Surface water management in the East Yornaning Catchment

Tilwin Westrup

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Surface Water Management in the East Yornaning Catchment

Tilwin Westrup
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3 Baron-Hay Court, South Perth WA 6151
Tel: (08) 9368 3333
Email: enquiries@agric.wa.gov.au
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Summary
This report documents the results of a surface water risk survey undertaken with landholders in the East Yornaning catchment group during 2008. It includes a description of the catchment, the landholders' interpretation of surface water risks, a field assessment by surface water specialists and suggestions for remedial work.

Acknowledgements
The author would like to thank the landholders in the East Yornaning catchment for their time and feedback during workshops, and for access to their properties. The Blackwood Basin Group provided logistical support during the workshops. Martyn Keen of the Department of Agriculture and Food, Bunbury provided technical advice and references. Cengiz Erol, of the Department of Agriculture and Food, Bunbury provided assistance during fieldwork. Bill Russell, of the Department of Agriculture and Food, Bunbury undertook a technical review of this document. Funding was provided by the South West Catchments Council, the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust.

Overview
This report documents surface water issues faced by landholders in the East Yornaning catchment. It follows on from Target Setting workshops run by the Department of Agriculture and Food in 2006 and a request for technical support in surface water management from the Blackwood Basin Group (BBG). The material in this document explains the rationale used when allocating funds for on-ground surface water management works via a grant from the South-west Catchments Council (SWCC).

East Yornaning is a catchment group with a lot of history (East Yornaning LCD in prep). Landholders have undertaken catchment planning in the past and have a history of facilitation and research support from the Department of Agriculture, CSIRO and various universities.

Although several sections of the catchment have had conservation earthworks constructed in the past, several paddocks are still not protected and peak flows after intense rainfall events are still causing issues in the receiving landscape. Water supplies and salinity are issues flagged as high priority amongst landholders in the catchment.

Constructing large dams and grade banks in the shedding landscape to ease the peak flow pressure is recommended. Some of the culverts in the receiving landscape need attention, as inappropriate size and installation are hampering surface water drainage upstream of the crossings. All proposed works should be designed and constructed to industry standards.

Catchment location and shape
East Yornaning is located 15 km northeast of Cuballing. It covers some 12 240 ha from the Commodine Road in the east to the Hotham River in the west. The top of catchment flows toward the west, joining the Hotham River.

The southern catchment boundary stretches from Webbs Road along Yornaning East Road, Gaths Road and to the top at Commodine Road. The boundary wraps north to the west of Kerruish Road and west along Popanyinning Road until Wakelams Road. It then bends to
the southwest to the intersection of Youngs and Yornaning East Roads. Stratherne Road runs across the middle of the catchment.

Three sub catchments of approximately 2 000 ha each with main stream lengths of 6–9 km join near the bridge on Stratherne Road near Dixons Road. The majority of the drainage lines are relatively well defined. There is a braided section just before Stratherne Road, indicating high velocity flows from the mid and upper slopes. A fourth linear sub catchment of 2 000 ha flows along the Wyonning Creek and joins the Wurrungnulling Creek to the west of the Stratherne Road bridge. The valley/floodplain broadens to 6-800 m wide after the intersection of Wyonning and Wurrungnulling Creeks and follows the drainage line through to the Hotham River.
Land tenure

The majority of land ownership in East Yornaning is private tenure (see Figure 2). Small reserves are vested in the Shire of Cuballing and in the Department of Environment and Conservation.
Table 1 List of land owners as at January 2008 (Source: DAFWA CPE Database 2008)

<table>
<thead>
<tr>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bailey, Kenneth Michael</td>
</tr>
<tr>
<td>Baxter, Scott Haldane</td>
</tr>
<tr>
<td>Bennier, John Colin</td>
</tr>
<tr>
<td>Burges, Michael Graham</td>
</tr>
<tr>
<td>Conservation and Land Management—Narrogin Regional Office</td>
</tr>
<tr>
<td>Cuballing Shire Council</td>
</tr>
<tr>
<td>Dent, Darrel Leslie</td>
</tr>
<tr>
<td>Dixon, Bruce William</td>
</tr>
<tr>
<td>Draper, Kenneth William</td>
</tr>
<tr>
<td>Furphy, Avon Maxim</td>
</tr>
<tr>
<td>Gath, Albert Malcolm</td>
</tr>
<tr>
<td>Grout, Colin Robert</td>
</tr>
<tr>
<td>McBurney, Bruce John</td>
</tr>
<tr>
<td>Patmore, Michael David</td>
</tr>
<tr>
<td>Patten, Duncan John Benjamin</td>
</tr>
<tr>
<td>Pauley, Kevin Michael</td>
</tr>
<tr>
<td>Sands, Timothy William</td>
</tr>
</tbody>
</table>
Climate description (related to surface water)

Cuballing experiences a Mediterranean climate, with warm dry summers and cool wet winters. Long term average rainfall is 500 mm. Post 1975, average rainfall has dropped to 450 mm. There has been a shift in rainfall patterns away from lead in autumn rainfall in April and May, followed by three months of soaking winter rainfall (June-August) with follow up rainfall in September, to a shorter rainy season. Rainfall models suggest this trend will continue (with slight increases in summer rainfall). The long term projections point to an increase in the chance of intense rainfall events. April 2003 recorded one of the wettest 10 days in the last 30 years with 63 mm in 24 hours. The wettest day in the last 30 years was in January 1990, with 110 mm. The events of May 2005 (43 mm) and January 2006 (35 mm) were the two most significant events in recent years. These high daily rainfall levels result in large volumes of runoff and flooding. Figure 3 and Table 2 indicate the design rainfall intensity for East Yornaning. It indicates that once every 20 years (on average) we can expect 26 mm rainfall over 1 hour, or a storm of similar magnitude.

![ARI curves for rainfall in the East Yornaning Catchment.](source)

Source: Bureau of Meteorology (BoM).
Table 2  ARI figures for rainfall in the East Yornaning Catchment. Source: BoM

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

<table>
<thead>
<tr>
<th>Duration</th>
<th>1 YEAR</th>
<th>2 YEARS</th>
<th>5 YEARS</th>
<th>10 YEARS</th>
<th>20 YEARS</th>
<th>50 YEARS</th>
<th>100 YEARS</th>
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<tr>
<td>5Mins</td>
<td>41.6</td>
<td>56.6</td>
<td>80.2</td>
<td>98.1</td>
<td>123</td>
<td>161</td>
<td>196</td>
</tr>
<tr>
<td>6Mins</td>
<td>38.7</td>
<td>52.5</td>
<td>74.4</td>
<td>90.9</td>
<td>114</td>
<td>149</td>
<td>181</td>
</tr>
<tr>
<td>16Mins</td>
<td>30.8</td>
<td>41.6</td>
<td>57.9</td>
<td>70.1</td>
<td>86.9</td>
<td>113</td>
<td>135</td>
</tr>
<tr>
<td>20Mins</td>
<td>21.5</td>
<td>28.6</td>
<td>38.5</td>
<td>45.7</td>
<td>55.7</td>
<td>70.7</td>
<td>83.8</td>
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<tr>
<td>30Mins</td>
<td>15.9</td>
<td>22.4</td>
<td>26.7</td>
<td>34.9</td>
<td>42.1</td>
<td>52.9</td>
<td>62.1</td>
</tr>
<tr>
<td>1Hr</td>
<td>11.0</td>
<td>14.5</td>
<td>19.7</td>
<td>21.7</td>
<td>25.9</td>
<td>32.1</td>
<td>37.3</td>
</tr>
<tr>
<td>2Hrs</td>
<td>7.09</td>
<td>9.25</td>
<td>11.8</td>
<td>13.6</td>
<td>16.2</td>
<td>19.9</td>
<td>23.0</td>
</tr>
<tr>
<td>3Hrs</td>
<td>5.47</td>
<td>7.14</td>
<td>9.10</td>
<td>10.5</td>
<td>12.4</td>
<td>15.2</td>
<td>17.5</td>
</tr>
<tr>
<td>6Hrs</td>
<td>3.52</td>
<td>4.59</td>
<td>5.33</td>
<td>6.89</td>
<td>7.90</td>
<td>9.67</td>
<td>11.1</td>
</tr>
<tr>
<td>12Hrs</td>
<td>2.24</td>
<td>2.92</td>
<td>3.71</td>
<td>4.26</td>
<td>5.03</td>
<td>6.15</td>
<td>7.10</td>
</tr>
<tr>
<td>24Hrs</td>
<td>1.39</td>
<td>1.81</td>
<td>2.30</td>
<td>2.65</td>
<td>3.13</td>
<td>3.63</td>
<td>4.42</td>
</tr>
<tr>
<td>48Hrs</td>
<td>.829</td>
<td>1.09</td>
<td>1.38</td>
<td>1.59</td>
<td>1.88</td>
<td>2.31</td>
<td>2.66</td>
</tr>
<tr>
<td>72Hrs</td>
<td>.600</td>
<td>.780</td>
<td>1.00</td>
<td>1.15</td>
<td>1.27</td>
<td>1.69</td>
<td>1.95</td>
</tr>
</tbody>
</table>

(Statistical data 14.04, 5.04, 0.81, 27.60, 5.45, 1.40, SIGMA=0.55) © Australian Government, Bureau of Meteorology
Soils and geology

East Yornaning is located at the western edge of the Yilgarn Craton. The geology is dominated by Granite and Gneiss. Dolerite dykes have intruded into this basement. Remnants of lateritic profile are up to 60 metres deep (Chin 1986).

The soil-landscape units mapped in the East Yornaning Catchment (Figure 4) include:

- Pingelly 1 Subsystem (257Pn_1)
- Pingelly 3 granite Phase (257Pn_3g)
- Pingelly 3 rock Phase (257Pn_3r)
- Noombling Subsystem (Dryandra) (257DyNB)
- Norrine Subsystem (Dryandra) (257DyNO)
- Biberkine Subsystem (Dryandra) (257DyBK)
- Noombling (Dryandra), rocky Phase (257DyNBr)
- Popanyinning Subsystem (Pumphreys) (257PbPG)
- Biberkine Subsystem (Pingelly) (257PnBK)
- Noombling Subsystem (Pingelly) (257PnNB)
- Noombling (Pingelly), rocky Phase (257PnNBr)
- Norrine Subsystem (Pingelly) (257PnNO)

Figure 4 Soil-Landscape associations in the East Yornanning Catchment.

Note: This mapping is based on survey work dating back to 1977 and at a scale of 1:150 000 and site assessment for verification is recommended when using it to make decisions.
Pingelly 1 Subsystem (257Pn_1)

The Pingelly 1 Subsystem is mapped as small remnants of detrital laterites forming prominent mesas. Larger remnants and reforming laterite have long, gentle, colluvial slopes on margins of granite pluton, (adamellite, some granodiorite, minor migmatite and dolerite intrusions.) in the western margins of the Yilgarn Craton, surrounding Pingelly and Brookton. The vegetation includes Powderbark Wandoo and Dryandra on shallow gravels, Jarrah and Marri open forest with Proteaceae understorey on gravelly slopes, and Wandoo in vales.

The soils include duricrust and shallow gravels. Larger areas of laterite have substantial backslopes with deeper sandy gravels, yellow sandy earths and deep pale sands. Pockets of this soil-landscape unit have sodic soils. The soils on these areas are prone to water erosion. The majority of soils have low risk of surface water related hazards (van Gool et al. 2005).

Pingelly 3 granite Phase (257Pn_3g)

This mapping unit includes irregularly undulating country where rocks outcrop on granite, adamellite with minor gneiss and granodiorite in the western margins of the Yilgarn Craton, surrounding Pingelly and Brookton. Vegetation is dominated by Wandoo, York Gum and Jam woodlands.

The soils are granitic, with gritty sands, sandy and loamy duplexes. Surface water related hazards are limited to water erosion and phosphorus loss on poorly drained brown sands in drainage depressions (van Gool et al. 2005).

Pingelly 3 rock Phase (257Pn_3r)

Crests and irregularly undulating slopes comprising mainly rock outcrops and skeletal soils surrounding outcrops. Rock Sheoak and Jam are the dominant vegetation. The soils are shallow coarse granitic sands. These have low risk of surface water related hazards (van Gool et al. 2005).

Noombling Subsystem (Dryandra) (257DyNB)

Noombling Subsystem (Dryandra) is made up of long gentle and undulating hillslopes and divides. Geology includes colluvium/weathered granite, gneiss and some dolerite. Vegetation includes Marri-Wandoo woodland with Jam-Sheoak understory.

Soils include yellow/brown and grey deep sandy duplexes, brown deep loamy duplexes, sandy gravels and shallow duplexes. Isolated areas of this soil-landscape unit are at risk of salinity and water erosion. The majority has low risk of surface water related issues (van Gool et al. 2005).

Norrine Subsystem (Dryandra) (257DyNO)

This mapping unit includes plateau remnants, small areas of undulating and gently undulating laterised upland, breakaways on deeply weathered profile over granite, gneiss and occasionally dolerite or duricrust in the Murray River catchment. Vegetation is dominated by Wandoo-Mallet woodland with a Sheoak-Parrotbush understory.

Soils include loamy gravels, duplex sandy gravels, shallow gravels and red shallow loamy duplexes. Some areas are at risk of water erosion. The majority has low risk of surface water related issues (van Gool et al. 2005).
Biberkine Subsystem (Dryandra) (257DyBK)
Valley floors and associated footslopes surrounded by gently undulating rises and low hills on alluvium and colluvium over granite, gneiss and occasionally dolerite in the Murray River catchment. Vegetation includes Wandoo-Flooded Gum woodland with Jam-Sheoak-Tea tree understory.

Soils include yellow brown sandy duplexes (mostly deep), wet and semi-wet soils (sometimes saline) and brown deep loamy duplexes. Salinity, waterlogging and some erosion are issues which may cause problems in this mapping unit (van Gool et al. 2005).

Noombling (Dryandra), rocky Phase (257DyNBr)
This unit is mapped as long gentle and undulating hillslopes and divides with common rock outcrops on colluvium over granite, gneiss and sometimes dolerite; in-situ weathered rock in Murray River catchment. Wandoo woodland is the dominant vegetation with a Jam-Sheoak understory.

Bare rock, stony soils and yellow/brown and grey deep sandy duplexes are the soils found in this map unit. Water erosion on steep sections is the only significant surface water hazard on these soils (van Gool et al. 2005).

Popanyinning Subsystem (Pumphreys) (257PbPG)
Broad valley floors and associated footslopes surrounded by gently undulating rises and low hills on alluvium over granitic rocks in the Murray River catchment. Vegetation includes Wandoo-York Gum woodland with Jam-Sheoak understory and some Salmon Gum.

Yellow/brown deep sandy duplexes, brown deep sands, brown deep loamy duplexes and wet and semi-wet soils (sometimes saline) are the soils found in this unit. These may be at risk of salinity and some areas are at risk of waterlogging and erosion (van Gool et al. 2005).

Biberkine Subsystem (Pingelly) (257PnBK)
Valley floors and associated footslopes surrounded by gently undulating rises and low hills on alluvium and colluvium over granite, gneiss and occasionally dolerite in the Murray River Catchment. Vegetation includes Wandoo-Flooded Gum woodland with Jam-Sheoak-Teatree understory.

The soils in this unit include yellow brown sandy duplexes (mostly deep), wet and semi-wet soils (sometimes saline) and brown deep loamy duplexes. Salinity and waterlogging are issues on the semi-wet soils. The remaining soils have low risk of surface water related issues (van Gool et al. 2005).

Noombling Subsystem (Pingelly) (257PnNB)
Long gentle and undulating hillslopes and divides on colluvium over granite, gneiss and sometimes dolerite, in-situ weathered rock in the Murray River catchment. The vegetation is dominated by Marri-Wandoo woodland with a Jam-Sheoak understory.

The soils include yellow/brown and grey deep and shallow sandy duplexes, duplex sandy gravels and loamy earths. There is low risk of surface water related issues on these soil types (van Gool et al. 2005).
**Noombling (Pingelly), rocky Phase (257PnNBr)**

This unit is mapped as long gentle and undulating hillslopes and divides with common rock outcrops on colluvium over granite, gneiss and sometimes dolerite; in-situ weathered rock in the Murray River catchment. Wandoo woodland is the dominant vegetation with a Jam- Sheoak understory.

Bare rock, stony soils and yellow/brown and grey deep sandy duplexes are the soils found in this map unit. Water erosion on steep sections is the only significant surface water hazard on these soils (van Gool et al. 2005).

**Norrine Subsystem (Pingelly) (257PnNO)**

This mapping unit includes plateau remnants, small areas of undulating and gently undulating laterised upland, breakaways on deeply weathered profile over granite, gneiss and occasionally dolerite or duricrust in the Murray River catchment. Vegetation is dominated by Wandoo-Mallet woodland with a Sheoak-Parrotbush understory.

Soils include loamy gravels, duplex sandy gravels, shallow gravels and red shallow loamy duplexes. Some areas are at risk of water erosion. The majority has low risk of surface water related issues (van Gool et al. 2005).
Surface water risk identification in East Yornaning

Landholders were surveyed during 2008 on a range of agriculture related issues which included surface water hazards. These included:

- water supplies
- flooding
- waterlogging
- salinity in dams and water courses
- water erosion
- phosphorus export
- field work by DAFWA staff suggests that some culverts need attention.

Each hazard listed was scored on priority of the problem for each of the respondents.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Individual priority (0 = not applicable 1= low 5= high)</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus export</td>
<td>1 4 1 0 2 4 2</td>
<td>2</td>
</tr>
<tr>
<td>Flooding</td>
<td>2 4 1 0 2 2</td>
<td>1.8</td>
</tr>
<tr>
<td>Salinity in dams</td>
<td>3 2 4 5 5 3</td>
<td>3.7</td>
</tr>
<tr>
<td>Salinity in watercourses</td>
<td>3 2 5 3 5 3</td>
<td>3.5</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>4 2 3 2 3 1</td>
<td>2.5</td>
</tr>
<tr>
<td>Water erosion</td>
<td>1 2 3 1 3 1</td>
<td>1.8</td>
</tr>
<tr>
<td>Water supplies</td>
<td>4 3 2 3 5 5</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Salinity was an issue that was debated and explored in the Target Setting project. Group members had set targets to contain the spread of salinity to 9 per cent of the arable land in the catchment (up from the current 5 per cent, but less than the maximum of 12 per cent). Group members recognised it was a complicated problem which would require a combination of techniques to manage effectively.

The issues that scored the highest priority for members of the group were salinity in dams, salinity in water courses and water supplies. These averaged 3.5 or more out of 5. Three of the six respondents had a high value use for water (piggeries) and this contributed to fresh water being such a high priority.

Waterlogging was considered of moderate importance with a score of 2.5 out of 5. Flooding was only considered important to one member, but this was significant because of his position in the receiving landscape which means it should not be discounted or ignored as an issue.

Improved surface water drainage through W-drains in the valley floors was put forward as a preferred method for managing waterlogging on valley floors. Though flooding was not considered a major issue by most landholders, it is linked to waterlogging and salinity. Loss of fences across drainage lines was expected every few years. Flooding occurred regularly above road crossings, but relief limited the area affected.
W-drains are one way to alleviate some of the flooding and waterlogging. They will also increase the peak in flows for downstream proponents to deal with. The risk is particularly high if no effort is made to manage peak flows from the catchment above. The need to manage peak flow from shedding landscape was discussed and taken up well amongst landholders.

Siltation of waterways was the next issue to be discussed. The general feeling is that the amount of sand being deposited in the creek bed has reduced since the conversion to minimum tillage and reduced numbers of wet winters. This is supported by the low priority given to erosion in the survey.
Field assessment

Field assessments conducted during the summer of 2007–2008 supported the results of the risk assessment survey.

The waterways in the shedding landscape were mostly fenced to restrict stock access and revegetated although numerous sections of the waterway remain unfenced. The volumes of water produced from the shedding landscape during intense rainfall events still exceed the capacity of waterways in the receiving landscape and these are prone to flooding and salinity. Areas on the valley floor are poorly drained and prone to ponding, waterlogging and salinity.

A number of culverts are under-designed or not properly installed and water banking up behind them is adding to waterlogging and salinity problems. The performance of drainage works above these culverts is compromised due to the issue with culverts.

Many dams have under-engineered or non-existent overflows. There is an erosion risk associated with this and, in extreme events, this may result in dams being damaged. There are a large number of small dams in this catchment (< 3 000 m³). This has negative implications for water security.

Some attempts to improve water security have included roaded catchments. These catchments are also small but landholders have attempted to compensate by building them on steep slopes (5–12 per cent). The maximum grade for a roaded catchment according to the standards is 0.5 per cent (Keen, 2002). Silt washing from steep roaded catchments may actually reduce the reliability of dams instead of improving it.

Silt traps have been installed on some dams in an attempt to manage the silt washing from the roaded catchments. This helps to keep the silt out of the dam but the roaded catchment itself is still at risk from erosion. The silt will need to be removed regularly to maintain the function of the silt trap (Westrup, 2009). It also reduces the effectiveness of the catchment as the volume of water required to fill the silt trap does not enter the dam and because the portion of runoff remaining in the silt trap is regularly lost to evaporation between runoff events.

A large number of dykes, faults and other geological features criss-cross the East Yornaning catchment. These geological structures have resulted in the formation of a number of saline seeps. Evaporation over summer causes a concentration of salt on the surface. Run-on over these areas then contributes ‘plug flows’ of salt to stream flow in autumn and early winter, or after intense summer rainfall events.
Remedial works proposed

A selection of remedial works is proposed as a result of the input provided by farmers during the risk assessment and prioritisation survey and field assessment. These include some dam construction to retain water high in the catchment, dam and catchment modification for improved water supplies and culvert upgrades for some road crossings.

Works priority

Before considering the order for works to be constructed, it is important to recognise that all works must be constructed to industry standards.

This will require persons certified for planning and pegging conservation earthworks. It will also require construction machinery (graders, etc.) operators to have accreditation to construct conservation earthworks to industry standards. An example of a specification sheet is attached in Appendix 1 (Keen, unpublished).

Industry standards for all conservation earthworks require safe disposal points. A safe disposal point is a stable waterway which has the capacity to handle the increased flows resulting from the discharge of surface water from the conservation earthwork. All culverts and road crossings must also have the capacity to handle the increased flow.

All waterways in East Yornaning should be designed to accommodate a flow which is only exceeded once every 20 years (20 year Average Return Interval, ARI). This means that there is a 5 per cent chance that the waterway capacity is exceeded in any given year. The 20 year ARI can be estimated using formulae from Australian Rainfall and Runoff - a flood estimation for design system produced by the Australian Institute of Engineers, or by using flood modelling software such as XPrafts.

The model output for a 20 year ARI for any given design point is a volume of flow in cubic metres per second (m³/s). This is the volume of flow that must be contained by the waterway or culvert at that point.

Shire

There are numerous road crossings along the Wyonning creek and its tributaries. Some of these are performing at an acceptable level and others are suffering from lack of capacity or inappropriate location/installation.

The shire of Cuballing has jurisdiction over the roads, road reserves and creek crossings in East Yornaning. Any alterations to the crossings must involve the Shire from the initial stages.

Crossings that work well will safely convey flows up to the volume resulting from a 20 year ARI event. Flows greater than 20 year ARI will bank up behind the structure and overtop the road. Figure 6 indicates the 20 year ARI flows expected at a number of crossings throughout the catchment.
Water may be passed through an intersection via a culvert, floodway or combination of both. For flows of up to 5 m$^3$ per second, appropriately sized and located culverts are usually sufficient. For flows greater than 5 m$^3$, a combination of culverts to convey low flows and floodway for peak flows may be appropriate. Careful consideration to road design (curvature, approach angles, depth of flow, etc.) must be maintained when designing crossings. Failure to do this may result in a traffic hazard.

In cases where culverts lack the capacity to handle a 20 year ARI flow, an upgrade is recommended. It is important that they are installed flush with the drainage line on the up-stream side of the road so as to avoid water banking up behind the structure. Industry standards should be followed during the design and installation of the flow conveyance structure.

Once the crossings are modified to industry standards, the next priority is to reduce peak flows in large events. In this catchment, this is best done with grade banks and large dams because water supplies are a priority. Water held high in the catchment will ease the pressure on the receiving landscape, road crossings and waterways low in the landscape.

**Grade banks**

As a rule of thumb, grade banks can reduce peak flows by 25–30 per cent. They will also reduce the velocity of flows entering the waterways, reduce waterlogging and increase time of concentration. A number of grade and reverse seepage interceptor banks have already been constructed. Grade banks are required across the non-protected slopes to reduce peak flow and velocity in the waterways. Top banks will generally pick up flow from the steepest slopes and shallower soils. This restricts recharge into the mid slopes and subsequent waterlogging and discharge in the lower slopes and break of slope. Grade
banks can direct water into stable waterways or into dams to contribute to storage and water supplies (Westrup 2009). Banks should be constructed to industry standard. They should be constructed at a grade of 0.3 to 0.5 per cent and designed for a 10 year ARI (Keen 2002).

**Water supplies**

Dams located in the shedding landscape are a useful tool for reducing the impact of peak flow on the receiving landscape. Added to this, water supplies are one of the highest priorities for landholders (especially those with piggeries) in East Yornaning.

Piggeries require 10 DSE per sow with litter (Luke 1987), or 30 Litres per day for drinking, at quality of maximum salinity of 545 mS/m (Glauert 2007). Casey and Laing (1993) suggest a drinking to wash-down ratio of 1:11, with a 50 sow piggery consuming 4 500 KL/year.

Water security and yield sustainability are also issues. Most existing dams are small (1000 m³–3000 m³) and many do not have improved catchments. The combination of low capacity and unimproved catchments means they require regular rainfall to remain reliable (Westrup 2009).

There are some roaded catchments, but these are also small. Some landholders have attempted to compensate by putting them on steep slopes. According to the standards, the maximum slope for a roaded catchment is 0.5 per cent for roads up to 200 m in length, or 0.4 per cent for larger catchments (Keen, 2005).

Maintenance of roaded catchments is also important. A well maintained catchment may harvest water on a 4 to 5 mm rainfall event, but efficiency declines rapidly if the catchment is not well maintained (Stanton 2005). Efficiency falls quickly to 10–12 mm and even 25 mm in low intensity events (Westrup 2009). Maintenance of the catchment surface keeps initial and continuing infiltration loss to a minimum.

There are several roaded catchments at grades of greater than 5–12 per cent, more than 10 times the maximum recommended grade. They pose an erosion risk. Material washed from the catchment may end up in the dam, particularly where there is no silt trap. The silt will reduce the dam storage capacity, reducing reliability. In extreme cases, silt build-up may result in the back wall of the dam blowing out.

It is recommended that all future dams (and catchments) are designed in conjunction with Damcat 4 (Farmer 2004) to ensure 90 per cent reliability, and constructed with sufficient capacity and catchment. All future roaded catchments should be designed and constructed in accordance with the industry standard documented in Keen (2005). It is also recommended that existing roaded catchments be realigned to conform to the standards. The reduction in grade may require an extension of the roaded catchment to maintain harvesting capacity.

**Fencing for waterways**

Fencing should occur with enough width to accommodate a 20 year ARI (width varies throughout the catchment) and rows of trees. Fencing should be of sufficient quality to exclude stock and be well maintained. Allowance needs to be made in the fence layout for grade banks to pass through to the creek. A small gate needs to be included to facilitate maintenance.

The minimum width of revegetation required between the 20 year ARI and the fence depends on the individual waterway. All first and second order streams in the shedding landscape (above break of slope) require a minimum of four rows of trees either side of the 20 year ARI flow line. Planting a minimum of six rows lower in the catchment (second/third
order waterways below break of slope) is recommended. Planting serves the dual purposes of stabilisation and localised groundwater control.

Fencing and revegetation will result in a marked improvement in waterway stability. Fencing along sections of waterway previously used for stock and vehicle crossing may reduce (impede or change) farm workability by limiting stock and machinery movement.

The risk of erosion and siltation means leaving these sections unfenced is not recommended. Appropriately sited rock lined stock and vehicle crossings (see Figure 7) designed and constructed to Department of Water Guidelines (Janicke and Murray 2008) will result in improved vehicle access. It will also allow stock to cross without stirring up sediment and ensure stock spend a minimum amount of time defecating and urinating in the waterway.

Figure 7 Well designed stock and vehicle crossings are an asset to a farming enterprise. Source: Department of Water.

Saline pastures

Layout is in a way that the mounds are on a shallow grade to remove water from the area. Surface water earthworks such as W- and shallow relief drains are installed first. Removal of ponding is the crucial issue as this leads to the waterlogging.

The pastures are normally planted in hedges of 2–3 rows; 2 m apart with room between hedges for possible machinery access (spray rig and seeding system) with inter-row areas planted to a mixture of annual and perennial grasses and clovers. The area will require weed control and fertilising. Lines are pre ripped to 0.4 m with a mound 0.4 m high. Seedlings are planted 2 m apart along the hedge.
Planning to construction phases
Methodology prescribed for undertaking and completing products for clients is not often implemented. This is usually the result of time or budgetary limitations. For conservation earthworks to be planned and constructed successfully, a number of stages must be completed. The stages are summarised in Figure 5 and are, in order:

1. Consultation
2. Site assessment
3. Preparation of concept from available strategies
4. Draft product based on the prepared concept
5. Draft presented, discussed with clients, modified and accepted by client
6. Final report prepared, including any plan layouts and specifications
7. Expand plans and specifications into contracts/tenders for implementation
8. Supervise implementation
9. Evaluate completed implementation; and
10. Monitor for results.

Figure 8 Flow diagram illustrating the core requirements for successful implementation of conservation earthworks.
Products can be farm scale or catchment scale plans. The products produced in the process include:

1. site assessment and conceptual plan
2. agreements in principle by all parties involved, Shire included
3. surveying and works plan for on ground works (2nd landholder agreement)
4. supervised implementation to industry standards (Best Management Practices or BMP)
5. monitoring reports.

**Required competencies**

A number of competencies are required by people completing various parts of the process. Someone conducting a site assessment will need to be competent in RTC 32181 ‘Undertake a site assessment’. Planning and pegging will require RTD 4205A ‘Set out conservation earthworks’ and RTD 5204A ‘Plan conservation earthworks’. The design work requires RTD 5202A ‘Design control measures and structures’ and RTD5203A ‘Plan erosion and sediment control measures’.

Project managers will be skilled in applying knowledge of project management tools such as Microsoft Project, Outlook, Word and Excel. They will need to be able to manage acquisition, co-ordinate project integration activities and arrange building/trialling/testing of project.

This skill will be supported by knowledge of legislation, organisational policies and procedures; public sector codes of ethics/conduct; occupational health and safety and environment requirements; project governance requirements; quality standards; risk management; procurement guidelines; financial management; human resource management and development; equal employment opportunity, equity and diversity principles; project specifications and objectives; project management tools; project management principles and systems; critical analysis in a project management context; business and commercial issues related to the projects managed; and organisational and political environment. They will be expressed through attainment of competency in PSPPM502A ‘Manage projects’.

**Conclusion**

The combined land care experience of landholders in the East Yornaning catchment is one of the most valuable assets in the catchment. Landholders have a sound knowledge of the risks to the natural resources of their properties and this was reflected in their NRM priorities.

A SWCC grant managed by the BBG allowed landholders to construct conservation earthworks and establish perennial pastures in 2007-2008. Works targeted at landholders’ priorities included grade banks, dams, trees and perennial pastures. Challenges in sourcing accredited contractors contributed to the decision to run a Grader Accreditation course in Katanning in February 2009.

The volume of water produced from the shedding landscape during intense rainfall events still exceeds the capacity of waterways in the receiving landscape and these are prone to flooding and salinity. Areas on the valley floor are poorly drained and prone to ponding, waterlogging and salinity.
Constructing large dams and grade banks in the shedding landscape to ease peak flow pressure is recommended. Some of the culverts in the receiving landscape need attention, as inappropriate size and installation are hampering surface water drainage upstream of the crossings. All proposed works should be designed and constructed to industry standards. Works constructed in the catchment that have deviated from standards have resulted in associated degradation risks.
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