitive. New systems should aim for a 50% increase in profitability with a reduced environmental impact.

- There should be potential co-funding from AWI, CMAs, MLA and LWA.

- Collaborating organisations could include CSIRO, Melbourne, RMIT and Deakin Universities

Filling feed-gaps in pasture production systems

- Sheep farms suffer feed gaps in autumn and winter and these limit productivity and cause degradation of the environment through overgrazing. There are many ways to fill these gaps such as using alternative species and management practises and integration with cropping.

- Potential funding from AWI, GRDC, MLA, CMA’s.

- Collaboration with cropping R&D, DPI across the state, Southern farming Systems, plant breeders, NAPLIP, interstate and overseas scientists.

Sustainable sheep production in marginal environments

- Pressure on arable high-rainfall land may see wool sheep pushed into marginal environments in the headwaters of the catchments that already suffer sustainability and environmental problems.
• Species and management practises currently used in these areas have been sourced from more favourable situations. Work is needed to develop pasture packages specific to these areas.
• Some work has started in the Glenelg Hopkins CMA and there is potential to expand this through demonstrations of successful techniques in the CCMA area.
• Potential co-funding via LWA, AWI and CMA's with interstate and overseas research collaboration.

Environmental impacts of grazing industries
• Many sheep farmers in the HRZ have adopted "high input" farming that involves increased use of fertilisers and higher stocking rates. There is an assumption that "low input" systems are “better”. However, there is little information on long-term impacts of these production systems on the local and wider environment. The Long-term Phosphate Experiment at PVI Hamilton is one of the few resources able to assess these impacts.
• All environmental issues including effects on soils, water, atmosphere, biodiversity need to be considered.
• Potential funding from CMAs, AWI, MLA and LWA, Greenhouse Office.
• Collaborating research agencies include, Melbourne and Deakin Universities, other DPI institutes and overseas groups with environmental and grazing industries expertise.
• An assessment of environmental impacts is needed for all components of the grazing industry, wool, lamb and cattle production.

Persistence of perennial pastures
• Poor persistence of desirable pasture grasses is a limitation for sheep farmers. Wool sheep systems put pastures under more pressure than cattle or prime lambs. Dense perennial pastures improve both economic and environmental outcomes and are the cornerstone of sustainable grazing industries.
• Sustainable Grazing Systems project provided information about how to manage phalaris but relatively little is known about the management, cultivars, and compatibility of other species such as ryegrass, cocksfoot, tall fescue and lucerne or the place of native grasses in the region.
• There is potential to link with AWI, MLA, and several CMA's in southern Victoria.
• Potential collaborating organisations include DPI across southern Victoria, Melbourne, RMIT and Deakin Universities.

2.0 Meat industry

Meat production in southwest Victoria has increased as wool production has declined. In the last decade, lamb production has been the most profitable grazing enterprise but beef production the least profitable. There are different demographics in the beef and lamb industries with beef producers often older, semi-retired farmers, looking for lifestyle issues and prepared to subsidise their farming operation from off farm income (Beattie 1999). Lamb producers tend to be younger, much more business focussed and active in alliances and producer groups.

The beef industry in the region traditionally focussed on production of vealer or yearling cattle from British breed beef cows. In recent years, Midfield Meat at Warrnambool has developed a market for lean Friesian bull beef and has encouraged alliances with farmers to grow and finish these animals to around 500-600 kg by 30 months of age. Bull beef or steer fattening operations appear to be more profitable, allow greater flexibility, and be less damaging to the environment than the traditional beef systems. Cattle are not "owned" in the same way as breeding herds making farmers more able to sell or agist
under tough conditions. Large savings are made by eliminating the maintenance component of the traditional cow herd. While there is limited information on financial returns from bull beef, some farmers claim that returns can be double that from traditional cow:calf systems (Johnston pers comm. 2002).

2.1 Meat R&D Purchasers, current projects and future priorities

2.1.1 Department of Primary Industry
DPI is a significant funder of R,D&E for the meat industry across Victoria and fund production and environmental research at PVI; genetics, meat quality and food safety research at the Victorian Institute Animal Science Attwood and Werribee; and environmental and feedlot work at Rutherglen Research Institute. The principles for investment in R&D are as indicated previously for the wool industry. The Meat Strategy is managed by Geoff Kroker (DPI Bendigo) through Key Projects shown in Appendix 1. The strategy is currently being redeveloped but it is likely that it will continue to require adoption of environmentally and socially responsible production systems and a continuing need to improve on-farm productivity.

2.1.2 Meat and Livestock Australia (MLA)
MLA is the RIRC funding agency for RD&E in the red meat industry. Full details of staff and projects are provided in Appendix 1. Dr Ben Russell and Dr Hutton Oddy are key staff in commissioning and funding of R&D.

MLA have a wide-ranging charter and fund many activities including market research, extension, on-farm research, meat quality, food safety and genetic evaluation programs. In on-farm R&D, MLA see their role to direct research into improving productivity and reducing costs of production without compromising product quality and sustainability of the production system.

Sustainable Grazing Systems was a 5-year project that aimed to develop grazing systems that were more profitable and more sustainable than current systems. The project which finished in 2002, had research sites in northern and southern Victoria plus producers ran many on-farm sites. MLA have foreshadowed further work to improve the sustainability of grazing and mixed farming systems (grain, wool, meat, forestry). There would appear to be many opportunities for CMA's to collaborate with MLA once the operating arrangements for SGS Mark II are finalised.

During 2002, MLA commissioned 3 reviews of the southern Australian beef industry and summaries are provided below. Note that only material relevant to natural resource management and pasture base are included and issues such as genetic improvement, control of disease etc are not discussed.

Southern Beef program - 5 year strategic plan
This review (Oddy 2002) asked over 500 beef producers in southern Australia to identify the most important R,D&E outcomes to improve the efficiency and sustainability of their beef enterprises. The high priority outcome relevant to natural resource management was;

- How to maximise beef production from the feed resources on the property without degrading the land.

From the review, the following project areas were identified

- Environmentally sustainable beef production - to provide knowledge, skills and solutions to improve water use efficiency, water quality, water balance, soil acidity and biodiversity.
• Enhancing efficiency of the beef business - improving the productivity and financial efficiency of beef businesses. A suggested project was "More lean from Green" to better match feed requirements of the beef herd with the capacity of the pasture.

The level of pasture utilisation in southern Australia - a producers view
This review (Johnson et al. 2002) by several leading beef producers identified that beef herds in southern Australia only utilised 30-40% of the pasture resource and that this was a wasted opportunity. The review recommended that an integrated R,D&E project be developed to increase pasture utilisation on 30% of beef farms to at least 50%.

More beef from Pastures
This review (Black 2002) determined a prospectus for R,D&E to improve the pasture available and utilisation by the beef industry in southern Australia. The review indicated that;
• The greatest opportunity to improve the profitability of beef enterprises was to increase pasture growth and utilisation.
• Beef production is at less risk in southwest Victoria than NSW due to less variability in yearly pasture production.
• Many farmers are concerned about adoption of strategies to increase production of beef from pasture due to concerns about financial failure or long-term sustainability of pastures and soils.

The messages from the 3 reviews is in line with the views of DPI staff, viz. the traditional beef industry in south-western Victoria is unprofitable compared to alternative industries and needs profound changes if it is to remain a viable use of high value land. These changes need to concentrate on more efficient use of pastures while maintaining/improving environmental outcomes.

Following these reviews, discussions have been held between MLA and DPI to look for opportunities for collaboration. MLA have indicated that in the immediate future there is little research funding available to address the issues raised in the reviews.

2.3 Current beef research projects

• PVI Hamilton is involved in the Beef Cooperative Research Centre research program that is working to ensure that more cattle achieve market specifications using optimum combinations of genetics and growth pathways.
• During 2001-02, a collaborative project was undertaken with MLA and Midfield Meat to study the growth and performance of Friesian bulls at pasture.
• Staff at PVI are collaborating with DPI scientists across the state to undertake some studies of Greenhouse Gas implications of different industries. Hamilton scientists are measuring the methane emissions of beef cattle on different diets and in different seasons.

2.4 Lamb industry research priorities
In 2002, MLA established a 5- year plan for sheep-meat production research. The important elements for NRM managers in the plan are an increased commitment to improved environmental performance and improved meat production from Merinos. Specific goals are.
• Reduced cost of production improved productivity and product quality and compliance with specifications.
• Enhanced environmental sustainability and animal health and welfare through targeted research and improved management systems.
• Social development, technology adoption and innovation, and improved management practices by producers and their supply chain partners.

Given the increase in the lamb industry in western Victoria and interest by wool producers in moving a proportion of their flock to meat production, there appears to be considerable opportunities for CCMA to work with MLA in development and implementation of sustainable lamb production systems. MLA have also indicated that there is likely to be funding for R&D in this area.

2.5 Current lamb research projects

*Management Solutions- Morelamb.*

• This is a large project with an intensive research site at Hamilton and 4 satellite sites on farms across the southwest. Research led by Andrew Thompson is developing new innovative ways to increase production per head and per hectare from prime lambs, with specialist legume grass pastures. Only limited assessments are being made of the impacts of the differing treatments on soils and water quality.

*Lamb EMS.*

• This is a new project getting underway in NE Victoria to encourage farmers to participate in a whole of supply chain EMS.

*Meat extension*

• EDGEnetwork is the primary extension program for the red meat industries and works throughout the state to encourage farmers to adopt more sustainable and profitable farming systems.

• DPI in association with MLA are currently developing a series of NRM modules for the national EDGEnetwork® that will include Profit from Grazing Saline Land, WEEDgraze, Grazing for Biodiversity and Profit, and soil health (module names yet to be finalised).

3.0 Dairy industry

Since deregulation of the industry, dairying has expanded in Victoria at the expense of other states. As is shown in Table 1, dairy production in the southwest is worth over $500M, the leading agricultural industry in the region. It is Australia’s second highest milk producing region and is one of the few dairying regions to continue to expand since deregulation. Milk production increased by over 20% in the four years up to 1998 and a growth rate of 4-8% per annum is predicted into the future. New farmers are entering the industry but other farmers are relocating to southwest Victoria either from overseas or from regions hard hit by de-regulation of the industry.

To date, the industry has occupied the high rainfall (>750mm) along the coast between Colac and Portland. However, in recent years, competition for land has seen dairy farms established in drier areas around Mortlake and with irrigation close to Branxholme. Relatively low grain prices have encouraged many dairy farmers to increase milk production by feeding additional supplements. High grain prices and lower milk prices recently have reduced current returns with many farmers now being under financial pressure.

3.1 R&D Purchasers, current projects and future priorities

3.1.1 Department of Primary Industry

DPI dairy investment principles are in line with the policies outlined for the wool program. The Dairy Industry Strategy is coordinated by Richard Habgood, (Ellinbank Dairy Research Institute) through Key Projects shown in Appendix 1. Details of the current
strategy are provided below but it is currently being reviewed and a new program and priorities will be announced later this year.

Dairy research is conducted at 2 main centres, Ellinbank Dairy Research Centre and the Kyabram campus of the Institute for Sustainable Irrigated Agriculture. In addition, the dairy research group based at Warrambool undertake applied agronomic and environmental (soil, water and nutrient) R&D for the western Victorian dairy industry. Plant improvement for the dairy industry is undertaken at the DPI Institutes at Hamilton and Bundoora.

Soil, water and nutrient management is an important part of the strategy as the industry requires significant productivity gains from high-input intensive grazing systems, higher fertiliser levels and increased stocking rates to optimise pasture utilisation to continue export growth. At the same time, the industry needs to ensure its sustainability by protecting the natural resource base and minimising threats to water quality. Pasture remains the cheapest source of nutrients for dairy cows, but there is increasing use of grain-based concentrate supplements. Dairy farmers are looking to increase pasture production and consumption, combine different feedstuffs to meet cow requirements, and manipulate milk composition to meet factory requirements. Plant improvement programs are developing improved white clover and perennial ryegrass cultivars and other pasture plants using both molecular biology techniques and traditional breeding research.

Results for the dairy strategy are communicated to farmers via a range of extension activities with Target 10, a statewide project being the main vehicle for the industry.

3.1.2 Dairy Research and Development Corporation

DRDC is a research and development business working on behalf of, and funded by, the Australian dairy industry and the Federal Government. DRDC spends about $30M per year on R&D. Most projects are expected to deliver outputs or outcomes within the short to medium term (1-5 years), however, up to 25% of the R&D budget goes to research that may take up to 10 years to produce results. This long-term funding is directed towards Program areas of fundamental importance (e.g. biosciences) and with the potential for high returns to the industry.

Dr Tom Davidson and Steve Coates are the Farm Portfolio Managers with Dr Davison focussing on projects with DRDC and RDP funding and Mr Coates on regional projects. In addition Mr Coates plays the lead role for extension activities.

DRDC manages its R&D activities through a 4 portfolio's with the Farm Portfolio focussed on improvements to on-farm productivity and profitability. Within the Farm Portfolio, there are 6 programs, with 3 relevant to this report.

Regional development boards are funded by DRDC and provide a framework for involvement of key local people in the development and customising of activities in particular regions. WestVic Dairy led by Tim Nelson, is one of three regional development boards for the dairy industry in Victoria. WestVic dairy aims to ensure that all farmers and stakeholders benefit from practising sustainable agriculture and that farmers and the industry promote sustainable farming practises.

Managing natural resources portfolio focuses on efficient use of resources, protection and enhancement of on-farm resources and minimisation of impacts of dairying off-farm. The program works major environmental issues facing dairying such as water quality, soil health, biodiversity, greenhouse gas, land use change, adoption of best practise and
working with catchments and community organisations to enhance environmental outcomes.

The Feedbase portfolio provides farmers with information and techniques to manage forage production and quality in a sustainable way. A major challenge for dairying is to manage the variability in seasonal pasture production within the boundaries of community concern about the management of natural resources.

3.1.3 Gardiner Foundation
The Geoffrey Gardiner Dairy Foundation was established in 2002 to improve the international competitiveness of the Victorian dairy industry. The Foundation provides funding for:
- Research, development, extension, technology transfer
- Education, training, skill development
- Projects benefiting Victorian dairy communities
- Other activities, which improve dairy industry productivity and competitiveness in accordance with the Victorian Dairy Act, 2000.

To date, GGF have funded a small project at PVI and are developing several large industry wide projects. Their interest in environmental and on-farm production research is unclear.

3.2 Current Dairy research projects in SW Victoria

Dairy effluent - Dairy research group Warrnambool
- Developing guidelines for applying dairy effluent to pasture and forage crops to provide safe, longer term economical and sustainable effluent disposal systems.
- Quantification of the benefits (production and economic) of utilising the nutrients and water contained in dairy shed effluent for forage production on farm and sustainable levels of dairy effluent use for particular soil types in western Victoria
- Funded by DPI, DRDC, WestVic Dairy and Gardiner Foundation

Phosphorus x Nitrogen fertiliser interactions - Dairy research group Warrnambool
- Defining the relationship between the P status of 3 soils in western Victoria and herbage production, on commercial farms, with and without applied N fertiliser input to determine whether the P and P x N response curves change on different soil and pasture types.
- Further work is needed on environmental implications in relation to P and N use at higher production levels and should be linked with run off and leaching studies and work in meat and wool industries.
- Funded by DPI and DRDC and WestVic Dairy.

Irrigation of alternate species - Dairy research group Warrnambool
- This project is developing systems to use limited water available for irrigation water to efficiently reduce forage to fill the summer–early autumn feed gap.
- Further work is needed to link with fertiliser use and with environmental measurements
- Funded by Water for Growth Initiative (DSE)

Southern Dairy systems - Dairy research group Warrnambool
- Development of forage systems that consistently, economically and sustainably provide 20t of high quality forage on high rainfall (including supplementary irrigation) southern dairy farms.
- The work needs to link with environmental BMP work to ensure that increased productivity does not damage the environment. Also, the concept needs to be
considered across all grazing industries (wool, meat, dairy) as they all face a similar challenge of growing forage more from less land.

- Funded by DPI, DRDC, WestVic Dairy, GippsDairy and TasDairy

**Pasture renovation - Dairy research group Warrnambool**

- This project aims to determine pasture renovation guidelines to optimise the supply of high quality dairy pasture in SW Victoria. The project will also determine the potential environmental effect of different renovation strategies on soil physical health and implications on nutrient run off and soil loss.
- Funded by DPI, DRDC and WestVic Dairy

**Productive Grazing, Healthy Rivers: Improving riparian and in-stream biodiversity**

- This project is being undertaken by Warrnambool dairy group and staff at Ellinbank with DPI funding
- Undertaking a detailed survey of riparian zone biodiversity on 16 sites in southwest Victoria (fenced and unfenced, dairy and beef).
- Producing management guidelines on the recruitment of native flora, based on research investigating barriers to recruitment in remnant riparian vegetation.
- Developing a riparian weed management decision support tool specific to intensive grazing areas of south west Victoria and BMP guidelines for riparian areas on dairy farms based on the identification of on-farm management practices that influence riparian condition.

### 3.3 Future Priorities for dairy R&D in SW Victoria

**Growing and using more pasture; 20 t pasture/ha consumed**

- There needs to be continual improvement in productivity and utilisation of pastures. Many farmers are looking for ways to increase herbage production and 20t/ha is a stretch target for the industry.
- Implicit is the need to match production to landscape and implications with nutrient use in terms of amounts, run off and leaching so the target must be achieved within transparent environmental guidelines
- To achieve this ambitious target will require an integrated approach including pasture species, management, soil modification, nutrition, renovation, etc.
- Potential collaboration with other grazing industries and funding providers

**Improved water use efficiency**

- In western Victoria, there are limited supplies of irrigation water. As dairying pushes into drier areas, rainfall deficient will become more important. How can this limited resource be used to grow more pasture from less inputs? Systems specific to the VVP need to be developed.
- A key component of such work will be an improved understanding of water infiltration rates for different soils. This will enable better matching of irrigation system (type and size) to soil type and also the appropriate species to irrigate

**Natural resource management**

- Westvic dairy have indicated a need to do more to encourage dairy farms to understand and implement farming practises that are more profitable and sustainable. These include items such as improved land use and planning, managing intensification, streamflow and ground water management, soil health and protection, protection of biodiversity and improved effluent and nutrient management.

**Dairy Effluent – Environmental impacts**

- Although there is existing work focussing on the potential of using dairy effluent for improving forage production, further work is required to determine the implications of
effluent use on farm environmental issues such as soil structure, nutrient run off and leaching.

• Work is required on a range of soil types.

4.0 Grain industry

Over the last 10 years, the area under crop on the VVP has increased by over 200,000 ha as shown in Figures 1-2. It is expected that in 2003-04, this could expand dramatically in response to high-anticipated prices for grain and a lack of livestock for farmers to purchase after the drought. One million ha of the southwest could be under crop in the near future. Gross margins for crops in the region appear to be very favourable compared to the broad-scale grazing industries. Waterlogging has traditionally restricted cropping in the region but most of the data shown in Table 1 was collected in the last 10 years when rainfall in the region was well below average. It is unclear if the advantage of crops over livestock will continue in the future when rainfall patterns swing back to a wet cycle.

Raised bed cropping has been a major innovation during this period to reduce the impact of waterlogging. However, the area where this technique can be used is limited by slope, soil type and the limitations to grazing of raised beds by livestock. Also, the system has not been tested under really wet conditions. It is likely that in the short-term, raised beds will continue to expand, especially with specialist grain producers.

Grain production is also limited by a lack of varieties and cultural practices specific to the region. Most cultivars and techniques have been adapted from northern regions and recent work has highlighted major deficiencies in current recommendations on wheat cultivars and sowing times in the area.

4.1 R&D Purchasers, current projects and future priorities

4.1.1 Department of Primary Industry

DPI is a significant funder of R,D&E in the grain industries across Victoria and fund some production research through PVI Hamilton and a full range of production, environmental, variety and product quality work through institutes at Horsham and Rutherglen. These institutes undertaken some R&D in the higher rainfall areas but as the grain industry has been traditionally based in the lower rainfall areas, relatively limited R&D has been conducted on the VVP. CAS groups at Ballarat and Hamilton also undertake grain industry development projects on the VVP. Principles for investment in R&D are determined by judgement on who are the main beneficiaries of the work as previously indicated for the grazing industries.

The Grain Strategy is managed by Phil Haines based at DPI Rutherglen. Key Projects and managers relevant to this report are shown in Appendix 1. The strategy for the next 5 years is currently being redeveloped but it is likely that the strategy will continue to require the implementation of environmentally and socially responsible production systems and a continuing need to improve on-farm productivity.

4.1.2 Grain Research and Development Corporation (GRDC)

Three regional panels play a key part in setting the priorities for GRDC investment. The Southern Panel is lead by Ian McKinnon and visited southern Victoria in spring 2002. The panels talk extensively with producers and researchers, review projects and other information to determine the R&D needs. Much of the GRDC program is involved in crop improvement, crop protection and product and service delivery. The area of interest to southern Victoria and CCMA is in the Sustainable Farming Systems program, details of which are shown below.
Objective: To develop sustainable farming systems adapted to each GRDC agro-ecological region that are responsive to grower, community and catchment needs. Strategies; Develop new technology and practises that;

- Assist in overcoming soil constraints
- Use the beneficial effects of soil flora and fauna
- Assist growers in dealing with spatial variability
- Provide a wider range of options for use in rotation with grain crops
- Provide opportunities for nutrient input from nitrogen fixation
- Allow for weather and climate variability
- Lead to efficient water use and reduced drainage below the root zone
- Provide efficient nutrient uptake and minimise nutrient loss
- Contribute to shared catchment outcomes especially for salinity and water quality

For the high rainfall area, GRDC has identified that there is significant potential to increase the area under crop, yield and quality of grain produced. However, there are constraints in crop agronomy and poor crop architecture that stop crops reaching their potential. The GRDC is currently reviewing the options needed and is expected to release a paper setting out the basis of future investment in the region by June 2003. Given the increase in cropping and the similarities in the needs of the GRDC and CCMA, high rainfall crop agronomy and environmental impacts, this topic is a high priority for CCMA to consider for joint investment.

4.2 Current grain industry research projects

4.2.1 Southern Farming Systems

SFS based at Geelong (key contact Colin Hacking), undertakes a range of applied agronomy trials with cereals, canola and pulses at several sites across the VVP between Gnarwarre and Lake Bolac and in Tasmania (Anon 2002). Most of the current work is at sites in the 550-650 mm rainfall areas with few in regions with >650mm rainfall. DPI staff are involved with many of these trials and but they are sponsored by SFS and so included in this section. Many of the trials are conducted in collaboration with private companies and other parties.

Full details of results from SFS trials are available in SFS Trial results (Anon 2002). Major trials include;

- Cereal agronomy including fungicides, canopy management, nutrition and varieties
- Canola agronomy including growth regulation, varieties, direct drilling, disease control,
- Raised bed trials
- Pulse trials
- A farming systems trial looking at cropping and pasture systems on raised beds at Gnarwarre.
- Farming systems, to test if drainage of waterlogged soils through raised beds will increase crop and pasture production.

4.2.2 Department of Primary Industry

In addition to involvement in SFS projects, DPI staff undertake R&D projects as shown below.

*Adopting Profitable pasture:crop rotations: on farm research across the HRZ of Victoria.*

- This is a new project managed by Pedro Evans from PVI to encourage farmers to adopt pasture crop rotations that reduce the need for N fertiliser and provide a disease break between crops.

*High Rainfall Crop Agronomy Project*
• In this project managed by Penny Riffkin at PVI and completed in 2002, compared crops (wheat and canola) grown on flat land and raised beds in the high rainfall zone of south-western Victoria.

**Variety trials (wheat, Barley, Canola, legumes)**

• Angela Clough based at Ballarat CAS office undertakes a range of crop variety trials across the region.

**Victorian Winter Crop Summary,**

• This publication produced from VIDA Horsham summarises crop variety comparisons across the state and includes data from southern Victorian sites

**Nutrient Runoff**

• Tim Johnston from Rutherglen Research Institute has been monitoring nutrient and chemical runoff from cropping sites near Gnarwarre.

**Hydrodynamics under raised-bed tillage systems**

• This work by PhD student Phil Newton on a basalt soil at Hamilton is concerned with the discontinuity between spatial and temporal scales of water movement during rainfall events and the subsequent dispersal of water through evapo-transpiration by drying of the soil and its use by the crop. Comparisons are on the raised-bed itself and the furrow, which have different vertical and lateral transmission characteristics and conventional tillage treatment.

### 4.3 Grain research priorities

GRDC ran a workshop in Mt Gambier in November 2002 to determine future priorities for R&D in the HRZ. Participants included researchers from CSIRO, DPI, Melbourne and Tasmania Universities, Southern Farming Systems, GRDC southern panel members and leading producers. It was anticipated that the program team would make final recommendations regarding HRZ investment to the Southern Panel for their meeting in February 2003 and that these would be circulated to the National GRDC Panel in March 2003. To date, no recommendations from the workshop have been circulated. The information provided below is DPI staff feedback on the priority areas for R&D.

• Soil and sub-soil constraints to achieving potential yield

• Integrated grain and grazing systems - Systems approach to integrate stock, crop components, risk management, seasonal weather prediction, biodiversity, etc. Need to do this on a regional basis;

• Linking profit and the environment through refined nutrient management leading to improved catchment health- Big picture catchment monitoring of off-farm pollutants (N salinity etc).

• Matching crop genotypes with regional environments.

• Co-ordination of information / knowledge across the 4 High Rainfall Zones.

Sustainable Grain and Grazing Systems is a new initiative jointly funded by MLA and GRDC. As part of the initiative, $250K/year is being provided to 10 priority catchments (one of which is CCMA) to encourage development and implementation of more sustainable mixed farming systems. There is potential to link this funding to current grain productivity R&D.

### 5.0 Private Forestry

Over the last 10 years, farm forestry has become a major industry in the region as shown by the change in land use shown in Figures 1-2. The Private Forestry Council Victoria published *"Private forestry in Victoria: strategy towards 2020"* and indicated an aim to treble the area of plantations on private land from 250,000 to 750,000 ha by 2020 with a focus on fast-growing eucalypts and pine but encouragement of other species to meet a range of market requirements. The Green Triangle Regional Plantation Committee...
strategy plan published in 1998 "Strategy Plan - Forests for the future: towards the 2020 vision" was to double the area of pines from 150,000 ha to 300, 000; establish 100,000 ha of blue gums; expand farm forestry to at least 10% of farm area, integrated with farming activities, for a range of species; process a significant part of the resource in the region.

More recently, NRE West Regional Forest Agreement (2002) indicated that the sustainable yield of timber from the region is inadequate for future needs for value-added products. State Government announcements in 2003 indicated that there will be further reductions in timber available from State forests in the Otways. The NRE Firewood Strategy draft report (2002) also flags greater restrictions on availability of firewood from Crown lands, in order to preserve biodiversity in the woodlands.

5.1 R&D Purchasers, current projects and future priorities

5.1.1 Department of Sustainability and Environment
The Department of Sustainability and Environment (DSE) fund farm forestry R&D in collaboration with groups such as National Heritage Trust and Rural Industries Research and Development Corporation. John Houghlin in the Private Forestry Unit manages DSE funding. Key staff in the region includes Rod Bird at PVI Hamilton, and Liz Hamilton and Sue Harris based at Colac.

5.1.2 Rural Industries Research and Development Corporation
The Joint Venture Agroforestry Program (JVAP) was established in 1993 and is jointly funded by the Rural Industries, Land and Water Resources and Forest and Wood Products Research and Development Corporations (RIRDC, L&W Australia and FWPRDC). The Grains R&D Corporation, the Cotton R&D Corporation, the Murray Darling Basin Commission and the Natural Heritage Trust also contribute to the program.

The program aims to develop strategies for implementation of farm forestry, focusing on identifying impediments and opportunities and improving information flow, investigate how agroforestry can contribute to more sustainable management of natural resources, optimise the productivity of crops and pastures by assessing the effects of agroforestry on productivity of other agricultural enterprises, promote direct returns from trees through species development, including in medium and low rainfall areas and investigate harvesting, processing and management systems.

5.2 Current farm forestry research projects in SW Victoria

Corangamite Farm Forestry Project - Sugar gum firewood/sawlog project
- Sugar gum has been identified as a key species for fine furniture and firewood and R&D is currently underway in Corangamite lead by Liz Hamilton. A marketing group SMARTimbers has been formed.

Australian Low Rainfall Tree Improvement Group germplasm trials.
- The project run by PVI is comparing spotted gum, sugar gum, red ironbark and swamp yate for production of superior seed for farm forestry purposes. Part of the JVAP project, it is identifying the best species and seed sources for commercial forestry in the dryland areas of southern Australia and establishing breeding programs for selected species.

Southwest Farm Forestry project.
- PVI maintains some 300-tree sites for research and demonstration purposes, with ongoing funding from DSE. These sites provide longterm data on timber production from a range of species on different soils and rainfall area. As part of this project, PVI staff have published several books such a 'Farm forestry in southern Australia: a focus on clearwood production of specialty timbers' (Bird PR 2000).

5.3 Research and demonstration priorities
**Integration of trees/shrubs into grazing systems for multiple benefits**

- Salinity strategy plans have recognised that trees are required for recharge control in many high rainfall areas. We need examine ways in which revegetation with trees and shrubs can be done increase water use and add other objectives, including biodiversity and improved animal production and welfare, as well as providing farm forestry options. It is likely that 20% vegetation will be required to effectively control recharge in many areas.

- Demonstrations of forestry/vegetation options are needed and these could provide material for subsequent research on recharge, animal production, impacts on pasture and impacts on biodiversity.

**6.0 Cross industry and landscape project opportunities**

**6.1 Our Rural Landscapes**

Our Rural Landscape is a new State government initiative that will provide $50M over 4 years under four themes. The theme most relevant to the broadscale farming industries is *Dramatic improvements in efficient use of natural resources for high value, sustainable agriculture*, managed by Greg Buchanan (DPI Mildura). The initiative is about doing things differently and achieving dramatic improvements rather than incremental change. There is an emphasis on strategic R&D and less importance on return on investment than in current industry projects. Projects must be innovative and it is likely that projects will be commissioned and cover significant areas of work rather than small single issues. A proposal to build a "VVP" project to develop fundamentally new and innovative farming practises for the high rainfall areas of southern Victoria was discussed recently when Greg visited Hamilton. This concept would build on this current scoping study.

**6.2 CRC Plant based Management of Dryland Salinity**

DPI is a key contributor to this CRC. Staff at PVI are involved in projects that are looking at trees and plants that will reduce ground water recharge, alternative uses for saline land and breeding, developing and evaluating new pastures plants for the grazing industries. DPI staff at CLPR Bendigo and SCL Werribee are working on hydrological assessments of catchments and social impacts to salinity while the Arthur Rylah Institute is involved in biodiversity projects. As this CRC is still in the early stages of development, there is considerable opportunity for collaboration and co-funding with interested CMA's. Dr Garry McDonald from Rutherglen is the overall manager of DPI involvement in the CRC.

**6.3 Ecologically Sustainable Agriculture Initiative**

This project aims to encourage farmers with remnant native grasslands and grass woodlands to better manage these areas to maintain the biodiversity values. Work is being undertaken on the basalt plain in western Victoria (PVI staff) and Riverine plains of northern Victoria (Rutherglen staff). Project leader is Steve Clark based at PVI Hamilton.

**6.4 Greenhouse Initiative**

The Greenhouse Strategy will prioritise research and development in the agricultural sector to develop emissions profiles for each agricultural industry in Victoria; identify and implement actions to reduce agricultural emissions; increase the level of our understanding about climate change in rural Victoria; and identify the impacts of climate change and develop ways to adapt to these improvements in carbon and greenhouse accounting. This work will provide more accurate data on agricultural methane emissions, improved understanding of nitrous oxide emissions and agricultural soil carbon fluxes, development of best practice guidelines to minimise nitrous oxide and methane emissions from agricultural activities.
Some research is currently underway at Hamilton (project leader Bruce Knee) to determine the methane emissions from beef cattle at different times of the year. There is potential to undertake further studies of impacts of different diets, genetic differences in methane output and the use of improved pastures to act as carbon sinks.

6.5 Land and Water Australia (LWA)
LWA fund projects that encourage the productive and sustainable management of land, water and vegetation resources and seem to favour projects that work across industries and that are in collaboration with other RIRC’s or funding bodies. Andrew Campbell (originally from Hamilton, led the Potter farmland Plan) is Executive Director of LWA.

6.5.1 Land Water and Wool
Land Water and Wool is a program that focuses on sustainable wool production in Australia. It is a partnership between Australian Wool Innovation Limited, Land & Water Australia, MLA and DPI. Current project include;

Marrying biodiversity conservation and productivity in wool production landscapes.
- Jim Crosswaite at DSE Melbourne is leading this project co-funded by DPI/DSE in Victoria, demonstrating at 4 on-farm sites ways that farmers can obtain dual benefits to biodiversity and profitability.

Sustainable Grazing of Saline Land.
- This project is researching the profitable use of land that may have previously been considered unproductive as a result of dryland salinity. A site near Hamilton was established in 2002 and is managed by Malcolm McCaskill from PVI Hamilton.

Climate Variability in Agriculture.
- This program is working with the Australian agricultural sector to develop and implement profitable and sustainable management strategies using climate information. In 1998-2001, Steve Clark of PVI was funded through this program to undertake a study of farmers understanding of the impact of climate variability on management practises.
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Appendix B Research issues in the VVP: suggestions from PIRVic

Please treat as commercial in confidence by request of authors

Science / Discipline area: Crop pasture systems
Issue title: - Benchmarking the environmental impact of cropping.

Description of issue: - Traditionally, farm enterprises in the high rainfall zone of south-western Victoria have focused on animal production. As a result, most of the region has been under permanent pastures. Farmers adopting cropping systems following long-term pastures have experienced good crop yields due, in part, to high soil fertility and improved soil structure. Sustainability of long term cropping in the region is questioned.

This project will provide a benchmark for physical, chemical and biological soil properties so that the on-site impacts of cropping on soils in the region can be identified and assessed. It provides an alternative approach to long-term cropping experiments, which are costly and can be inflexible. The information will be available for use in predictive models, to further develop regional soil maps and to landholders through field days and extension programs to increase awareness of soil management issues. This project will provide information that will aid in the development of on-farm environmental management systems. It will enable landholders to assess and manage the environmental impacts of their grain production enterprises in the Basalt Plains. Data and archived soil samples will be available to researchers in the future as a benchmark to assess the effect of a particular farming practice on the environment and on crop yields.

Existing knowledge
Some soil data is available from information from previous studies such as the Geological Survey of Victoria and south-western Victoria soil survey data (e.g. Maher and Martin).

Current research related to this issue
None that we are aware of.

Knowledge needed to advance understanding / solution of this issue
Data needs: Soils will be sampled for soil properties to determine the current chemical, physical and biological status of soils in the region under both pasture and crop.

Understanding of processes: identify and assess the importance of existing and potential environmental impacts of the grains industry in the high rainfall zone of southern Australia.

Development of solution: Information will be disseminated to farmers through field days on the internet (e.g. Victorian Resources Online) and the Soil Smart extension program developed to create awareness by farmers of soil management issues. Increased awareness of soil management issues through close links with the Soil Smart extension program.

Research proposed
Description of type of research needed addressing
Objective: To provide a benchmark for soil properties (biological, chemical and physical) in the high rainfall zone of south-western Victoria to monitor the impacts of the change in land-use from permanent pastures to cropping, and to enable effects of unsustainable farm practices on crop yields and the environment to be averted.

Method: Soils will be characterised in terms of physical, chemical and morphological properties to identify soil variability, soil/water characteristics, constraints to root growth, seedling emergence, re-establishment of aeration following rainfall etc. Soil properties to be measured will include; physical - infiltration, bulk density, soil structure, classification, and texture; chemical – N, P, K, S cations, organic carbon, EC, pH and; biological – earthworms, cotton strip assay and microbial respiration. Sites will represent a range of soil types, slope, history, rainfall etc in the region. Sampling areas will be marked using GPS and buried transponders for future reference.

Timeframe: Three years
Cost: $150,000/year

R&D agencies with capability to deliver this research
Science / Discipline area: (Water quality/environment)

**Issue title; Identifying Runoff hotspots to improve water quality**

Description: The broadscale farming industries are under pressure to show that its activities do not cause environmental damage off-site, such as increased P runoff into waterways. Key findings relevant to streamwater quality from the Sustainable Grazing Systems (SGS) project were:

- The higher the P status of a soil, the greater is the P concentration of surface water flow.
- A small proportion of the landscape contributes a high proportion of flow, even if no P is applied; P concentrations in surface flow are still above healthy stream standards. Source areas for surface runoff, which are usually close to drainage lines, should be managed as low-P systems, whereas areas further away from drainage lines can be managed as high-P systems, with little risk of affecting waterway health. Source areas are typically less than 10% of the total area of a catchment.

Land managers need to be able to identify the source areas for surface runoff. Land use systems, such as those based on native species with minimal grazing, need to be developed for runoff source areas which protect the soil but require little P. Techniques for improving water quality prior to its leaving the farm are necessary for situations where other means of control are inappropriate, such as the use of artificial wetlands.

**Existing knowledge**

Results from the Sustainable Grazing Systems project, and those from elsewhere in Australia (Barling et al. 1994) and overseas. In the United States, these principles are used as the basis of extension programs to enable landholders achieve improved water quality. There is also knowledge of nutrient issues, at other institutions, including CSIRO, Centre of Land Protection Research, Melbourne University.

**Current research related to this issue**

This proposed project is building on past research and overseas findings. There is no current research in this area.

**Knowledge needed to advance understanding / solution of this issue**

- **Data needs:** Streamflow data from streams in the region.
- **Understanding of process:** Analytical techniques to identify local hotspots for the generation where surface runoff occur within catchments. These models are based on digital elevation data.
- **Development of solution:** These models will be used to develop case studies of identifying the “hotspots” in collaboration with landholder groups representing a range of catchment types throughout the region.

**Research proposed**

Description of type of research needed addressing (point form)

- **Objective** (i) To use streamflow data to estimate the proportion of catchments in the region which contributes to streamflow, and (ii) To develop guidelines for landholders to recognise and manage runoff hotspots to achieve improved streamwater quality.

- **Method:** Streamflow data from streams in the region will be used to estimate the proportion of each catchment that contributes to stream flow. Analytical techniques will generate locally relevant data useable by landholders throughout the region on the proportion of area that needs to be targeted for low-P production systems. Spatial models based on digital elevation data will be used to assist in identifying where these “hotspots” for the generation of surface runoff occur within catchments. These models will be used to develop case studies of identifying the “hotspots” in collaboration with landholder groups representing a range of catchment types throughout the region.

- **Timeframe:** 2 years
- **Cost:** $30,000/year estimate
R&D agencies with capability to deliver this research
Agency: DPI Pastoral and Veterinary Institute, Hamilton,
Contact: Malcolm McCaskill (03 55730900)
Collaboration: Melbourne University, Dr Andrew Weston Melbourne University, Centre of Land Protection Research, Bendigo.

Science / Discipline area: Groundwater
Issue title: Impacts of agronomic practice on nitrate in groundwater

Intensification in the dairying and cropping industries has led to an increase in the rates of N fertilizer applied. Nitrate concentrations in groundwater in the southern part of the basalt plain are high. There is a need to identify the soils at greatest risk of N leakage into groundwater, and develop best-practice guidelines for the maximum rates of N that can be applied on a range of soil types. Nitrate leaching also accelerates soil acidification.

Existing knowledge
There is a limited amount of groundwater nitrate data from the bore network. There has been no analysis of these data, relating groundwater quality to soil type or agricultural practice. A study of N application to dairy pastures was conducted on a heavy basaltic soil at DemoDairy between 1997 and 2000. An extensive data set was collected, including nitrate concentration of water below the root zone, soil moisture dynamics, climate data, pasture growth and pasture nitrogen concentration. While some aspects of this study have been published, there is scope to use the data with modelling to develop guidelines for long term safe nitrogen application rates.

Current research related to this issue
The only current research on this issue we are aware of is a study of the relationship between groundwater and flows in Brucknell Creek.

Knowledge needed to advance understanding / solution of this issue
Data needs: Update of nitrate data from the bore observation network, along with description of adjacent soil and land use
Understanding of processes: Test an existing model of water and N movement against the DemoDairy dataset, and used to develop scenarios of N use for this and other soil types
Development of a solution: Guidelines for N usage tailored to the major soil types of the region

Research proposed
Objective: To tailor N application guidelines for dairying and cropping to major soil types of the region

Method: (i) Water samples will be collected from the bore network and analysed for nitrate. These and past data will be related to surrounding land use. This component of the study could be suitable for an interested post graduate student.
(ii) An existing model will be calibrated against the DemoDairy dataset, and used to develop scenarios of N use for this and other major soil types in the region. (3) Findings will be disseminated through local media, field days, fertilizer agents, CMA facilitators.

Timeframe: 2-3 years depending on resourcing levels
Cost: $100,000/yr

R&D agencies with capability to deliver this research
DPI PVI Hamilton, contact Malcolm McCaskill
Collaboration: DPI Warrnambool (N balance from the DemoDairy N experiment), Deakin University, Warrnambool, John Sherwood Associate Professor, School of Ecology and Environment Faculty of Science and Technology, Deakin University
Science / Discipline area: Climate/modelling

**Issue title: Current and future climates - implications for land-use**

The Basalt Plains spread from the western outskirts of Melbourne to Hamilton and south to Geelong, Colac, Camperdown and Port Fairy. The climate varies enormously with rain shadow areas near Werribee and high rainfall in the southwest coastal areas. Frost incidence increases with distance from the coast. Soil type and summer rainfall have large impacts on pasture and crop production. Crop production and horticulture are emerging industries and little is known of how to match enterprise to climatic region. Climate change scenarios indicate some major shifts in rainfall patterns, frost incidence and temperatures by 2020 and 2050 which have implications for land use now and in the future. Two examples are the northward spread of dairy farming and cropping moving southwards. There is likely to be pressure for dairying to move south again if predicted climate changes occur, with a continued southern movement of cropping. More accurate estimations of current and future climate patterns will be advantageous in forecasting future land use and the associated environmental effects.

**Existing knowledge**

Most of the larger towns and cities on the plains have long-term daily rainfall data and a few have records of temperature, wind speed etc. This can be supplemented with the patch point data from the Queensland Department of Primary Industry. The GrassGro decision support tool can be used to simulate pasture and animal production and similar models are available to simulate crop production. CSIRO Atmospheric Research has developed fine scale climate change scenarios for Victoria and these can be used to assess likely changes to land use on the Basalt Plains. A similar study to that proposed here has been conducted for Gippsland and one is now underway for the Wimmera-Mallee.

**Current research related to this issue**

‘Options for Victorian Agriculture in a “new” climate’ – a pilot study linking climate change scenario modeling and land suitability modeling conducted for Gippsland.

Strategic Resources Planning Unit of DPI and CSIRO Atmospheric Research

Contact: Adam Hood, DPI, State Chemistry Laboratories, (03) 9742 8787

**Knowledge needed to advance understanding / solution of this issue**

climatic records from towns and cities on Basalt Plain
patch point data to fill in gaps
soil type and pasture and crop growth data
GrassGro and an equivalent crop growth model (e.g. APSIM)
Output from CSIRO Atmospheric Physics climate change models

**Research proposed**

**Objective:** Characterisation of the current and future climate of the Basalt Plains and their implications for future land use change

**Method:** Use daily climate data from representative localities to drive pasture and crop growth models. Investigate changes in pasture and crop production with expected climate change scenarios for 2020 and 2050

Will be an essential component of the planned study of climate change scenarios and land suitability in south western Victoria

**Timeframe:** 18 months

**Cost:** $50,000

**R&D agencies with capability to deliver this research**

Victorian Department of Primary Industries Pastoral and Veterinary Institute Hamilton

Contact: Steve Clark (03) 5573 0977

Collaboration: Resources Planning Unit of DPI and CSIRO Atmospheric Research

Contact: Adam Hood, DPI, State Chemistry Laboratories
Science / Discipline area: (Environment footprint)

**Issue title: Greenhouse/emissions from grazing systems**

*Description:* Sheep, beef and dairy cattle are significant land use on the basalt plains, but there is little knowledge of effects on greenhouse emissions. While many assumptions can be made in order to assess this footprint, little empirical data is actually available to formulate a true and accurate conclusion.

An issues paper discussing a strategic framework for greenhouse and agriculture, produced by the Australian Greenhouse Office, state that key areas for further action should include amongst other things (i) An approach to improving the understanding of nitrous oxide and methane emissions from Australian agricultural production systems, and effects of management practices on these emissions. (ii) An assessment of carbon sequestration potential of environmental plantings and sequestration management practices and improved understanding of the dynamics of greenhouse gas emissions and carbon sequestration in improved pastures and rangelands. There is therefore a need to obtain information on the effect of different grazing systems (Inputs of fertilizer, grazing systems, pasture type) on the greenhouse emissions (Outputs) mentioned above.

**Existing knowledge**

The Greenhouse Office has published estimations of effects on greenhouse gases by different industries, but there is very little real time data. Preliminary data on the Long Term Phosphate Experiment suggests that high productivity treatments are sequesting up to 2 tonne of carbon per year, whereas the low fertility low productivity plots are releasing 1 tonne per year. Preliminary data from a small study at PVI indicates differences in methane output due to diet, but these differences did not always correspond to predicted values.

**Current research related to this issue**

*Related project:* The Environmentally Sustainable Agriculture Initiative greenhouse project, monitoring nitrous oxide emissions from dairy (Warragul) and cropping pastures (NE Vic) where nitrogen fertiliser is used. Some monitoring of methane emissions from dairy cows and steers is being undertaken in a collaborative project with the CRC for Greenhouse Accounting and DPI.

*Contact:* Dr Richard Eckard, Melbourne University/Ellinbank Research Centre, Warragul

**Time frame and funding:** Three years

**Potential for integration:** Some background data will have been collected from dairy pastures and northern cropping

**Knowledge needed to advance understanding / solution of this issue**

*Data needs:* Actual measurements, soil, carbon, biota, nutrient status, nitrous oxide, methane measurements from cattle and sheep. Associated satellite/ground images

*Understanding of process:* Relationships between soil type, nutrients, pastures, animals and imagery techniques. Ground truthing, to enable greenhouse/environmental classification of the different systems

*Development of solution:* Results would be extended to the wider farming community so that benchmarking of impacts of different systems could be demonstrated.

**Research proposed**

*Description of type of research*

*Objective:* Improved knowledge of the greenhouse gas impact including carbon sequestration of various grazing systems.

*Method:* use existing fertiliser production sites, to measure of soil carbon and nutrients, pasture quality, composition, soil biota, N₂O, methane, animal production, satellite and ground imagery. And correlate greenhouse production with inputs and pasture quality to establish relationships, so that guidelines on the effects of different systems on greenhouse emissions can be used.

*Timeframe:* Three years

*Cost:* $100,000

**R&D agencies with capability to deliver this research**

*Agency / division / contact:* DPI, PVI Hamilton, Contact John Graham (0355730908)

*Collaboration:* CRC for Greenhouse Accounting, DPI Ellinbank, Melbourne University, CSIRO WA.
Science / Discipline area: Animal production and water use

**Issue title:** Environmentally Friendly Pasture Finishing Systems.

**Description of issue:** Lamb, beef and bull beef producers find it difficult to finish livestock by the end of spring, and need to use expensive supplementary feeding systems to finish them to age related market specifications. Development of new and novel pastures, and the recent introduction of cropping into the high rainfall zone (eg pastures crop rotation systems) may enable producers to meet target specifications that are often difficult to meet in the summer autumn period. Environmental aspects of using these systems is not well known, i.e. water use, effects on soil structure, soil nutrient balance, soil biota. This project will identify finishing systems that provide the environmental benefits with desired animal production targets.

**Systems tested will include:** Deep rooted perennials, (lucerne, chickory, kikuyu, and summer active fescues), perennial ryegrass/subclover pasture silage, bi cropping silage, crop-legume rotation, fodder crops, specialist late season legumes (arrowleaf), chickory, and pasture only. Little or no information is available from these new emerging systems and whilst there is some information available on the productivity of existing systems, comparisons in terms of herbage production, animal production, soil water use, soil physical properties, and effects on eating quality of meat have not been made.

**Existing knowledge**

Currently there is information on fodder crop production, pasture silage production, pasture production, but there is little comparative information on the various systems, particularly those using novel pastures and cropping systems. Knowledge of agronomy and pasture systems and appropriate contacts in other institutions, Southern Farming Systems, DPI, Institute of Grassland and Environmental Research (United Kingdom - Bob Clements).

**Current research related to this issue**

There is limited evaluation of some species near Hamilton

**Knowledge needed to advance understanding / solution of this issue**

**Data needs:** - Measurements of comparative herbage production and quality of various systems, measurements on water use, soil biota, structure.

**Understanding of process:** - Modelling of the measured herbage production from plots, and likely animal performance

**Development of solution:** - Evaluation of systems, using different animal classes on a paddock scale system.

**Research proposed**

Description of type of research needed addressing (point form)

**Objective:** (i) To evaluate environmental differences of pasture systems in, water use, soil biota, soil physical qualities. (ii) To provide different management options to finish livestock to market specifications using novel pasture and cropping finishing systems with environmental outcomes. (iii) To evaluate effect of finishing system on meat quality.

**Method:** (i) The herbage productivity and quality of the different systems will be evaluated on a large plot design in different locations as well as water use, soil biota and diversity, nutrient balance. Results will be modelled to predict animal production. (ii) After modelling, systems will be evaluated on a paddock scale and environmental aspects of water use, soil physical properties, soil biodiversity, and animal production, meat quality will be measured.

**Timeframe:** Three years

**Cost:** $120,000 first year plot work, $150,000 Following years.

**R&D agencies with capability to deliver this research**

**Agency:** DPI, Pastoral and Veterinary Institute, Hamilton.

**Contact:** John Graham 03 55 730 908, Penny Riffkin 03 55 730 926

**Collaboration/Linkage:** DPI, Warrnambool, Southern Farming Systems, DPI, Institute of Grassland and Environmental Research (United Kingdom - Bob Clements).

Science / Discipline area: Agronomy of Lucerne

**Issue title:** Agronomy of Lucerne for productivity and water use
Description of issue (50-200 words) In the 60’s - 70’s lucerne was widely used in the Corangamite region to prolong spring growth. However when large areas were decimated by the lucerne aphid, most producers decided not to persist with this pasture system. With new aphid resistant varieties, the realization that Lucerne needs specialized grazing management to persist, and with new technologies such as raised beds and drainage systems, lucerne now offers potential to both extend the growing season and increase water use. With raised bed technology and deep drainage systems, there is potential to extend the use of lucerne into areas that previously, were seen to be unsuitable due to water-logging.

Existing knowledge
There is reasonable knowledge regarding the use of lucerne in drier areas of Australia, Pedro Evans PVI Hamilton has evaluated lucerne, and Geoff Aurick SARDI has undertaken research on Lucerne cultivars the South East of SA.

Current research related to this issue
Currently no research in this area. DPI at PVI will collaborate with SARDI Lucerne agronomist Xionguang Zhang.

Knowledge needed to advance understanding / solution of this issue
Data needs: Detailed study of growth of different varieties under different environmental conditions and drainage, management, species, soil manipulation, drainage etc
Understanding of process: Plant phenology including root vigour/depth will be evaluated
Development of solution: Modelling impacts on animals.

Research proposed
Description of type of research needed addressing
Objective: Evaluate the productivity and water use of lucerne under different environmental conditions and systems
Method: (i) Different lucerne varieties would be evaluated for production, quality and root vigour in small plots on different soils and drainage options, and under different management options (rotation length). (ii) Animal production would be modeled from the herbage production and feed quality data.
Timeframe: Initial study 2 years
Cost: $70,000/yr

R&D agencies with capability to deliver this research
Agency: DPI, PVI Hamilton,
Contact: John Graham, 0355730908, Penny Riffkin 03 55 730 926
Collaboration: DPI at PVI will collaborate with SARDI Lucerne agronomist Xionguang Zhang, Wrightsons seeds, CAS staff will assist in extension, CRC for salinity.

Science / Discipline area – Sustainable, productive land-use and biodiversity enhancement
Issue title - Integration of trees/shrubs into grazing systems for multiple benefits

Salinity strategy plans have recognised that trees are required for recharge control, for long-term stability, in certain areas. Pasture ‘solutions’ have demonstrably failed. We should examine ways in which revegetation can be done to advance this and other objectives, including biodiversity and improved animal production and welfare. These multiple objectives of planting trees/shrubs in the catchment include:
Recharge control to prevent salinisation of land and streams
Shelter to improve animal production and welfare
Biodiversity (especially conservation of indigenous flora and fauna)
Farm forestry (short or long-term diversification)
Fodder production
Ecosystem services, including C storage
Practical designs can take account of these objectives with varying emphasis. Some will accentuate recharge or shelter benefits; others might concentrate on farm forestry or biodiversity.
Good farm demonstrations of such designs are needed and these could provide material for subsequent research on recharge, animal production, impacts on pasture and impacts on
biodiversity. Anything less than 20% revegetation is unlikely to be effective in controlling recharge, and anything substantially greater is unlikely to be acceptable to farmers.

**Existing knowledge**
Revegetation skills and farm forestry expertise at PVI and strong links other farm forestry experts in DPI and Melbourne University.
Knowledge of biodiversity issues and appropriate contacts in other institutions, including Parks, Flora & Fauna, Arthur Rylah Institute and CSIRO.

**Current research related to this issue**
Various farm forestry and revegetation sites and projects established by PVI over 20 years on farms; biodiversity research from CSIRO and other sources.

**Knowledge needed to advance understanding / solution of this issue**
Farm forestry and native vegetation establishment skills
Organizational ability and rapport with potential collaborators

**Research proposed**
Description of type of research needed addressing (point form)
**Objective** - Establish demonstrations of 4 designs of tree establishment constituting 20% tree cover that will provide a range of multiple benefits

**Method** – the designs will include alley systems, shelterbelts and blocks, each system established in a 400 m x 400 m block to occupy 20% of that system. The vegetation would be planted seedlings and direct-sown.

**Timeframe** – the systems would be established over 3 years

**Cost** – Establishment $100,000, Monitoring and maintenance $80,000/yr

**R&D agencies with capability to deliver this research**
Agency / division / contact: - DPI, Pastoral and Veterinary Institute Hamilton, contact Rod Bird (0355730900),

Science / Discipline area: Crop Agronomy

**Issue title: Bi-cropping – Production and environmental benefits to livestock and grains**

**Description of issue:** Cropping in South West Victoria has expanded to 200,000 ha over the past 10 years. Bi-cropping is the growing of a cereal crop with a clover understorey. Systems in the UK generally include a cereal with white clover. However, in the high rainfall zone of Australia there are 20 legume species available to use in the system (e.g. arrowleaf, Caucasian, Persian, strawberry and lucerne).

**Production Benefits:**
(i) Whole crop silage: Whole-crop silage is the ensiling of cereal and clover when the cereal is at the soft dough stage of development. (ii) Grain: The cereal crop may also be left and harvested as grain. The presence of the clover improves the digestibility of the stubble providing additional benefits for grazing stock and stubble removal.

**Environmental Benefits:** The bi-cropping system provides a number of environmental benefits through the reduced use of agrochemicals (pesticides, herbicides and fungicides), N fertiliser (due to nitrogen fixation) and machinery usage (through fewer operations). Other benefits include reduced soil erosion; increase earthworm numbers and greater biodiversity due to more invertebrates on which birds and animals feed. Options for stubble removal (other than burning) and control of herbicide resistant grasses provide additional benefits.

**Existing knowledge**
Clover:cereal bi-cropping systems are common in the UK and provide a number of production and environmental benefits. Studies from the UK have reported high dry matter yields (around 16t/ha), digestibility and protein levels resulting in high intake and weight gain from stock. Knowledge of existing cropping systems and collaboration with appropriate contacts in other institutions, Institute of Grassland and Environmental Research (United Kingdom - Bob Clements)
Current research related to this issue
None locally, there has been research done overseas.

Knowledge needed to advance understanding / solution of this issue
Data needs: Research: Initial replicated plot work, herbage and grain production measurements, environmental measuring – soil biota, earthworms, and biodiversity
Understanding of process: Herbage production results would be used to model animal production.
Development of solution: This would be expanded to paddock scale with animal production measurements, and evaluation and extension of a whole farm system.

Research proposed
Objectives: To increase animal production (meat and milk) through high quality silage production and the grazing in summer of crop stubbles with improved nutritive value. (ii) To provide environmentally friendly management options for stubble removal other than burning. (iii) To provide management options to control herbicide resistant grasses in crops. (iv) To provide recommendations to farmers on how to maximize the benefits of bi-cropping systems. (v) To evaluate environmental effects.
Methods: Initially experiments will be conducted using 10m x 10m plots farms covering a range soil types and climatic conditions. Suitable clover species will be identified through the National Annual Pasture Legume Improvement Program. Cereals (wheat and oats) and alternative clovers (perennial and annual) will be sown in different combinations and at different sowing rates.
Measurements taken: Will include silage and crop yields, quality, sward dynamics, animal production (second year) and an economic analysis comparing the bi-cropping system and conventional practices. Environmental and biodiversity monitoring will also be done, including nutrient status, water use, soil erosion/sediment movement, earthworm numbers, soil biota and monitoring invertebrate numbers
Cost: Plot work first year $100,000.

R&D agencies with capability to deliver this research
DPI, PVI Hamilton, contact: Penny Riffkin (03 55 730926)
Collaboration: Grains Research and Development Corporation, Dairy Research and Development Corporation, Southern Farming Systems, DPI, Institute of Grassland and Environmental Research (United Kingdom - Bob Clements), Melbourne University.

Science / Discipline area: Environmental Management Systems (EMS)
Issue title: Achieving broad-scale adoption of EMS in Victorian agriculture and potential to link EMS with catchment targets
Interest in EMS within Victoria and indeed throughout Australia has been steadily gaining momentum over recent months. This is due to the recognition that: EMS has the potential to be a very effective tool for government to meet natural resource management outcomes that relate to public good issues (such as biodiversity) and to ensure sustainable growth in agriculture; and justifying Australian agriculture’s ‘clean and green’ credentials on the world market (maintaining market access should EMS become a requirement in the future). There is potential for EMS to create confusion and fear among farmers, particularly due to large number of EMS approaches and issues of integration with QA and other farm management systems. EMS pilots throughout Victoria have shown positive results and have identified the need for a common EMS framework. Latest EMS research indicates that EMS would be better delivered using a tiered approach. There is a long way to go in achieving broad scale adoption (particularly in absence of market incentive), however EMS is a very effective tool for increasing farmer understanding of the principles of environmentally sustainable agriculture.

Existing knowledge
Different industries are at different stages of EMS development and implementation. The grains industry (through GRDC) have made major investment over the last 4 years in developing and piloting an EMS approach for grains in Victoria, Northern NSW and WA). GRDC are now keen to
identify how EMS fits in with QA. The GRDC pilots recommend a tiered approach to EMS (see Appendix 1).

The concept of EMS in dairy is relatively new although BMP’s checklists, whole farm plans etc have been used to address environmental issues. A 3 year dairy project in Northern Vic (MDBC funded) is looking at EMS audit and certification. DRDC have funded a project to develop a Dairy Self-Assessment Tool.

Beef industry EMS pilots have recently finished with major findings from MLA: a four-tiered approach to EMS should be used, with all tiers supported by environmental training in basic environmental principles.

A National EMS Working Group has developed a National EMS Framework for EMS in Agriculture.

AFFA have developed a National EMS Training Package and have an EMS Incentives Scheme.

AFFA have also funded a number of EMS pilot projects throughout Australia (we are yet to hear which bids have been successful).

An EMS Policy Group has been formed as a partnership with DPI, DSE and the VFF, which aims to ensure a coordinated approach for EMS in Victorian agriculture and to minimise any consistencies in relation to EMS publicity, policy, training and implementation. The VFF conducted a series of 11 workshops to Victorian CMA to find out the drivers and challenges for EMS adoption in Victoria.

**Current research related to this issue**

Current and recently completed EMS research related to EMS has been carried out at a number of levels (see Appendix A), ranging from simple self-assessment and awareness raising, up to the full EMS process. Within DPI/DSE there have been EMS projects that have involved farmers in the Basalt Plains and other areas throughout the state. Some of the important to consider in terms of applying the knowledge to the Basalt Plains are:

**GRDC funded Riverina EMS Project** (Anna Ridley ph. 0260304500). Full EMS for the grains industry (but not ISO14001 level). A group learning approach to EMS is recommended.

**GRDC-funded Barwon Basin EMS** (Philip Newton ph. 0260304500). Full EMS for grains industry (but not ISO level).

**Communities Using Environmental Best Practices in Developing Local Area Action Plans (NHT)**. This project involved 425 farmers across a number of agricultural industries. Based on self-assessment and action planning. Would have involved farmers in the Basalt Plains (contact Geoff McFarlance or Bindi Heard ph. 0354 820440).

**Consistency of On-farm EMS for Victorian Agriculture** (DPI, Ecologically Sustainable Agriculture Initiative). Involves 3 DPI institutes & DSE staff to provide coordination and networking of EMS projects in DPI/DSE. Will develop an EMS website, develop a EMS network, monitoring tools and reviews of EMS issues in irrigated horticulture and dairy (contact Eloise Seymour 0260304500).

**Mallee EMS (NAP)**. Using a whole farm planning approach to address salinity and biodiversity issues in the Mallee. Aims to link to RCS targets. (Peter Hammence ph. 0350514352).

**EMS: A marketing advantage for graziers in NC Victoria (NHT)**. Developing EMS for dryland grazing based on full EMS cycle (contact Kathyrne Trewick 0354304389).

**Development of an EMS on Australian Beef Properties (MLA)**. Recently concluded and involved GippsBeef. DPI’s involvement was the inclusion of biodiversity standards. Practical implications of ISO14001-level EMS was investigated.

**EMS for lamb production (see below)**

**Dairy Self-Assessment Tool Project** (DRDC, EPA Vic, GippsDairy). A SAT will be developed to help farmers identify NRM issues on their farm. Will be a coordinated approach across the dairy industry (contact Cindy Nielsen ph. 0356242231).

**There are a number of viticulture & horticulture EMS projects**: based on risk assessment, BMP guidelines, regional EMS development, Integrated Fruit Production.

**Knowledge needed to advance understanding / solution of this issue**

how to achieve broad scale EMS adoption in agriculture (and how to do this in the absence of market incentives)

how EMS links to catchment targets (identified in Regional Catchment Strategies)

how to integrate EMS with QA and other management on farms to identify the drivers of EMS and the current barriers to adoption

is Landcare an effective vehicle to help achieve EMS adoption

how to eliminate confusion due to large number of EMS systems out there
how to overcome the perceived fear among the community that EMS is regulation

R&D agencies with capability to deliver this research
MLA are planning to fund an EMS pilot for the lamb industry which may involve some farmers from the SW.
AFFA EMS pilot – A project bid involving 3 Victorian catchments (North East, North Central & Glenelg Hopkins) was submitted to AFFA. If successful, this will link EMS to catchment targets in the 3 CMA areas (including areas of the SW/Basalt Plains).

Science / Discipline area: Biodiversity Conservation

issue title: Enhanced biodiversity outcomes through greater habitat connectivity in agricultural systems

Broad-scale habitat loss and fragmentation since European settlement has been identified as one of the prime reasons for the loss of native biodiversity, especially in agricultural landscapes. To meet this problem, a number of mitigation strategies have been advocated, some of which focus on extensive revegetation or the improvement of existing native vegetation. However, what is not so clear is how revegetation, in all its manifestations, will affect native biodiversity. The Basalt Plains, like many agricultural landscapes, are characterised by remnant patches of native vegetation that are either too small or isolated to support viable populations of many fauna species. An evaluation is required of the benefits that increased habitat connectivity, through revegetation, holds for biodiversity in this region. ‘On-farm’ revegetation (e.g. ‘shelter-belts’) is considered a compromise between land required for biodiversity and for agricultural activities in this region where land values usually makes it uneconomical to set aside large blocks for conservation purposes. ‘Between-farm’ revegetation (e.g. roadside reserves) is often makeshift, with no apparent landscape strategy underpinning it.

Existing knowledge
Some recent studies, both overseas and in Australia, have investigated the use of habitat corridors/shelterbelts by vertebrates for dispersal, local movements, migration routes, and as extended habitat. Usually, their focus has been narrow — restricted to a particular species (or functional group) and a small area or number of sites. Other studies have also investigated specific fragmentation issues, such as ‘edge effects’ (e.g. species composition, levels of predation), in corridors or patches of native vegetation. No studies of this type have been undertaken in the distinctive basalt plains region.

Current research related to this issue

Title: A Framework and Preliminary Assessment of the Biodiversity Benefits of Vegetation Enhancement Activities. A methodological framework to assess the biodiversity benefits of vegetation enhancement activities.
Environment Australia and the Biodiversity Benefits Task Group: David Freudenberger and Judith Harvey (CSIRO Sustainable Ecosystems)
time frame and funding: desk report, recently completed.
potential for integration into Basalt Plains vision — may be useful as a guide to the approach needed; definitely useful as a means by which the future success of revegetation activities can be evaluated. Emphasises the point that ‘support is needed for developing better predictive models for assessing the biodiversity benefits of vegetation enhancement activities’.

Knowledge needed to advance understanding / solution of this issue

Data needs: occurrence & abundance of faunal species in native vegetation of varying configurations, at landscape scale (e.g. bioregion, catchment). Broad-scale native vegetation cover and pattern (vegetation mapping of the CCMA area has been submitted to the CCMA as a potential investment proposal by Flora Research Section, ARI).
development of solution:

Research proposed
Description of type of research needed
objective: to determine the value of patches of native vegetation for faunal diversity in agricultural landscapes.

method: fauna survey of stratified replicate sites with consequent development of an explanatory model to describe the relationship between faunal diversity and patches of native vegetation in the agricultural landscape.

timeframe: 3-4 years

cost: approx $100K/year

R&D agencies with capability to deliver this research
Arthur Rylah Institute for Environmental Research, DSE, Geoff Brown (03 9450 8600)