Surface water management in the Daping Creek Catchment

Tilwin Westrup

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Surface Water Management in the Daping Creek Catchment

Tilwin Westrup
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Summary
This report documents the results of surface water risk identification process and conceptual planning undertaking with landholders in the Daping Creek catchment group during 2007 and 2008. It includes a description of the catchment, the landholders’ interpretation of surface water risks, a field assessment by surface water specialists, suggestions for remedial work, conceptual plans and suggestions for future research and development.

Acknowledgements
The author would like to thank the landholders in the Daping Creek catchment for their time and feedback during workshops, and for access to their properties. The Blackwood Basin Group provided logistical support during the workshops. The local knowledge supplied by Ella Maesepp, Katanning Landcare, was invaluable. Martyn Keen of the Department of Agriculture and Food, Bunbury and Noel Dodd, of Systems of Landcare, Moora provided technical advice, photographs and references. Rachelle Crawford, of the Department of Agriculture and Food, Bunbury and John Paul Collins, of the Department of Agriculture and Food, Katanning 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
The Daping Creek catchment group has not received a lot of Government support in the past. Landholders have not been involved in catchment planning and have not had a history of facilitation and research support like some of the other catchments in the Southwest Agricultural Region. Some landholders have had farm planning support from the Department of Agriculture, but that was several years ago.

This report documents the surface water issues faced by landholders in the Daping Creek catchment. It follows on from work during Target Setting workshops (Keipert, N unpublished) run by the Department of Agriculture and Food in 2006 and a request for technical support in surface water management from the Blackwood Basin Group (BBG).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). A risk prioritisation workshop for surface water management issues was run with the group in 2008 and this helped prioritise remedial work in the catchment.

The priority for this catchment is stabilisation of waterways, followed by grade banks, dams and waterways in the shedding landscape to ease peak flow pressure on waterways in the receiving landscape. All proposed works should be designed and constructed to industry standards.

Catchment location and description
Daping Creek is located 10 km north of Katanning. It covers some 16 540 ha from the Katanning-Dumbleyung road in the west to the Coblinine River in the east. The top of the catchment flows east-north-east, joining the Coblinine drainage system.

The western catchment boundary, and the top of the catchment, runs parallel to the Katanning-Dumbleyung road in a northerly direction. The boundary turns at right angles
14 km down the system and heads east in a linear pattern down to the Coblinkine River. The southern boundary follows the direction of Warren Road to the east-north-east and the regional drainage line associated with Crackin Swamp.

Three linear sub catchments of approximately 2–3 000 ha with mainstream lengths of 10 km join near the intersection of Newton with McKenzie and Gibney Roads. The bottom 5 km of each system is heavily braided, indicating high velocity surface water flows from the mid and upper slopes. The valley/floodplain broadens to 12–1 500 m wide after the intersection and follows the southern catchment boundary through to Crackin Swamp. Crackin Swamp has historical and possibly cultural significance. This area overflows into the regional system (the Blackwood River) or over Warren Road in a northerly direction to join the regional system a further 6 km away.
A fourth rounded sub catchment of 1 000 ha flows 3 km north of the main system and joins the floodplain near Badger Road. This sub catchment is in the centre of the Daping Creek catchment. A fifth linear sub catchment (3 800 ha) flows along the northern catchment boundary parallel to Robinson Road. This flow line becomes ill defined as it nears the regional system and the outlet for sub catchment four.

All the sub catchments flow/spread out on to a broad floodplain associated with the regional system. Air photos suggest these drainage lines have shifted over time. Lines of washed alluvial sands across the area beneath the break of slope.

![Sub catchments with flow lines and regional drainage line.](image)

**Second order streams and slopes**

Active stream channel erosion is prevalent in all areas except where stock access to waterways has been restricted. The capacity of these channels is proportional to the area of catchment feeding the waterway.

The velocity or speed of flow in the waterway when at full capacity is proportional to depth. A stream with depth up to 2 m may have a velocity of 2.5 ms$^{-1}$. This is twice the maximum permissible velocity of 1.3 ms$^{-1}$ for water flowing over a stable clay surface (Keen 2001). With 2.5 ms$^{-1}$ of flow, erosion will occur when the waterway is full. The equivalent waterway running at a depth of 0.3 m will have a velocity of 0.75 ms$^{-1}$. This velocity is less that the maximum permissible velocity of 1.3 ms$^{-1}$ and can be handled by stable waterways without erosion.
Land tenure

The majority of land ownership in Daping Creek is private tenure (see Figure 2, Table 1). A number of small reserves are vested in the Department of Environment and Conservation.

Figure 2 Property location and tenure in the Daping Creek Catchment.
Table 1 List of land owners as at January 2008 (Source: DAFWA CPE Database 2008)

<table>
<thead>
<tr>
<th>Property owner</th>
<th>Property owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE Quartermaine &amp; Co</td>
<td>CA and LA Butterworth</td>
</tr>
<tr>
<td>Thompson, David Solomon</td>
<td>O'Toole, Robert John</td>
</tr>
<tr>
<td>Rees, David William</td>
<td>DA and AJ Earnshaw</td>
</tr>
<tr>
<td>Tagliaferri, Ian Philip</td>
<td>KS Davies and GP McDonald</td>
</tr>
<tr>
<td>Minnowarra Farm</td>
<td>Hanna, Ian Bruce</td>
</tr>
<tr>
<td>Kerin, Peter John</td>
<td>Harris, Dawson</td>
</tr>
<tr>
<td>Crouch, James</td>
<td>Smith, Douglas J</td>
</tr>
<tr>
<td>Brooks, Ian Stanley</td>
<td>Day, Christine Susan</td>
</tr>
<tr>
<td>Ball, William</td>
<td>Potter, Peter John</td>
</tr>
<tr>
<td>Quartermaine, Eric Walter</td>
<td>Bielby, Wayne Robert</td>
</tr>
<tr>
<td>Stade, Colin Maxwell</td>
<td>Hobley, Michael Ernest</td>
</tr>
<tr>
<td>Haddleton, William Francis</td>
<td>Poett, Gregory Frank</td>
</tr>
<tr>
<td>Harris, Ashley J</td>
<td>I &amp; N Knapp</td>
</tr>
</tbody>
</table>
Climate description (related to surface water)

Katanning experiences a Mediterranean climate, with warm, dry summers and cool wet winters. Long term average rainfall is 430 mm. Post 1975, average rainfall has dropped to 410 mm (Department of Water 2006). 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 and a slight increase in summer rainfall will be experienced. The long term projections point to an increase in the chance of intense rainfall events. April (51 mm) and May 2005 (75 mm) recorded two of the wettest 10 days in the last 30 years. The wettest day was in January 1982, with 116 mm. The summer events of March 1993 (70 mm) and January 1990 (60 mm) also resulted in high daily rainfall. These high daily rainfall levels result in large volumes of runoff and flooding. Figure 3 and Table 2 indicate the design rainfall intensity for Daping Creek. It indicates that once every 20 years (on average) we can expect 25 mm rainfall over 1 hour, or a storm of similar magnitude.
Review of Options for Maintaining Low Salt Concentrations for Water Quality in Agricultural Dams

Figure 3 ARI curves for rainfall in the Daping Creek Catchment. (Source: Bureau of Meteorology (BoM))

Table 2 ARI figures for rainfall in the Daping Creek Catchment (Source: BoM)

<table>
<thead>
<tr>
<th>Average Recurrence Interval</th>
<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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 Mins</td>
<td>40.3</td>
<td>55.3</td>
<td>79.7</td>
<td>98.6</td>
<td>125</td>
<td>166</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>6 Mins</td>
<td>37.4</td>
<td>51.3</td>
<td>73.9</td>
<td>91.3</td>
<td>115</td>
<td>153</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>10 Mins</td>
<td>29.8</td>
<td>40.6</td>
<td>57.3</td>
<td>70.0</td>
<td>87.5</td>
<td>115</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>20 Mins</td>
<td>20.8</td>
<td>27.8</td>
<td>37.9</td>
<td>45.3</td>
<td>55.5</td>
<td>71.0</td>
<td>84.5</td>
</tr>
<tr>
<td></td>
<td>30 Mins</td>
<td>16.4</td>
<td>21.8</td>
<td>29.1</td>
<td>34.4</td>
<td>41.7</td>
<td>52.6</td>
<td>62.1</td>
</tr>
<tr>
<td></td>
<td>1 Hr</td>
<td>10.6</td>
<td>14.0</td>
<td>18.2</td>
<td>21.2</td>
<td>25.4</td>
<td>31.6</td>
<td>36.9</td>
</tr>
<tr>
<td></td>
<td>2 Hrs</td>
<td>6.77</td>
<td>8.87</td>
<td>11.4</td>
<td>13.2</td>
<td>15.7</td>
<td>19.3</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>3 Hrs</td>
<td>5.20</td>
<td>6.79</td>
<td>8.71</td>
<td>10.1</td>
<td>11.9</td>
<td>14.7</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>6 Hrs</td>
<td>3.30</td>
<td>4.31</td>
<td>5.51</td>
<td>6.36</td>
<td>7.54</td>
<td>9.27</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>12 Hrs</td>
<td>2.08</td>
<td>2.72</td>
<td>3.48</td>
<td>4.02</td>
<td>4.77</td>
<td>5.87</td>
<td>6.80</td>
</tr>
<tr>
<td></td>
<td>24 Hrs</td>
<td>1.28</td>
<td>1.68</td>
<td>2.16</td>
<td>2.50</td>
<td>2.97</td>
<td>3.66</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td>48 Hrs</td>
<td>0.76</td>
<td>1.00</td>
<td>1.30</td>
<td>1.50</td>
<td>1.79</td>
<td>2.22</td>
<td>2.58</td>
</tr>
<tr>
<td></td>
<td>72 Hrs</td>
<td>0.55</td>
<td>0.721</td>
<td>0.942</td>
<td>1.09</td>
<td>1.30</td>
<td>1.62</td>
<td>1.90</td>
</tr>
</tbody>
</table>

(Raw data: 14.47, 2.89, 0.75, 27.15, 5.18, 14.43, skew=0.66) © Australian Government, Bureau of Meteorology
Soils and geology

Daping creek is located at the western edge of the Katanning Zone. The geology is dominated by granite and granite gneiss of the Yilgarn Craton. Dolerite dykes have intruded into this basement. Remnants of lateritic profile are up to 60 metres deep (Mathwin 2001, Chin and Brakel 1986).

The soil-landscape units mapped (Percy 2000) in the Daping Creek Catchment (Figure 4) are listed below. Descriptions of each sub-system follow:

- Carrolup 1 Subsystem (257 Ca_1)
- Carrolup 2 Subsystem (257 Ca_2)
- Carrolup 3 Subsystem (257 Ca_3)
- Carrolup 5 Subsystem (257 Ca_5)
- Coblinine 2 Subsystem (259 Cb_2)
- Coblinine 3 Subsystem (259 Cb_3)
- East Katanning 1 Subsystem (259 Ek_1)
- East Katanning 2 Subsystem (259 Ek_2)

Figure 4 Soil-Landscape associations in the Daping Creek Catchment.
Carrolup 1 Subsystem

The Carrolup 1 Subsystem is mapped as mid to upper slopes and crests on laterite over weathered granite in the Blackwood and Gordon River Catchments from Woodanilling to south of Tambellup. Wandoo and rock sheoak woodland with parrot bush and grasstrees are the dominant vegetation.

The soil types include deep sandy gravels, shallow gravels, duplex sandy gravels and grey deep sandy duplex with loamy gravels, gravelly pale deep sands and pale deep sands. The database suggests the risks of waterlogging, salinity and water erosion are low to moderate for soils in this mapping unit (van Gool et al. 2005).

Carrolup 2 Subsystem

The Carrolup 2 Subsystem is mapped as drainage lines, lower to upper slopes and crests on colluvium over deeply weathered granite in the Blackwood and Gordon River catchments from Woodanilling to south of Tambellup. Wandoo-sheoak-jam woodland is the typical vegetation type found here.

Grey deep and shallow sandy duplex soils are common. The database suggests the risks of waterlogging, salinity and water erosion are low to moderate for soils in this mapping unit (van Gool et al. 2005).

Carrolup 3 Subsystem

Mid to upper slopes and crests on weathered granite and dolerite rocks and colluvium over weathered granite in the Blackwood and Gordon River catchments from Woodanilling to south of Tambellup. Vegetation includes rock sheoak or York gum and jam woodland.

Soils include grey deep sandy duplex, brown deep sands (gritty) with grey shallow sandy duplex, yellow/brown deep sandy duplex, red shallow loamy duplex and outcrop. Land degradation hazards for this unit exist, but are not seen as a threat (van Gool et al. 2005).

Carrolup 5 Subsystem

The Carrolup 5 Subsystem is described as valley flats(100–300 m wide), stream channels and lower slopes on alluvial and colluvial deposits over weathered granite in the Blackwood and Gordon River Catchments from Woodanilling to south of Tambellup. The dominant vegetation is flooded gum and/or flat topped yate woodland with halophytes on saline soils.

Soil types include saline wet soils with grey deep sandy duplex and minor brown deep alluvial sands. Risks to the unit include salinity, waterlogging, water erosion and phosphorus loss (van Gool et al. 2005).

Coblinine 2 Subsystem

The Coblinine 2 Subsystem is categorised as plains with stream channels and dunes on alluvium over granitic rocks in the southern wheat belt between Katanning and Corrigin. Vegetation includes Mallee or woodland dominated by salmon gum, often with York gum and morrell.
Saline wet soils, alkaline grey shallow sandy duplex soils and grey deep sandy duplex soils are soil types found in this unit. Salinity, waterlogging, water erosion and phosphorus loss are all risks associated with this mapping unit (van Gool et al. 2005).

**Coblinine 3 Subsystem**

The Coblinine 3 Subsystem includes plains with stream channels and dunes on alluvium over granitic rocks in the southern wheat belt between Katanning and Corrigin. The dominant vegetation types include salt tolerant vegetation such as samphire with remnants of mallee and salmon gum-York gum woodland.

The soil types include saline wet soils with minor areas of grey sandy and loamy duplex soils and hard cracking clays. Salinity, waterlogging, water erosion and phosphorus loss are all risks associated with this mapping unit (van Gool et al. 2005).

**East Katanning 1 Subsystem**

The East Katanning 1 Subsystem is described as hillcrests and upper and middle slopes on ferricrete or colluvial sand and gravel derived from laterite over weathered granite in the southern wheat belt east of Katanning. The vegetation association on this unit is Wandoo and rock sheoak woodland or mallee with heath (Dryandra dominant).

The soil types include deep sandy gravels and shallow gravels with minor areas of duplex sandy gravels, loamy gravels and gravelly pale deep sands. The soil-landscape data base does not flag any surface water related risks for these soils (van Gool et al. 2005).

**East Katanning 2 Subsystem**

The East Katanning 2 Subsystem is a landscape dominated by lower to upper slopes and, less commonly, hillcrests on colluvial sand and gravel over deeply weathered granite (kaolinised clay) in the southern wheat belt east of Katanning. Vegetation found on this unit is usually Wandoo woodland and/or mallee.

Soils include grey shallow and deep sandy duplex soils, alkaline grey shallow sandy duplex soils and duplex sandy gravels, and the risks associated with these are limited to small areas of salinity (< 2 per cent presently saline), waterlogging and erosion (van Gool et al. 2005).

**Dykes and faults**

A large number of geological structures (dykes and faults) criss-cross the catchment. These structures compartmentalise groundwater aquifers in various sections of the catchment. Many of these have resulted in up-welling and pressurising of groundwater causing saline seepage. The saturated profile associated with these aquifers and areas means that in rainfall events there is virtually no infiltration and runoff approaches 100 per cent of rainfall. The continual saturation of the soil profile destroys soil structure increasing the erodability of the area. Geophysics would help map out the seepage problem areas.

**Areas of importance**

A search using the Department of Indigenous Affairs' Aboriginal Heritage search engine did not highlight any sites of cultural significance in the Daping Creek catchment. The Department of Environment and Conservation (DEC) manages land in the wetlands at the base of the system. This has implications for any drainage of natural flows and pumping or construction work. The DEC should be consulted where any proposed work will impact on these reserves.
Surface water risk identification in Daping Creek

Landholders came together for a catchment meeting in February 2008. The meeting was brokered by the Blackwood Basin Group and facilitated by DAFWA. A list of potential surface water hazards had been collated during works assessments and discussions with the landholders. These included:

- water security (drought prevention)
- flooding of roads and paddocks
- waterlogging of farm land
- spreading salinity
- gullying
- siltation of the Daping creek
- soils with sodic profiles and the lack of stable waterways (and discharge points) were noted by DAFWA staff.

Each hazard listed was discussed with the group. They were then scored on the severity of the problem on the basis of economic impact, area affected and the social, economic and environmental value of the assets at risk. The probability and historic regularity of that hazard eventuating was discussed and taken into account when scoring. Options to manage the risks associated with the identified hazards were discussed in the context of return on investment, protecting that investment, the importance of engineering standards and the impact of on-ground work on peak flow characteristics in the catchment.

Salinity was an issue that was debated and explored in the Target Setting project. Group members had set a Resource Condition Target for salinity to contain the spread of salinity to 10–12 per cent of the arable land in the catchment. Group members recognised that salinity is a complicated problem which requires a combination of techniques to manage effectively.

Landholders indicated that 10 per cent (15 per cent in wet years) of the land above the break of slope, or the shedding landscape, in the catchment was prone to waterlogging and estimated that 60 per cent (80 per cent in wet years) of the land in the valley floor, or receiving landscape, was prone to waterlogging. The extent varied from year to year depending on seasonal conditions. Anecdotal evidence suggests significant crop losses occurred 1 year in 7. This was an improvement on the 1 in 5 rate that was experienced in the 1960s–1970s, when rainfall was significantly higher. Landholders associated waterlogging problems with seepage areas above dykes, with poor drainage and as a product of flooding and inundation.

Improved surface water drainage through W-drains in the valley floors was put forward by landholders as a preferred method for managing waterlogging on valley floors.

Flooding was not considered a major issue by farmers, but was linked to waterlogging and salinity. Loss of fences across drainage lines was expected every few years. Flooding occurred regularly above road crossings, but topography limited the area affected. Landholders dealt with flooding by not cropping flooded paddocks and by promoting clover growth for grazing. This was only the case if the flooding occurred before seeding.
Removing silt to restore the capacity of waterways and W-drains was again put forward by landholders as the preferred management options.

Desilting waterways and W-drains is one way to alleviate some of the flooding and waterlogging. This will also increase the peak in flows for downstream proponents to deal with. The de-silted sections of waterway are prone to erosion because of disturbance and potential for increased velocity of flows. The risk is particularly high if no effort is made to manage peak flows from the catchment above, and no heed is paid to engineering standards when the waterway channel is reformed.

The need to manage peak flow from shedding landscape was then discussed. Examples of engineered work overseas and in Western Australia were used to highlight the value of constructing work to a standard. The use of grade banks constructed to industry standards was accepted as a suitable management tool by group members. Some concern was raised in regards to banks failing, and trial evaluation had not led to broad scale adoption because engineering standards had not been followed in the past. This highlighted the issue of management, with landholders being prepared to put up with some problems as long as crop production was not restricted. The positioning of earthworks thus becomes crucial for both technical and managerial reasons. The applicability of grade banks in controlled traffic farming was also questioned. The area of catchment under this system is still limited and 'roll over' banks will be explored.

Many group members cited the reduced capacity of the Daping Creek as a major contributor to flooding, waterlogging and salinity. Almost the full length of the waterway in the receiving landscape showed signs of silt build up and stream capacity was exceeded once every two years.

Options for de silting were discussed. Landholders agreed that there was little point in de-silting activities whilst stream banks in the shedding landscapes were unstable and still contributing silt to stream flow (to be deposited in the receiving landscape). The requirements for stream capacity and channel shape were discussed with reference to engineering standards and peak flow estimates. Landholders agreed that peak flow needed to be managed in the upper catchment to reduce peak flows needing to be contained by the waterway, and to act as an insurance policy against flood flows.

Landholders believed running out of water was not a regular problem. Several landholders had successfully established lucerne. They indicated that there may be an opportunity cost associated with not harvesting available fresh water for irrigating lucerne and cutting for hay.

The issues of sodic sub-soils and gullying were discussed, as was hillside seepage and water security. Water security did not score highly as it was not a regular problem. Saline seepage was a recurring issue through many parts of the catchment. Sodic subsoils and gullying contributed to the unstable waterways.

The issue of highest priority for this catchment is the lack of safe disposal points and unstable waterways in the upper catchment. The risk assessment process enabled landholders to shift their focus from the area where flooding, waterlogging and salinity problems are expressed and to recognise the need to increase the time of concentration of peak flows with grade banks and dams in the upper catchment. According to recognised standards, these needed stable waterways as disposal points. Stabilising waterways in the upper catchment will also reduce the amount of silt deposited in waterways in the receiving landscapes, reducing the need to repeatedly de-silt them.
Field assessment

Field assessments conducted during the summer of 2007–2008 supported the results of the risk assessment workshop. Waterways in the receiving landscape were severely silted (see Figure 6) while waterways in the shedding landscape were unstable and eroding. Some sections of the waterway had been fenced to restrict stock access and revegetated. Numerous sections of the waterway remain unfenced.

![Figure 6 Waterways in the receiving landscape are severely silted.](Photo: N Dodd.)

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 (< 3000 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. Silt washing from steep roaded catchments may actually reduce the reliability of dams instead of improving it.

A large number of dykes, faults and other geological features criss-cross the Daping Creek catchment. These geological structures have resulted in the formation of a large number of saline seeps. Evaporation over summer causes a concentration of salt on the surface. The concentration of sodium in the soil surface contributes to soil structure decline. 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 workshop and field assessment. The objectives of these works include:

- stabilising waterways to manage silt movement and provide safe disposal points for surface water management
- providing detention dams and increasing time of concentration in the shedding landscape to reduce peak flows
- maintaining continuation of flow in the receiving landscape
- reducing the impact of seepage on productivity, salinity and soil structure decline.

The remedial works include waterway restoration works, dam and catchment modification for improved water supplies and culvert upgrades for some road crossings. Other potential projects include syphons and pumping from production bores located in fractured rock zones above dykes.

Works construction standards
Before considering the order for works to be constructed in the Daping Creek catchment, 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 of surface water discharged from the conservation earthwork.

All waterways in Daping Creek 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 XP-Rafts.

The model output for a 20 year ARI for any given design point is a volume of flow in cubic metres per second (m$^3$/s). This is the volume of flow that must be contained by the waterway at that point.

The cross-section of a waterway will allow us to measure cross-sectional area (depth x width or $bd + Zd^2$) in (m$^2$). This figure multiplied by the speed or velocity of flow (m/s) will give us the capacity. Velocity of flow is estimated using Manning’s formula ($1/n R^{2/3} s^{1/2}$) where ‘n’ is a roughness coefficient, ‘R’ is hydraulic radius (proportional to depth and width) and ‘s’ is channel slope.
Earthworks for waterways
With peak flow figures in hand, the capacity of channels needs to be calculated to determine if levees or other appropriate earthworks are required down the length of each system. Some sections of waterways will require levees (single or double) to accommodate a 20 year ARI without flooding extensive areas of arable land. These will help to limit the spread of salinity and also reduce production losses resulting from flooding and waterlogging. Levees should be constructed prior to fencing and revegetating the waterways. The levees should be designed and constructed to industry standards (as per Keen 2001). Most of the existing waterways consist of an eroded channel that is difficult to stabilise in the short term without major remedial action including gully filling and gabion drop structures.

Stabilisation of waterways
The risk prioritisation and field assessment sections in this report conclude that the waterways in the Daping Creek catchment are prone to erosion and remain largely un-fenced. The waterways must be stabilised with prostrate grasses and fenced to restrict stock access. For these reasons, work to stabilise (and construct) waterways are the priority for Daping Creek.

The stabilisation of waterways will require:
- stock exclusion
- revegetation with appropriate species
- stock/vehicle crossings in appropriate locations
- sufficient capacity for a 20 year ARI event
- appropriate channel shape to manage velocity of flow
- drop structures to step down water in steep sections.

Stock exclusion is often regarded as the single most effective management option for rehabilitating waterways. Stock traffic breaks down soil structure, making it more prone to erosion. Stock also destroy under story and groundcover vegetation which is crucial for maintaining a stable waterway. Landholders have already made significant inroads to fencing waterways in an ad hoc way. The immediate priority is to ensure the remaining waterways are also fenced, revegetated, stabilised and protected.

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 for maintenance purposes.

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 catchment (second/third order waterways below break of slope) is recommended. Planting serves the dual purposes of stabilisation and localised groundwater control.
Daping Creek splits into a number of braided channels in the valley floor. These sections of waterways should be fenced and treed on the outside of the channels as per the standard waterways in the receiving landscape. A mixture of saltbush and saline pasture (including legumes, medics and perennial grasses) should be planted in and between the channels. Puccinellia has been shown to recruit effectively in the catchment but it’s tufted form means that monoculture stands of Puccinellia are not ideal for stabilisation. The increased depth of water flowing between the Puccinellia tufts can cause the soil between plants to erode. This problem can sometimes be alleviated by increasing the width of flow and reducing the depth considerably (0.1 m–0.2 m) Couch is not recommended because of its invasive nature and predisposition to trap large volumes of silt and choke waterways. Couch can choke the system more than the original silt.

Fencing and revegetation will result in a marked improvement to 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, allow stock to cross without stirring up sediment and ensure stock spend a minimum amount of time defecating and urinating in the waterway.

There will be a significant time lag between completion of fencing, revegetation, construction of stock crossings and the stabilisation of the treated waterways. There may be other areas which will require more intensive treatment such as drop-structures, channel reformation and so on. These are likely to be expensive and require in-depth design, so it is prudent to give the fenced and vegetated waterways time to recover and settle before re-assessing the situation. This time lag is likely to be around 3–5 years, and only once this has passed do we suggest taking the next step to treat continuing problem areas.
These problem areas are likely to exist where the fall in channel is excessively steep and velocity of flow too high to allow for stabilisation, even with stock exclusion, well designed crossings and revegetation. These sections may have actively eroding gully heads, or head cuts and so on. A drop structure may be constructed to step the water down and dissipate the energy without eroding the stream bed. A range of materials can be used to construct drop structures but they should be constructed to industry standards with sufficient capacity to handle a 20 year ARI and fail ‘safely’ in larger events. It is recommended that a demonstration drop structure is constructed at a suitable site in the short term.

**Grade banks**

As a rule of thumb, grade banks can reduce peak flows by 20–25 per cent (Scwab et al. 1992). They will also reduce the velocity in flows entering the waterways, reduce waterlogging and increase time of concentration. Grade banks are required across the 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 the subsequent waterlogging and discharge in the lower slopes and break of slope.

**Water security**

There is likely to be a significant increase in saltbush and salt-land pastures as the saline waterways and saline portions of the catchment are revegetated. Saltbush and salt-land pastures provide grazing opportunity, particularly during the autumn feed gap. They also help stabilise the soil during large flooding events.

Water requirements for sheep grazing on saltbush rise from 2.0–4.0 litres per Dry Sheep Equivalent (DSE) per day on normal pastures up to 7.3 litres per DSE on saltbush (Luke 1988). Ghauri and Westrup (2000) note that sheep grazing on salt-land pastures may use up to 12 litres per DSE.

An upgrade in water supplies will be required for full utilisation of salt-land pastures planned for the Daping Creek catchment.

Water security and yield sustainability are also issues. Most existing dams are small (1 000 m³–3 000 m³) and many do not have improved catchments. The combination of low capacity and unimproved catchments means they require regular rainfall to remain full.

There are some roadded 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 roadded 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 roadded catchments is also important. A well maintained catchment may harvest water on a 4 to 5 mm rainfall event, but this 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. Maintenance of the catchment surface keeps initial and continuing infiltration loss to a minimum.

There are several roadded catchments at grades of greater than 5–12 per cent (see Figure 8). These are more than 10 times the maximum recommended grade and 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.

![Image: There are several roaded catchments at grades of 5 to 12 per cent.](image)

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.

Saline pastures

Mound layout should be designed so they 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 waterlogging.

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) and inter-row areas planted to a mixture of annual and perennial grasses and legumes. 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 rows (Noel Dodd pers. comm.).
Road crossings and other major works

There are numerous road crossings along the Daping Creek and its tributaries. Some of these are performing at an acceptable level and others are suffering from lack of maintenance, capacity or inappropriate location/installation. The shire of Katanning has jurisdiction over the roads, road reserves and creek crossings in Daping Creek. 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 conveyance structure and overtop the road. Figure 9 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.
Figure 10 A box culvert in need of maintenance.  Photo: M Keen.

Figure 10 Undersized culverts with no head wall on a farm crossing.  Photo N Dodd.
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 clients
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 5 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, coordinate 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; and organisational and political environment. They will be expressed through attainment of competency in PSPPM502A 'Manage projects'.

**Budgeting**

There is more than 100 km worth of 2nd order or larger drainage lines in Daping Creek. Most of the 9 000 ha above the intersection of Newton with McKenzie and Gibney Roads would benefit from grade banks and constructed waterways, as would the upper part of the sub-catchments along Badger and Robinson Roads. Sections of the waterways in the receiving landscape within the catchment would benefit from single or double levies to allow for a 20 year ARI flooding event while protecting arable land from flooding.

It is difficult to quantify the ideal amount of investment required for the catchment, but it is possible to estimate the proportions. If $1 000,000 were to be spent in Daping Creek, $500 000 should be allocated to earthworks, $250 000 to fencing and $250 000 to revegetation. 15 per cent of the funds would be allocated to project management. These proportional breakdowns should be applied to any future funding sought for on-ground work in the catchment.
Maps/concept plan

Noel Dodd of Systems of Landcare, Moora was consulted to conduct a site assessment and provide a conceptual plan for eight farms in the catchment. These plans are attached in Appendix 2. One example is attached below in Figure 11. This plan for Peter Potter contains constructed waterways, grade banks and fencing. Several hectares of revegetation are also recommended. These farm plans can be combined to form a works plan for the catchment, as in Figure 12.

Figure 11 Surface water management conceptual plan for Potter’s.
Future management options

Once the waterways in Daping Creek are stabilised and the upper catchment is protected with grade banks, constructed waterways and dams, a number of projects may warrant further investigation. These include:

- groundwater pumping
- pumping of a closed drainage system
- airborne geophysics.

Groundwater pumping

There are a number of compartmentalised groundwater systems throughout the catchment which, as previously mentioned, result in high volumes of seepage. These areas need relief with large scale revegetation and/or groundwater pumping systems that remove the excess supply and pressure. In some cases, the groundwater needs to be controlled to control surface water flows. Examples are upslope in the catchment on Potters (just below Rees’ property), where an existing relief well needs active pumping at a minimum estimated rate of 100 KL/day. A sample of this water was sent to the Chemistry Centre for analysis. The analysis shows high alkalinity, high levels of calcium carbonate and salinity. There are several examples of midslope/break of slope seepages above dykes which may also warrant active pumping or siphons. A valley floor seep on Kerin’s near Kelly Road may also warrant attention.
The aim behind pumping is to sufficiently lower the groundwater levels to the point that trees can be grown to maintain the water level below the required depth. An experienced hydrologist is needed for water equilibrium modelling and aquifer yield estimation. A geochemist may be needed for advice on the potential impact of discharge water and management options for neutralisation of any risks.

**Pumping of a closed surface water drainage system**

There is a lake on the Bibiking South Road which is a closed surface water drainage system. As the lake fills, it has contributed to waterlogging and salinisation in the surrounding area. One option may be to pump the lake water into receiving bodies further down the lake chain. The top lake, which is actually crossed by the Bibiking South Road, has priority if pumping was to occur. The receiving areas are likely to include the Coblinine Flats Reserve, which is vested in DEC, and they should be consulted in any investigative or remediation work.

![Diagram](image.png)

**Figure 13** The lake in red contributes to waterlogging and salinisation of the surrounding area when full.

**Geophysics**

Geology has major impact on groundwater/surface water interactions in the Daping Creek catchment. The catchment itself is shaped by this geology. Geophysics is an expensive tool which will help improve the investigation work for any of the seepage intervention and pumping projects, and help target tree and saltbush planting away from the waterways.
References


Department of Water 2005, ‘10 mm rainfall surface data set’, Department of Water, Western Australia.

Farmer, D 2004, ‘Damcat 4: Dam and improved catchment water supply design software’, Department of Agriculture and Food, Western Australia.


Keen, M, unpublished ‘Design and construction of grade banks’, Specification sheet, Department of Agriculture, Western Australia


Stanton, D 2005, ‘Roaded Catchments to improve reliability of farm dams’, Bulletin 4660, ISSN 1448–0352. Department of Agriculture and Food, Western Australia.


Vanwyk, L in prep, ‘Resource condition target setting in Daping Creek Catchment’, Department of Agriculture and Food, Western Australia.
Appendix 1. Earthworks Specification Sheet

Construction Specifications
Alignment of bank is surveyed on correct grade using optical or laser level. Level to an accuracy of ± 0.050 metres or better and place alignment marks (pins or pegs). Survey interval, to establish alignment marks, should be no greater than 25 metres.
Extra alignment marks are required on tight bends, particularly when crossing ridges and small depressions.
When no level sill is constructed, extra grade is included at the bank outlet to allow the grade bank channel to return to ground level.
Construction machinery should have suitable capacity, horsepower and appropriate attachments. Both bulldozers and graders are suitable.

Maintenance
Grade bank channel, bank and/or side slopes damaged by stock or run-ons are to be repaired to original construction standards as soon as practicable.
Breached banks are to be repaired as soon as run-off event has passed. Breaches are to be filled with compacted material of the same quality or better than that used in the original bank construction.
Correctly constructed grade banks, with adequate channel capacity, correct side slopes and adequate bank compacted freeboard, may only need reconstruction maintenance at greater than 5 yearly intervals. However, all grade banks should be reconstructed when capacities are less than the original construction.

Caution: Drawing not to scale

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<th>Specification Sheet – Grade Banks</th>
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Grade bank specifications

Freeboard 0.2 metres

Water level

Original ground level

Side slope ___ :1

Channel depth ___ metres

Channel width ___ metres

Side slope ___ :1

Side slope ___ :1
Appendix 2. Conceptual farm plans for surface water management in Daping Creek