2. Hydrophysical characterisation

This section describes the hydrology, geomorphology and riparian vegetation of the Little Swanport River catchment.

The Little Swanport River catchment is located in eastern Tasmania and drains an area of approximately 600 km^2. It lies in a rain shadow from the westerly rains that prevail in southern Tasmania, and flows in an easterly direction, discharging into the Little Swanport Estuary at Tasman Highway. Rainfall events can occur at any time of year, but tend to be larger during summer with easterly weather patterns bringing greater rainfall to the catchment.

The major tributaries drain from up to 800m ASL elevation along the catchment borders and converge on the mainstream at regular intervals. For the purposes of this characterisation, the major tributaries of the Little Swanport River are considered to be Green Tier Creek (including Rocka Rivulet), Eastern Marshes Rivulet, Crichton Creek, Nutting Garden Rivulet and Pepper Creek. Ravensdale Rivulet is included because it discharges into the Little Swanport estuary thus is considered part of the catchment, as is the estuary itself.

2.1 Catchment Hydrology

In 2004 a water balance model of the Little Swanport catchment was constructed by Sinclair Knight Merz (SKM) for a Draft Water Management Plan being prepared at the time (SKM 2004). This model was well calibrated with the historical flows from the old gauging station 3 km upstream of Tasman Highway, and was used to produce a daily flow time series over 100 years, of natural, current water use and future water use scenarios. The natural time series were used to characterise the natural flow regime (Poff et al. 1997) of the catchment, and the current water use time series was used to provide an indication of how much the current flow regime departs from the natural flow regime. The Time Series Analysis module of the River Analysis Package (Marsh et al. 2003) was used for these analyses.

Flow duration

Flow duration curves are used to provide a visual representation of the range of flows present in a system and their relative occurrence. They display the relationship between streamflow and the percentage of time it is exceeded. The natural flow duration curves at locations throughout the catchment indicates that there is very little difference in the pattern of flows throughout the catchment, except in magnitude which is due to differences in subcatchment areas (Figure 3). All the curves have a similar shape; steep at the high flow end with very low exceedance times, which indicates a rapid response to precipitation and is typical of "flashy" rivers. A steep curve at the low flow end (at the right-hand side of the curve) indicates minor baseflows with not very significant groundwater contributions. The fact that all flows occur *less* than 95% of the time, means there are periods of no flow under natural flow conditions, and that these cease-to-flow periods occur throughout the catchment. (Note that the streamflow is on a logarithmic scale, so the smaller flows are emphasised relative to the large peak floods.)

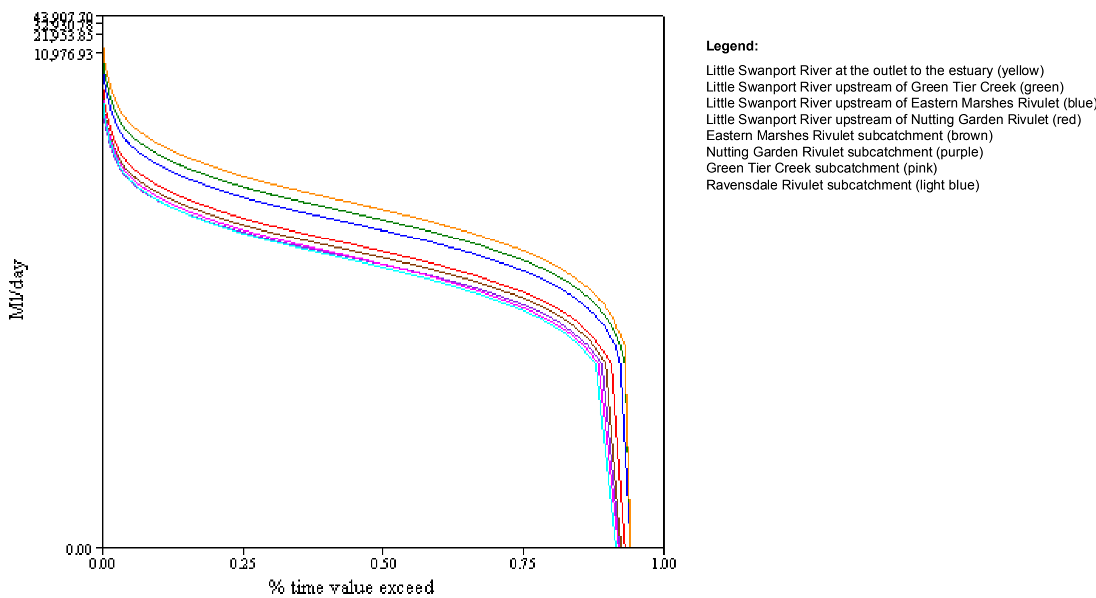

Figure 3: Flow duration curves showing the relationship between streamflow (in ML/day) and the percentage of time it is exceeded under natural flow conditions, from selected locations throughout the Little Swanport catchment (see text for interpretation):

As the pattern of streamflow is similar throughout the catchment, comparisons between natural and current flow conditions have only been presented for the Little Swanport River at the outlet and at the upper gauging station (halfway up the catchment). The impact of current water use on natural flows can be seen by comparing the flow duration curves under these two flow conditions (Figure 4).

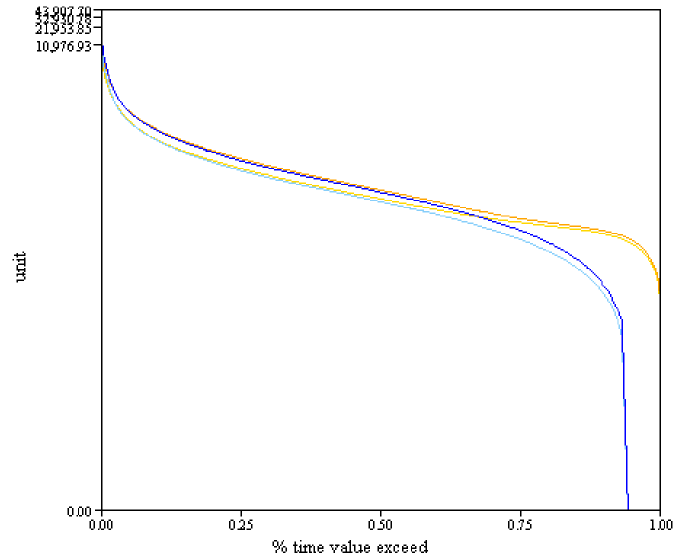

Figure 4: Flow duration curves at the Little Swanport outlet under natural (blue) and current (orange) flow conditions, and also at the Little Swanport upper gauge under natural (light blue) and current (yellow) flow conditions.

Figure 4 shows that flows occurring less than about 70% of the time are very similar under natural and current flow conditions, whereas the flows occurring more than 70% of the time (the lower flows) are quite different under current conditions. Under natural conditions, all flows occur less than 95% of the time, meaning flows cease for approximately 5% of the time, and these cease-to-flow periods are a part of the natural flow regime. This does not occur under current flow conditions; there are no times where flow ceases, and this is most likely due to irrigation runoff during in the upper parts of the catchment.

Annual flow conditions

While the flow duration curves give an idea of the range of flows and that the Little Swanport has highly variable, flashy flows, they do not provide much guidance regarding "average" conditions. Average annual flow conditions refer to aspects of the flow regime such as daily flows, baseflows, percentile flows, and the rate at which flows rise and fall, and generally concentrate on the middle, flatter part of the flow duration curve. They are averaged across all years in the flow time series, hence are referred to as average, or mean annual flow variables.

Mean annual flow variables were calculated from two locations in the Little Swanport catchment: the outlet to the estuary, and the upper gauging station (Table 6). The flow variables calculated were chosen to give a picture of the "average" flows in the catchment under natural and current water use conditions, and were as follows:

- *Mean daily flow* is the average of daily flows throughout the year, across all years.
- *Mean daily baseflow index* refers to the proportion of total flow occurring in the absence of runoff due to recent rainfall events. If the baseflow index is under 0.5, it indicates that less than half of the total flow is due to baseflow, and a larger proportion of the total flow is due to rainfall-induced high flow.
- *Mean annual flow* is the average volume of water discharged in a year, and gives an indication of catchment size, its climate, and the "typical" amount of water it delivers.
- *Mean annual CV* is the average coefficient of variability, and indicates how much variation there is around the mean daily flow. Values above 1.0 reflect a greater variation of daily flows relative to the average daily flow, and values above 3.0 indicate extreme hydrological variability.
- *Mean annual 10% exceedance flow* indicates that flows larger than this amount occur less than 10% of the time. This variable gives and indication of a high flow, but not necessarily a flood flow.
- *Mean annual 90% exceedance flow* indicates that flows larger than this amount occur 90% of the time. This variable gives an indication of a low flow, but not necessarily a baseflow.
- *Mean days of zero flow* is the average number of days of zero flow per year.
- *Mean annual minimum* is the lowest flow in a year, averaged across all years.
- *Mean annual maximum* is the greatest flow in a year, averaged across all years.
- *Mean magnitude of rise* is the average volume by which the river rises in a year, averaged across all years.
- *Mean duration of rise* is the average amount of time in days that it takes the river to rise that volume.
- *Mean rate of rise* is calculated from the two previous variables, and indicates the average speed, in ML/day, at which the river rises.
- *Mean magnitude of fall* is the average volume by which the river falls in a year, averaged across all years. It is very similar to the mean magnitude of rises.

- *Mean duration of fall* is the average amount of time in days that it takes the river to fall that volume, back to its original volume.
- *Mean rate of fall* is calculated from the two previous variables, and indicates the average speed, in ML/day, at which the river falls.

In average terms, the current water use conditions have had an impact on natural flows in the Little Swanport catchment, more so at the upper gauge than at the outlet (Table 6). However, the effect of current water use is greater on some variables than others, particularly those relating to low flows, as already indicated by the flow duration curves (Figure 4).

Mean annual flows, mean daily flows, and mean maximum flows are all slightly lower under current use conditions, whereas 90th percentile flows, the baseflow index and mean minimum flows are considerably greater (Table 6). This is most likely due to irrigation practices in the upper parts of the catchment where irrigation runoff during the drier months actually contributes more water to the river than would normally occur under natural conditions. This is particularly apparent when comparing the number of days of zero flow; under natural conditions there are on average about 21 days of zero flow in the catchment, and under current conditions, these cease-to-flow periods no longer occur. Surveyor's notes on parish plans from the early 1800's indicate refer to the river as a permanent water source, but it is not clear whether refers to permanently flowing water, or pools that remain throughout the summer.

Table 6: Average (mean) flow variables at two locations in the Little Swanport catchment: the outlet, and the upper gauging station (halfway up the river). The variables are presented for natural and current water use flow conditions, and units are ML/day unless otherwise stated. Hydrological variables are described in the text.

Catchment Location	Little Swanport River outlet		Little Swanport River upper gauge	
Flow Condition	**Natural**	**Current**	**Natural**	**Current**
Mean daily flow	238.25	227.80	157.95	148.46
Mean daily baseflow index	0.124	0.147	0.125	0.156
Mean annual flow	87,023.82	83,208.54	57,691.43	54,228.07
Mean annual CV	3.70	3.31	3.68	3.10
Mean annual 10% exceedance	424.43	431.24	282.80	295.71
Mean annual 90% exceedance	3.40	8.43	2.36	7.19
Mean days of zero flow	21.28	0.07	21.28	0.12
Mean annual minimum	0.52	3.50	0.37	2.92
Mean annual maximum	11,088.61	9,329.17	7,311.16	5,580.31
Mean magnitude of rise	732.79	474.73	483.57	295.39
Mean duration of rise	1.56	1.65	1.55	1.67
Mean rate of rise	450.24	287.67	297.35	178.42
Mean magnitude of fall	720.39	470.27	475.41	292.66
Mean duration of fall	6.46	4.00	6.44	3.81
Mean rate of fall	157.28	121.57	103.81	79.33

Where the impacts of current water use on natural flows are also apparent is the manner in which streamflows change in volume. Current water use reduces the average magnitude and rate at which water rises, but not the time it takes for the water to rise. This suggests that farm dams collecting water runoff from offstream sources and drainage lines are collecting a proportion of the water during a precipitation event that would reach the river under natural conditions. This leads to a reduction in the volume of flows reaching to the river, and therefore a reduction in the rate and time over which flows fall compared to natural conditions.

However, despite the fact that current water use conditions affect the absolute values of these variables, the variability of flows, as indicated by the CV, is relatively similar. This suggests that current water use affects the amount of water the river delivers, and when it is delivered, but the overall variation of flows compared to average flows is not very different. The fact that the mean annual CV is over 3.0 indicates there is extremely high variability in flows, and "average" values take in a very large range of flows.

Monthly flow conditions

Average flow conditions for each month give an indication of how flows change throughout the year, particularly between seasons where precipitation can differ markedly, and at what times of the year current water use might have greater effects. For example, average daily flows for each month are considerably higher in the winter months (June, July and August) than the warmer months (November to March), although mean daily flows are also higher over December, probably due to easterly rainfall patterns (Figure 5). While there is some difference between natural and current flow conditions, the pattern of average daily flows in each month is the same, and the high variability in daily flows (Table 6) is likely to mean this difference is not significant. The major differences in daily flows are between the winter and summer months.

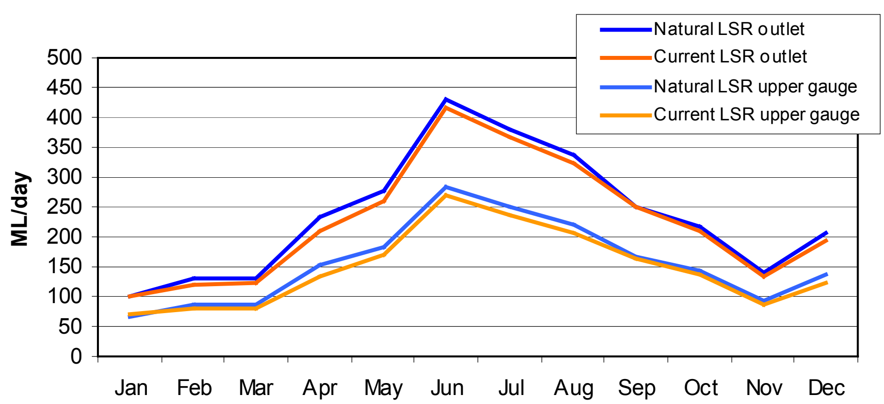

Figure 5: Average daily flows for each month in the Little Swanport River at the upper gauging site and at the outlet, under natural flow conditions (blue) and current flow conditions (orange). All flows in ML/day.

This pattern is similar for the high flows (10% exceedance flows) and the average maximum flows per month (Figure 6); the high flows and floods are larger over the winter months. The high 10% exceedance flows are relatively similar under natural and current flow conditions, but the maximum flows are reduced under current water use conditions. This is possibly due to farm dams capturing a greater proportion of these maximum flows than the average high flows. Note the scale of these high flows compared to average daily flows per month (Figures 5). Average high flows are approximately double the average daily flows.

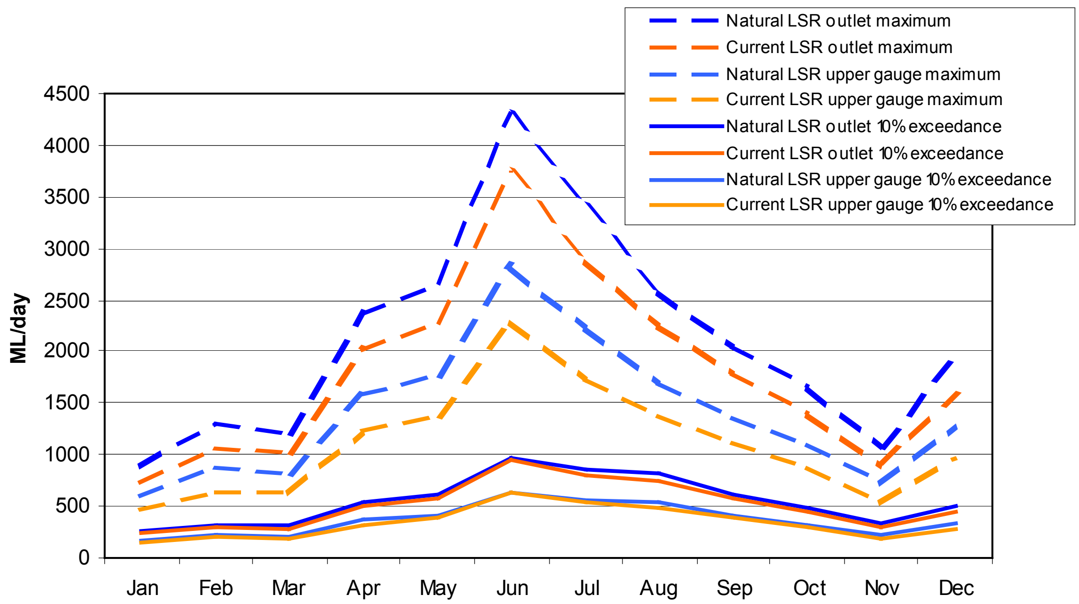

Figure 6: Average maximum flows (dashed lines) and 10% exceedance flows (solid lines) for each month in the Little Swanport River at the outlet and the upper gauge, under natural (blue) and current (orange) flow conditions. All flows in ML/day.

The low 90% exceedance flows are those flows which occur more than 90% of the time, and, like the average minimum flows in each month, are generally lower over summer compared to winter (Figure 7).

As shown on the flow duration curves (Figure 4), low and minimum flows are significantly altered under current flow conditions. These flows can be as much as two times larger than they are under natural flow conditions, and this is particularly apparent during the dry summer months (Figure 7). As mentioned earlier, this is probably due to irrigation runoff in the upper parts of the catchment. The low flows are also higher over the winter months, and this may be due to the interbasin transfer that occurs at Hobbs Lagoon, where water from the Prosser River catchment is channelled into the Little Swanport catchment.

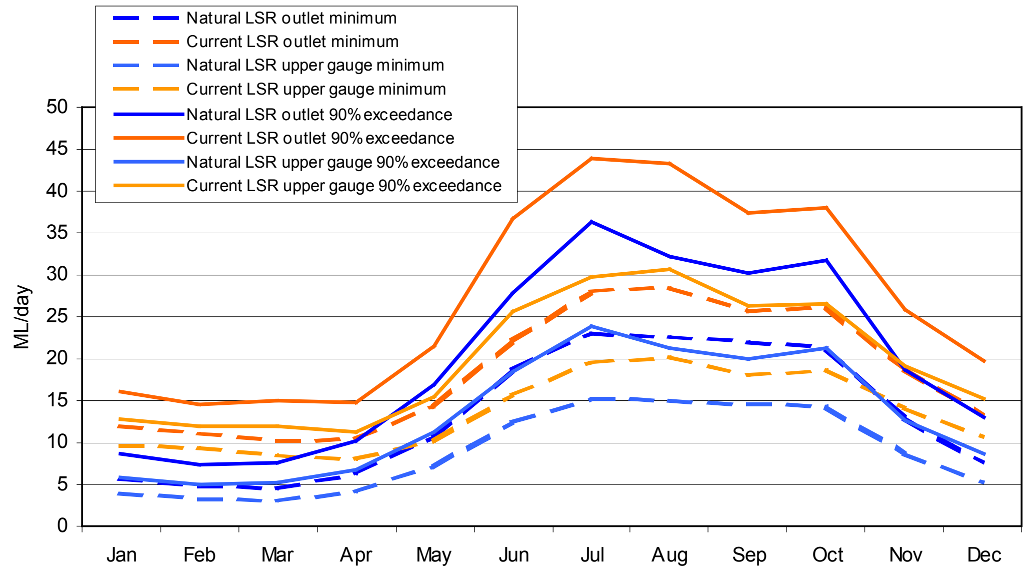

Figure 7: Average minimum flows (dashed lines) and 90% exceedance flows (solid lines) for each month in the Little Swanport River at the outlet (blue) and the upper gauge (orange), under natural and current flow conditions. All flows in ML/day.

As with the annual flow statistics, the impact of current water use is most apparent when considering cease-to-flow periods (Figure 8). Under natural conditions, days of zero flow are most prevalent during the summer months (December to March), but under current conditions, these cease-to-flow periods no longer occur.

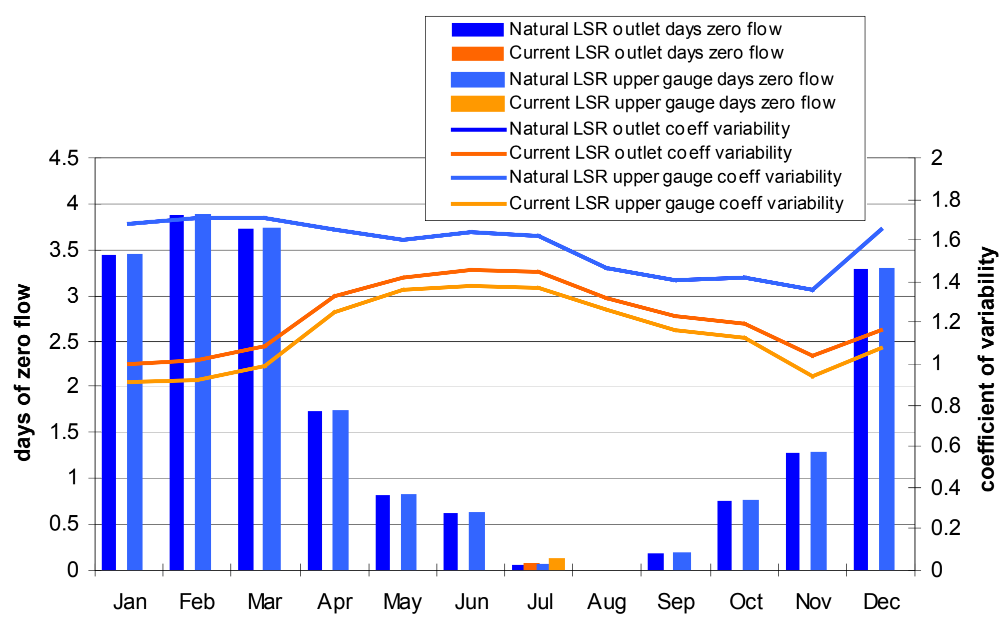

Figure 8: Average number of days of zero flow (solid bars) for each month in the Little Swanport River at the outlet and the upper gauge, under natural (in blue) and current (in orange) flow conditions. The solid lines represent the coefficient of variability for each month under natural (blue) and current (orange) flow conditions. The coefficient of variability is the same at the outlet and the upper gauge under natural conditions.

The removal of cease-to-flow periods from the current flow regime means that the flow variability has also changed, as indicated by the lower coefficient of variability across the year, but particularly during summer (Figure 8). Under natural flow conditions, the greatest variability of flows occurred during the summer months, but under current flow conditions, summer flows are now among the least variable. This effect is greater at the upper gauge than at the outlet.

Flood frequency

While average flow statistics provide information about the "normal" hydrology of the catchment, flood frequency statistics provide information regarding peak flow events and their occurrence under natural and current conditions. Flood frequency analyses gives an indication of how often floods of different magnitudes are likely to occur. The average length of time between two floods of the same size is known as the *average return interval*. The average return interval (ARI) indicates the period of time in which it is likely that a flood of a given size will occur, but not when it will occur within that interval. By conducting a flood frequency analysis under natural and current flow conditions, the effect of current water use on the size, and likely recurrence, of floods can be estimated (Figure 9).

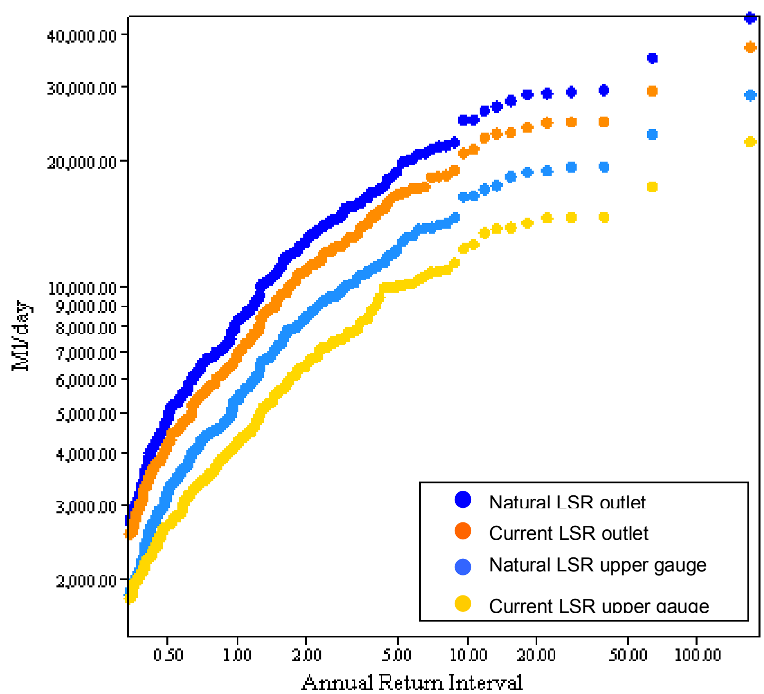

Figure 9: Flood frequency analysis of natural (blue) and current (orange) daily flow time series, for the Little Swanport River at the outlet and at the upper gauge. Flood size is in ML/day.

The flood frequency analysis for two locations in the Little Swanport catchment (the outlet and the upper gauging station) shows that under current water use conditions, a flood of a given size will have a slightly longer average return interval (Figure 9). For example, under natural conditions, a 5,000 ML/day flood is likely to occur once in 1 year, or annually, at the upper gauging station on the Little Swanport River. Under current flow conditions, this flood is more likely to occur once in a 1.4 year period.

Another way of looking at the flood frequency analysis is to compare how big a flood of the same ARI will be under natural or current flow conditions. In the Little Swanport, floods of the same ARI, or with the same likelihood of occurring, are smaller under current flow conditions, probably due to catchment dams capturing a proportion of the flood. However, the difference in flood volume due to current water use is proportionally less at the river outlet than at the upper gauge (Figure 9), which is probably due to natural tributary inflows to the river between the upper gauge and the outlet.

High Spells

Flood frequency analysis is useful to determine the relative size of large floods, and their relative occurrence, under different flow conditions, but does not provide information about their duration and is not appropriate for looking at within-year events. This information requires a "high spell" analysis. A high spell is defined by a flow threshold, such that any flow event that goes over this threshold is automatically considered a high spell, regardless if it is just over or extremely over it. High spells represent "flush" or "pulse" events that are higher than average flows and are likely to occur multiple times in a year, but may not be considered major floods.

Two high spells analyses were conducted for two locations on the Little Swanport River; the outlet and the upper gauge, under natural and current flow conditions (Table 7). The thresholds for these high spells were set at the 10% and 5% exceedance flows at each location. This means that any event that occurs less than 10% of the time, regardless of its size, is included as a flush or flood event. Similarly, all events that occur less than 5% of the time are included, and these events are larger and less frequent. Both high spell events were defined as lasting for at least one day, and having at least three days between them to be considered independent events.

Table 7: High spell analyses of two flood events at the upper gauge and the outlet in the Little Swanport River, indicating the flood threshold, average frequency, average magnitude and average duration of each high spell under natural and current flow conditions. The flood thresholds are set at the 10% and 5% exceedance flows for each location. The threshold is the level that defines the beginning and end of a high spell, so the flow can be any volume over this threshold to be considered a high spell. High spell independence was defined by there being at least three days between spells. Units are ML/day unless otherwise stated.

Catchment Location	Little Swanport River outlet		Little Swanport River upper gauge	
Flow Condition	**Natural**	**Current**	**Natural**	**Current**
10% exceedance threshold				
High spell threshold	369.46	386.20	247.06	255.60
Number of high spells per year	7.50	6.90	7.55	6.87
Mean magnitude of high spell	3552.57	3106.68	2351.99	1999.94
Mean duration of high spells (days)	4.06	4.26	4.04	4.34
5% exceedance threshold				
High spell threshold	776.82	807.19	518.18	539.73
Number of high spells per year	4.17	4.02	4.21	4.13
Mean magnitude of high spell	6159.74	5454.10	3982.88	3268.98
Mean duration of high spells (days)	3.67	3.74	3.61	3.69

The 10% exceedance threshold events under natural flow conditions have an *average* magnitude of 3552 ML/day at the outlet, and 2352 ML/day at the upper gauge. These events are slightly reduced under current water use conditions, probably due to catchment farm dams capturing a proportion of the surface run-off. These events last for approximately four days and occur approximately seven times a year, and again are slightly less under current flow conditions.

The larger events, defined by the 5% exceedance threshold, have an *average* peak of 6160 ML/day under natural flow conditions at the outlet, and 3983 ML/day at the upper gauge. These events are also reduced under current flow conditions. They occur about four times a year, and last for about three and a half days.

Examining the occurrence of these events throughout the year indicates that the smaller, 10% exceedance events are more frequent during winter and spring, but the larger 5% exceedance events occur predominantly over winter (Figure 10). Current water use has little impact on the frequency of these events over the year.

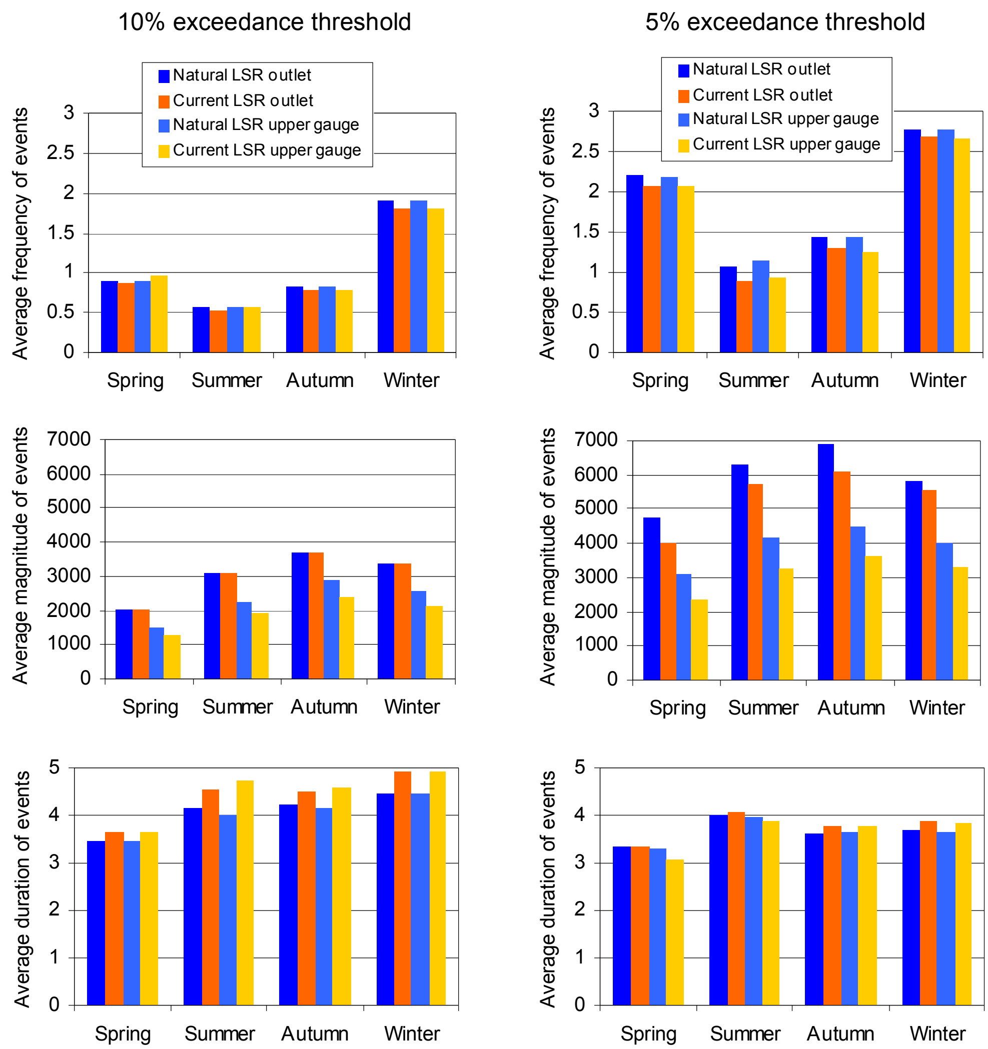

Figure 10: Characteristics of high flow spells in the Little Swanport River at the upper gauge and the outlet, under natural (in blue) and current (in orange) flow conditions. The graphs to the left are for 10% exceedance events, whereas those on the right are for 5% exceedance events. High spell events are defined as having a threshold of either 10% or 5% exceedance flows as a threshold, so incorporate all events which go over this level regardless of their size. The 10% exceedance threshold represents those events that occur less than 10% of the time, 5% exceedance events are those that occur less than 5% of the time, and are therefore larger events. The top graphs show the average number of flush events occurring in each season, the middle graphs show the average magnitude of events (in ML/day) and the bottom graphs show the average duration (in days) of events.

The average magnitude of these events is slightly greater over summer and autumn, reflecting the easterly weather patterns, which can bring large rainfall events to the catchment over the warmer months. The larger 5% exceedance events are reduced under current flow conditions (Figure 10).

The 10% exceedance events generally last slightly longer than the 5% exceedance events, and are also slightly longer under current conditions (Figure 10). There is little difference in duration between seasons, although the summer events seem to be of slightly shorter duration.

Overall, the average frequency, magnitude and duration of these high flow events are not significantly affected by current flow conditions, and they maintain the same pattern as events occurring under natural flow conditions.

Cease-to-flow events

Cease-to-flow events are a normal part of the natural flow regime, but as indicated by the flow duration curves (Figure 3), do not occur under current flow conditions. A cease-to-flow period represents a “low spell”, which is defined by the length of time flows are *under* a certain threshold. A low spell analysis can be conducted like a high spell analysis to determine their average frequency, duration and timing.

The low flow spell threshold was defined as the 95% exceedance flow, meaning that 95% of the time flows are above this level. In the Little Swanport under natural flow conditions there are no flows under this threshold, so it occurs as a cease-to-flow event. Under current flow conditions, these low flow events are not cease-to-flow as there is still water in the system due to water use activities in the catchment. These low flow events are more frequent under current flow conditions, but only last about half as long compared to natural flow conditions.

Table 8: Low spell analysis of cease-to-flow events at the Little Swanport River outlet and at the upper gauge, indicating the average frequency and duration of low spells in a year under natural and current flow conditions. The flow threshold *below* which a cease-to-flow event is defined is the 95% exceedance flow. The low spell threshold is the level which defines the beginning and end of the low spell, so the flow can be any volume under this threshold to be considered a low spell.

Catchment Location	Little Swanport River outlet		Little Swanport River upper gauge	
Flow Condition	**Natural**	**Current**	**Natural**	**Current**
95% exceedance threshold				
Low spell threshold (ML/day)	0	4.6	0	4
Number of low spells per year	1.49	2.206	1.49	2.206
Mean duration of low spells (days)	13.788	7.415	13.788	7.574

By breaking down the year into seasons, effects on the timing of these events can be seen. The timing of these low flow events changes markedly from being most common in summer, then autumn, under natural flow conditions, to being rare in summer and most common in autumn and winter (Figure 11).

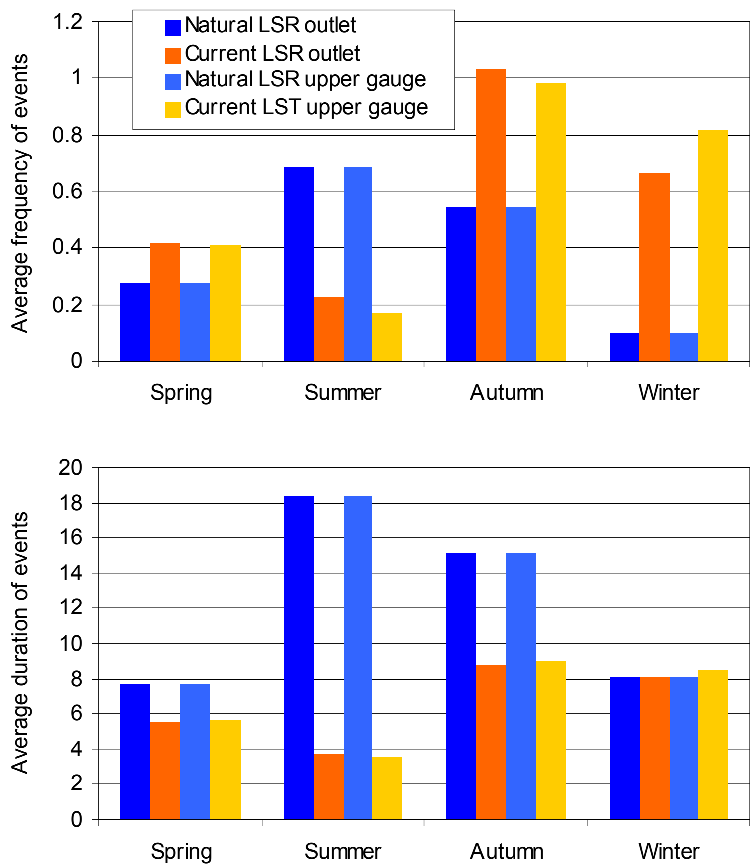

Figure 11: Characteristics of low spell events occurring in each season under natural (in blue) and current (in orange) flow conditions, at the Little Swanport outlet and at the upper gauge. The top graph shows the average number of these events occurring in each season, and the bottom graph indicates the average duration of low flow events. Low flow events were defined as flows below a threshold of 95% exceedance flows, and are actually cease-to-flow events under natural conditions.

Current flow conditions also affect the duration of these events, but this effect depends on season. In winter low slow spells last on average for about 8 days, regardless of current water use activities (Figure 11). However, under natural conditions, low flow events last for over 18 days (on average) over summer, but last less than four days under current flow conditions. Current water use activities in the catchment markedly change the very low flow events in the catchment and their pattern of occurrence.

Summary and conclusions

This hydrological characterisation of the Little Swanport catchment has shown that flows are naturally highly variable in this catchment, that cease-to-flow periods are a natural part of the flow regime, that most of the river's flows are due to rainfall events, and that the river responds rapidly to such events. Furthermore, this flow regime is characteristic across the catchment.

Current water use in the catchment does not significantly affect flood events or "average" flows, and the pattern of these flows is similar to natural. However, low flows and particularly cease-to-flow periods are impacted by irrigation runoff. Low flows are higher than natural, and have been altered (particularly in the case of cease-to-flow events) compared to natural flow conditions. Current water use activities also alter the timing and duration of low flow events, and therefore change the low flow end of the flow regime.

The effects of current water use are greater in the upper part of the catchment, and inflows from tributaries with natural flows downstream help to ameliorate these effects towards the bottom of the catchment.

2.2 Soils and Land Use

There is little quantitative or qualitative description of soils in the Little Swanport catchment. The following description is general in nature only and is largely derived from Davies (1988). With the exception of the coastal plains of the Little Swanport catchment, the descriptions in Davies have not been field tested and are derived from a generalised land classification system based on rainfall, geology and altitude. The most recent soil map for Tasmania is largely based on modelled data, has no field data for the Little Swanport catchment, and has not been used for this section. It is likely that the soil distribution and character for the Little Swanport catchment is far more complex than any current description available. Land use is depicted in Figure 12.

The soils of the Little Swanport catchment are derived mainly from Jurassic dolerite, which is the dominant geological unit within the catchment. On stony crests, these soils are shallow and overlay bedrock, while deeper soils are found on protected slopes, in gullies and on the flats. The soils are generally resistant to erosion although disturbance on steeper slopes may lead to sheet, rill and gully erosion. Steeper, more elevated areas in the middle/lower catchment tend to support native forest either as freehold land or production forest managed by Forestry Tasmania. A land capability modelling system (Lynch, 2002) describes these areas as having only marginal suitability for grazing and recommends retention of natural vegetation cover.

There are a number of reserves in the steeper, forested dolerite country in the lower catchment. The largest forested region consisting predominantly of eucalypt woodland is the Buckland Military Training Area, covering 23 428 hectares. In the upper catchment, grazing occurs where dolerite forms low rolling hills, such as those in the upper Eastern Marshes catchment. Lower catchment areas or areas with low relief are described under the land capability modelling system as being well suited to grazing but having limited potential for cropping. The remaining cleared areas are described as having some limitation for pastoral use requiring soil conservation measures. Cropping within the catchment mainly occurs in areas of low relief in the lower part of the catchment that have been drained.

The natural resources contained within the Buckland Military Training Area have been documented for the purposes of land management (Wells et al., 1977, Hepper-deGryse Team, 1991). The area is dominated by Jurassic dolerite with a small area of Triassic sandstone in the Pepper Creek catchment. Deep weathering has produced clay and nutrient rich soils with abundant gravel and boulder material. These soils are generally resistant to erosion unless grossly disturbed (Hepper-deGryse Team, 1991). It is also likely that this terrain transmits significant groundwater flows (Hepper-deGryse Team, 1991). Slopes are often covered in thin layers of potentially unstable talus with thick dolerite screes present on some steeper slopes, although the presence of larger particles within the soil profile has led to increased natural erosion on exposed slopes (Hepper-deGryse Team, 1991).

The sandstones in the majority of the training area have weathered to nutrient poor, sandy soils prone to erosion. However, sandstones within the Pepper Creek catchment have a mudstone component resulting in more clay rich, fertile soils, with a slight increased resistance to erosion. These sandstones are frequently rich in soluble salts and it is likely that groundwaters in these areas have elevated salt contents (Hepper-deGryse Team, 1991). Extensive forestry operations have occurred within the training area, mostly during the 1970's. By 1978 over 20% of the training area had been clearfelled (Wells et al., 1977), however since that time forestry has continued on a more limited basis. Roads constructed during the clearfelling period have resulted in increased erosion in some areas. Some minor clearing and burning for grazing has occurred in the northern portion of the training area and has been implicated in severe sheet and gully erosion on the southern side of the upper catchment of Pepper Creek.

Soils derived from Permian mudstones and Triassic sandstones occur in the upper catchment between Nutting Garden Rivulet and Hobbs lagoons, in addition to a small area in the middle catchment between Eastern Marshes Rivulet and Green Tier Creek. These soils are shallow, stony and sandy and overlay bedrock on elevated areas, grading to more uniform sandy soils on lower slopes with deeper sandy loam/clay soils on the flats. The predominant land use on these soils is grazing, and there are some pockets of remanent vegetation, generally at higher elevations. These soils are susceptible to erosion due to their light textures and low organic matter. Areas of low-moderate relief are described by the land capability classification as having limited cropping potential while areas with greater relief are considered suited to only light pastoral grazing. Those areas supporting remnant vegetation are considered to have severe limitations for grazing and should be retained in their current state.

The coastal plain surrounding the estuary contains widespread sandy flats with relatively deep soils and a sandy loam surface. Low hills to the south and east of the estuary consist of Triassic sandstone with shallow gravelly sandy soils. North of the estuary, low rocky hills contain very shallow soils, with deeper clay dominated soils on the flats and on protected slopes. The dominant land use in this area is grazing, with remanent native vegetation on the Triassic sandstone outcrops and adjacent higher ground to the west. Soils and groundwater in this area have elevated salt levels (Dell, 2000). Crests are prone to sheet and rill erosion while the sandy flats are susceptible to gully and streambank erosion. Land on the coastal plain of the Little Swanport is considered suitable for grazing but of limited cropping capacity.

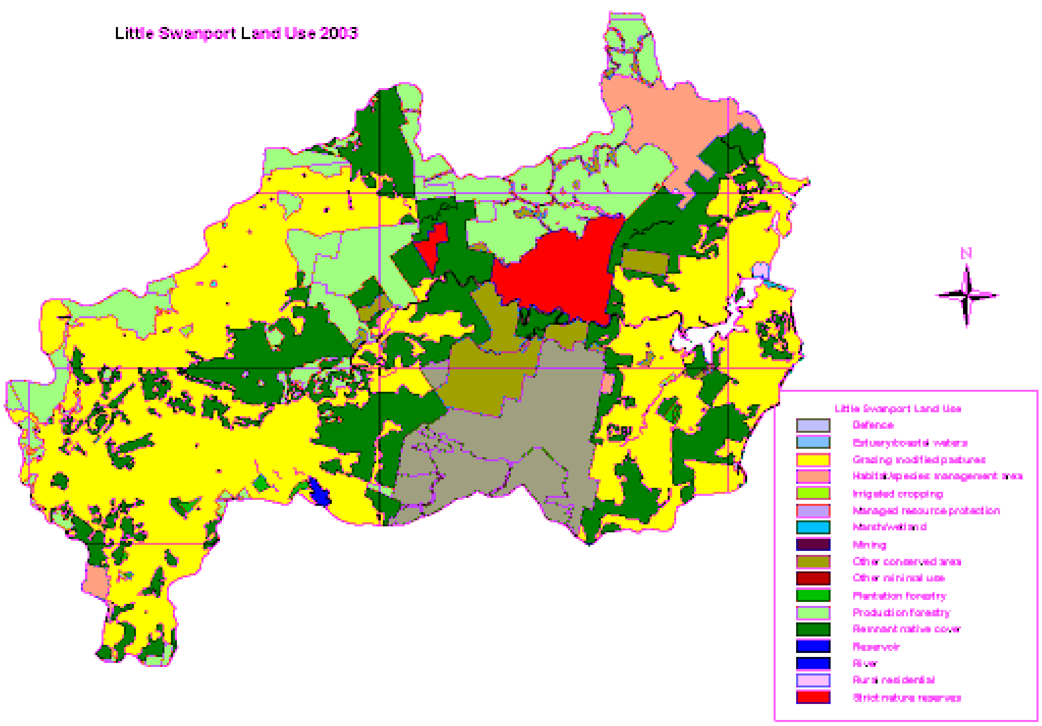

Figure 12: Location map of the Little Swanport catchment displaying land use.

2.3 Catchment Geomorphology

The geomorphology of a catchment drainage system is influenced by a number of factors, including geology and hydrology, and riparian vegetation can interact with these variables to influence channel morphology. Characterising the fluvial geomorphology of a river is important for determining river condition, because hydrological and geomorphic processes control the transport and distribution of sediment and organic matter, which in turn dictates the shape of the channel and its floodplain, and the types of biota it contains. A geomorphic characterisation of the Little Swanport catchment was conducted as part of a project to develop a holistic environmental flow methodology funded under the National Action Plan for Salinity and Water Quality (Koehnken 2005, in Warfe 2005), and much of that information is included here.

Geology

The topography of the Little Swanport catchment consists of steep valley controlled dolerite sections with two major floodplains present at 250 m (Stonehenge floodplain) and at 150 m (Swanston floodplain).

The predominant geology in the catchment is Jurassic dolerite (Figure 13), although there are Triassic sandstone deposits on the southern side of the estuary and in the far west of the catchment, around the uppermost reaches of the Little Swanport River. Triassic mudstone deposits are present around Crichton Creek, which have a low water-holding capacity and produce sandy, nutrient-poor soils. There are also significant deposits of Quaternary alluvial sediments on both floodplains, and which extend up the Nutting Garden Rivulet valley.

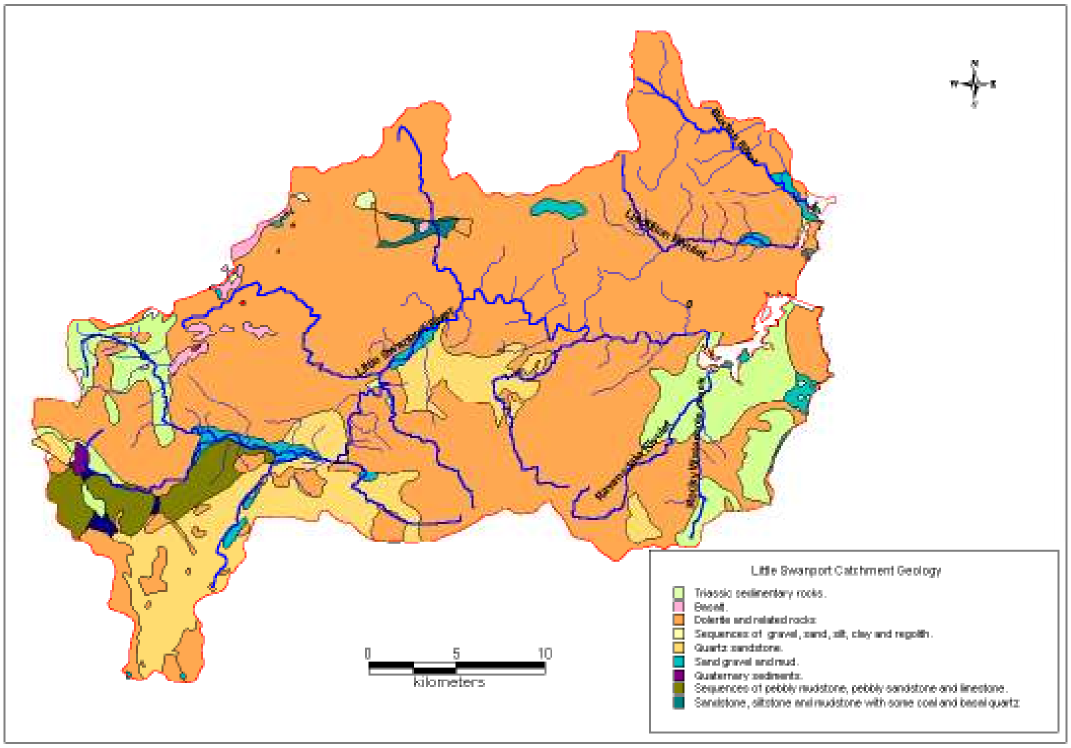

Figure 13: Geological map of the Little Swanport River catchment.

Geomorphology

The uppermost parts of the catchment, around Crichton Creek and the upper Little Swanport River, are characterised by low relief, gently sloping hills situated at approximately 350 m above sea level. These areas are also characterised by the presence of broad river basins developed on sedimentary rocks and surrounded by steeper dolerite topography. This area corresponds to the *southern midlands foothills and valleys* geomorphic sub-region identified in the Conservation for Freshwater Ecosystem Values (CFEV) database.

Further downstream, around Pages Creek and Swanston, CFEV identifies the geomorphic sub-region as *inland slopes,* which are characterised by broad rolling hills and moderate to steep valleys developed predominantly on dolerite and Permian and Triassic sediments.

In the eastern (bottom) half of the catchment below Green Tier Creek, the surrounding topography is steep with bedrock-controlled gorges, and there are no lowland meandering reaches, leading to a catchment structure fairly common on the

Tasmanian east coast (Jerie et al. 2003). This area corresponds to the *steep dissected eastern escarpment* identified by CFEV and has steep, high relief gorges resulting from headward incision of rivers into the uplifted Eastern Tiers.

The major sources of sediment for the river are fine-grained materials derived from the erosion of dolerite soils from cleared areas in the upper part of the catchment, and colluvial dolerite cobbles and boulders derived from the steep, confined reaches of the river. Major sediment-transporting events are limited to infrequent and large flood events.

The present river is undersized for its valley, reflecting large historical flows occurring during wetter glacial periods. Deposits of large boulders throughout the lower half of the river also suggest that larger river flow once occurred.

Geomorphic zones

The river's response to natural effects, such as flooding, and to anthropogenic effects, such as land use, will depend on the geomorphic factors that control the river's character and behaviour. Such factors include the type of geology, channel gradient or bedslope, valley width, the degree of floodplain development, channel morphology and instream features, as well as the associated riparian vegetation. Characterising the river into relatively homogeneous zones can assist in predicting the river's response to, and targeting, water management practices (Davies et al. 2002). Based on the above features, and the geomorphic subregions identified within the CFEV database, the Little Swanport River and its major tributaries have been divided into 4 geomorphic zones (Figure 14), the characteristics of which are summarised in Table 9.

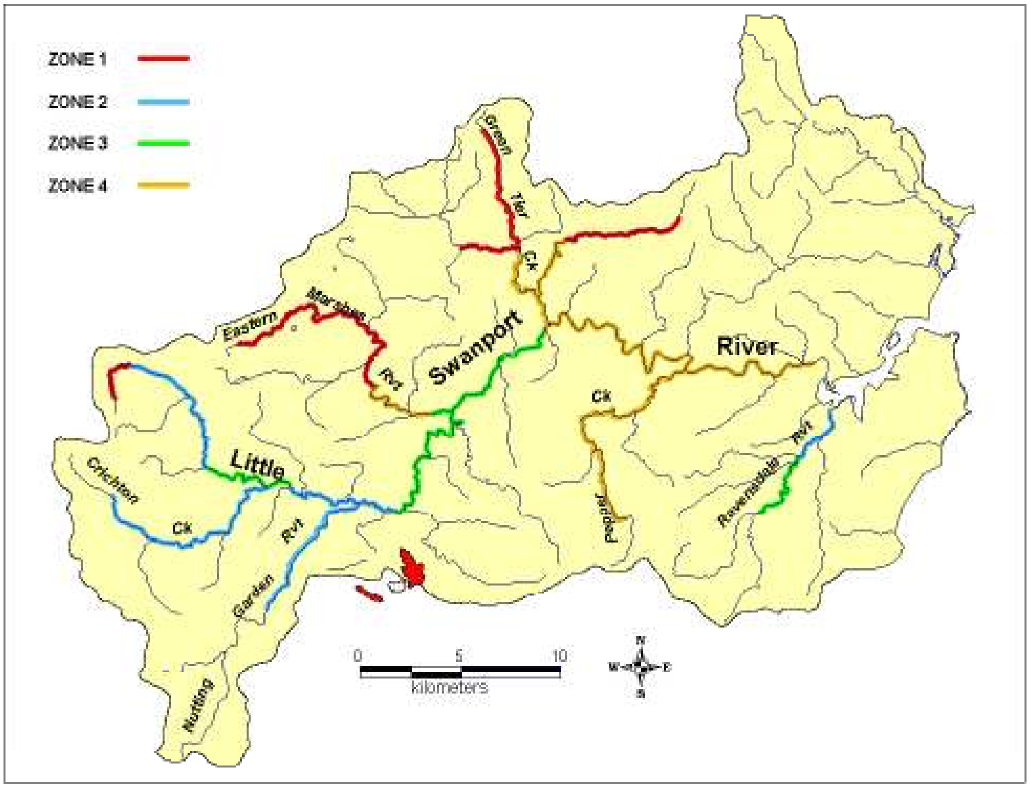

Figure 14: Map of the Little Swanport catchment indicating major geomorphic zones.

A long profile of the Little Swanport River and its major tributaries (Figure 15) also shows the position of each geomorphic zone in terms of its distance from the source (in kilometres) and its elevation (in metres above sea level). Variations in river gradient (or bedslope) can be seen from this graph, however, this characteristic interacts with the size of the river. For example, the cascade-pool zone on the Little Swanport River does not appear as steep as the corresponding zones on the tributaries; this is because it is a larger river here with permanent pools separated by "steps" rather than gorges. The uppermost headwaters of the river and its tributaries are not represented in the geomorphic zones or on the long profile. These reaches represent the small, often ephemeral gullies as they drain the headwater slopes and begin their respective watercourses. They are very steep over a short distance and are drainage lines rather than significant channels thus are not considered in this geomorphic characterisation.

It is important to remember that these zones are essentially a catchment-scale categorisation of a continually varying system containing a great deal of diversity, thus the zone boundaries may be "fuzzy" and there may be significant small-scale variability within zones.

Table 9: Summary of the major characteristics of each geomorphic zone.

Zone	**Major characteristics**
1: upland chain-of-lagoons	• dolerite geology • shallow bedslope • alternating chains-of-lagoons and defined channel • fine bed sediments • holds water
2: mobile	• sandstone/mudstone geology • shallow bedslope • small shallow channel • floodplain development • fine bed sediments
3: partly-confined	• dolerite geology, although some sandstone may be present • moderate bedslope • moderate channel with gravel bars and scour zones forming riffles and pools when flowing, some floodplain development • moderately steep valley sides • cobble bed sediments
4: confined	• dolerite geology • steep-moderate bedslope • bedrock-controlled valley • steep valley sides • boulder/cobble bed sediments, bedrock/boulder cascades and deep permanent pools may be present

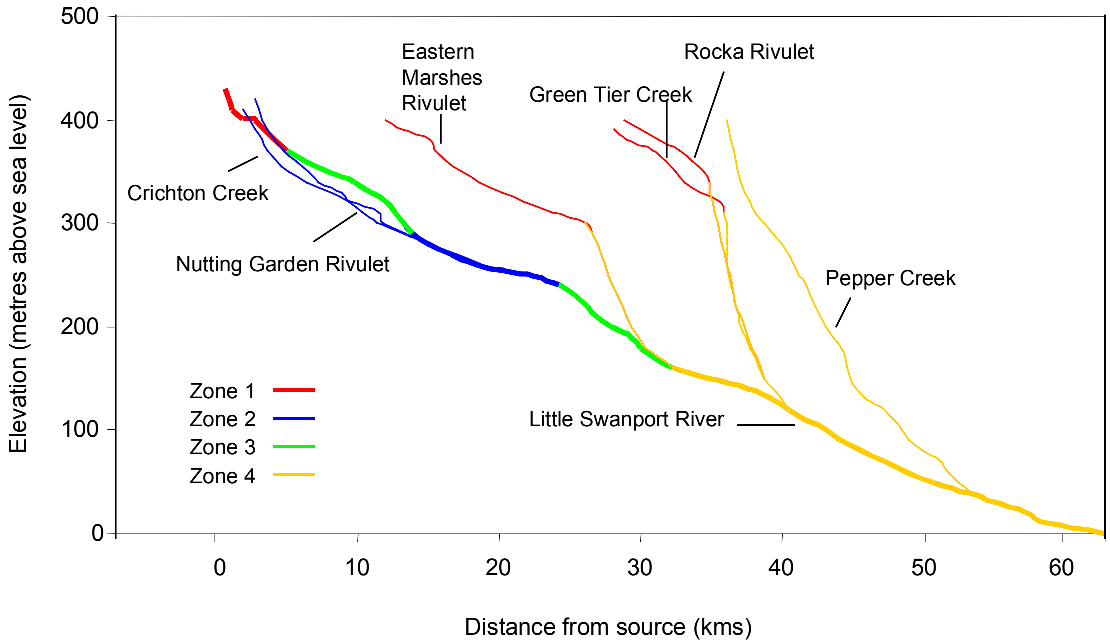

Figure 15: Longitudinal profile of the elevation (metres above sea level) of the Little Swanport River and its major tributaries, from its source to the estuary. Geomorphic zones are indicated by colour.

Zone 1: upland chain-of-lagoons zone

This zone is an upland chain-of-lagoons zone, sitting at approximately 350 m elevation and encompassing the very top of the Little Swanport River at Ashgrove Lagoon, the upper parts of Eastern Marshes Rivulet, Green Tier Creek and Rocka Rivulet, as well as the Hobbs Lagoon irrigation complex (Figure 14). It is a series of headwater plains comprised of marshes, swamps and lagoons connected by distinct channels.

These relatively flat headwater plains have a predominantly dolerite geology and naturally hold water for periods of time. The bed sediments are fine, comprising sand, gravel and some pebble, reflecting the low-energy environment. These areas constitute sediment storage areas in the catchment, although large inundation events probably redistribute some of these sediments throughout the lagoons, and may contribute some sediment supply for downstream reaches.

Differences in land use between these areas leads to their differences in appearance (Plate 1). For example, Eastern Marshes Rivulet and its associated lagoons have been cleared, cut and drained for agricultural purposes and unless there are actual dams, these areas have lost some of their ability to retain water and their original chain-of-lagoons morphology. It is likely that vegetation clearance has increased gully erosion and reduced the input of woody debris, both of which have increased sediment supply to downstream reaches and reduced the instream physical structure and habitat (K. Jerie, DPIW, *pers. comm.*, (Webb and Erskine 2003).

The Hobbs Lagoon irrigation complex was constructed during the early 1960s to provide irrigation infrastructure for the associated property, South Rhodes. It comprises two large dammed lagoons, a number of smaller associated natural lagoons, and network of linked drainage canals. Yorky's Lagoon lies next to Hobbs Lagoon and fills every 2-4 years; it is an essentially natural marshy wetland and probably gives a reasonable indication of what much of the Hobbs Lagoon complex was like before the irrigation infrastructure was constructed.

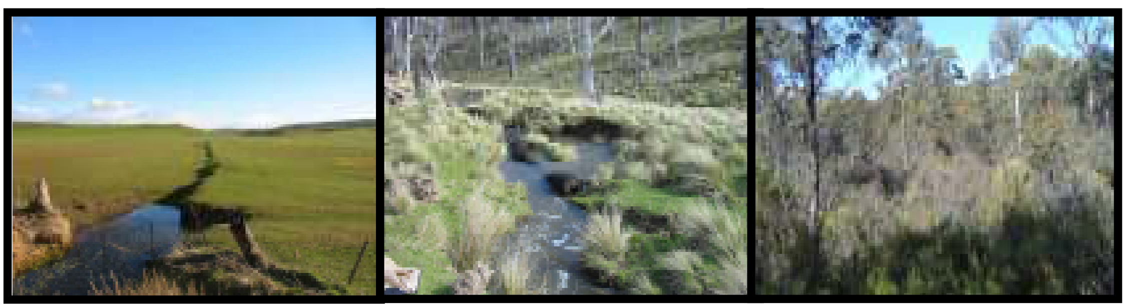

Plate 1: Examples of geomorphic Zone 1, the upland lagoon zone, at (from left) Eastern Marshes Rivulet, Green Tier Creek and Rocka Rivulet.

Green Tier Creek and particularly Rocka Rivulet are relatively unmodified and possess the geomorphic characteristics of this zone (a relatively flat bedslope and fine sediments) and retain much of their original vegetation. Consequently the instream physical structure is more variable and complex due to the contribution of woody debris, which influences sediment movement and deposition, creating more small pools and sand/gravel/pebble bars and thus providing more diverse instream habitats.

Zone 2: mobile zone

This zone is a mobile zone, dominated by sandstone/mudstone geology. On the Little Swanport River, this extends from below Ashgrove Lagoon to the channel constriction at Charlie's Mount, and from McGills Marsh to the confluence of Pages Creek. It also encompasses the mid-to-lower reaches of Crichton Creek and Nutting

Garden Rivulet, which meet the Little Swanport on the Stonehenge floodplain (Figure 14).

This mobile zone is characterised by fine riverbed sediments (such as sand, gravel, pebble and some cobble) and has a defined but relatively low-gradient, shallow, narrow channel on an associated floodplain (Plate 2). The presence of levees and benches on the floodplain indicate lateral movement of the channel in the past (hence its mobile status), and its current role as a sediment storage and supply region for downstream river reaches.

Plate 2: An example of geomorphic Zone 2, the mobile zone, on the Little Swanport River off Inglewood Road.

While the channel is defined and there is little evidence of sudden lateral channel migrations (avulsions), floods still have the capacity to redistribute sediments within the channel and onto the floodplain. The fine bed sediments and floodplain makes this the most susceptible of all the geomorphic zones in the catchment to changed land use and flow conditions. For example, collapsed banks in some parts has been caused by a combination of vegetation clearance, stock access and channel incision, which has increased sediment supply to the channel and led to the channel itself becoming wider and shallower.

The instream physical structure of streams in this zone range from sand/gravel substrates (e.g. in the Little Swanport River below Ashgrove Lagoon) to gravel/pebble/cobble substrates on the open floodplain at Stonehenge. When the river is flowing, there is a combination of riffle/run habitats, but little instream structure to provide physical diversity. These floodplain areas occur on quaternary alluvial deposits that provide rich productive soils. Because of this most have been cleared for agricultural purposes and there is little input of wood.

Zone 3: partly-confined zone

This zone is a partly-confined zone controlled by dolerite geology with some sandstone segments and is characterised by some floodplain development (but not as extensive as in Zone 2), steeper bedslope and a channel partly constrained by bedrock or the valley sides. It incorporates the dolerite intrusion on the Little Swanport River between the two mobile sections described above, extending from the valley-floor constriction at Charlie's Mount to McGill's Marsh, and describes the river reach from the Pages Creek confluence to Swanston (Figure 14).

The partly-confined nature of the channel in this zone leads to higher energy flows, and the smaller riverbed sediments are flushed through these reaches or deposited in large pools, leaving a coarser cobble/boulder substrate with some bedrock control (Plate 3). These coarser substrates create a more physically diverse channel morphology of riffles and pools, as does the contribution of woody debris from relatively intact riparian vegetation.

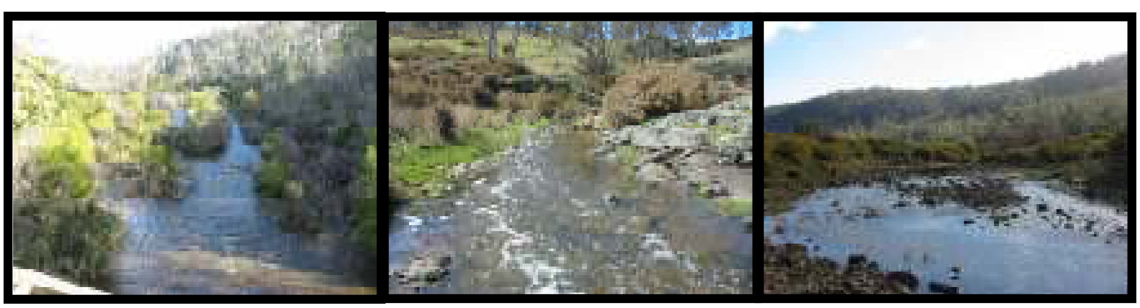

Plate 3: Examples of geomorphic Zone 3, the partly confined zone, on the Little Swanport River at (from left) Pine Hills South, Charlies Mount and at Swanston.

This zone represents an historical combination of depositional and erosional processes, with lower flows today. There is evidence of old secondary channels and terraces on the floodplain, which may occasionally become inundated under large flood events, but were probably created under greater historical flows when the channel was mobile and laterally active. Collapsed banks at the bottom of Eastern

Marshes Rivulet (Plate 4) reveal alternating layers of rich quaternary alluvial deposits (0.5-1 m thick) and cobble armouring which represent the alternating deposition of alluvial sediments by periglacial processes and erosional, high energy, glaciation events.

Plate 4: Collapsed bank at the bottom of eastern marshes Rivulet before it enters the Little Swanport River, showing the sediment layers of the associated floodplain.

Zone 4: confined zone

This zone is highly constrained by dolerite geology, and is characterised by a steep bedslope and surrounding terrain with no floodplains. It has a bedrock-controlled channel with boulder/bedrock "cascades" and gorges separating large, deep permanent pools. It incorporates the lower reaches of Eastern Marshes Rivulet, Green Tier Creek and Rocka Rivulet, Pepper Creek, and the Little Swanport River from Swanston to the outlet at the estuary (Figure 14).

Historically, the channel conducted larger volumes of water, which had greater energy and transported very large boulder sediments throughout this reach. The channel is comprised of boulder/cobble riffles that drop steeply over short distances, hence are referred to as cascades, and separate large permanent pools (Plate 5). These cascades are often exposed during the summer, although water can be heard flowing through the interstitial spaces created by these large bed sediments.

Plate 5: Examples of geomorphic Zone 5, the confined zone, on the Little Swanport River downstream of the Thallans Creek confluence.

Summary and conclusions

The geomorphology of the catchment reflects the geology and the hydrology of the catchment. The upper part of the catchment in low relief, rolling hills with dolerite, sandstone and mudstone soils, and intermittent rainfall, has combined to produce the upper lagoon and mobile geomorphic zones. This landscape has also proven amenable to agricultural development, therefore these areas have been cleared, and channels modified, through agricultural practices.

A flashy hydrology combined with a hard dolerite geology has led to a steep, constrained channel in the bottom half of the catchment. This landscape is relatively inaccessible with poor soils, and has not been modified for agriculture. This lower part of the catchment is in good geomorphic condition.

2.4 Riparian Vegetation

The riparian vegetation of the Little Swanport catchment is a function of the hydrology and geomorphology of the catchment, but also interacts to influence sediment transport and channel morphology. This section gives an overview of the riparian vegetation in the catchment according to geomorphic zones. This information has been obtained from surveys conducted as part of a project to develop a holistic environmental flow methodology funded under the National Action Plan for Salinity and Water Quality (Barker 2005, in Warfe 2005), and from research conducted by students from the University of Tasmania (Wintle 2002, Daley 2003).

Catchment overview

The vegetation of the catchment is characterised by dry sclerophyll vegetation. The predominant types include black (*Eucalyptus amygdalina*) and white peppermint (*E. pulchella*) forests and woodlands on dry dolerite soils, Black peppermint on sandstone, and silver peppermint (*E. tenuiramis*) on mudstone soils. White gum (*E. viminalis viminalis*) and blue gum (*E. globulus*) forests are present on the slopes of more fertile valleys that have not been cleared.

There are few non-forest vegetation types, and most are native grasslands derived from the clearing of trees. The upper catchment has been cleared for agriculture and now supports introduced pasture grasses and significant areas of gorse (*Ulex europaeus*). A map of the main vegetation types present in the catchment is presented in Figure 16.

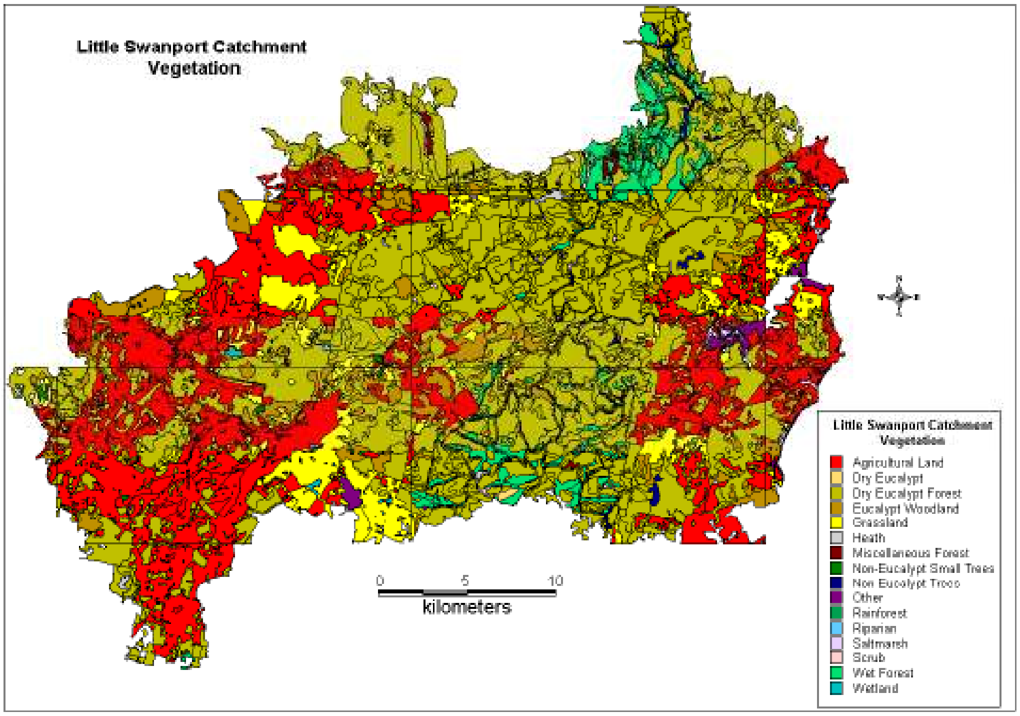

Figure 16: Map of the different vegetation types in the Little Swanport catchment.

Riparian vegetation in this catchment has not been mapped in detail, however, distinct riparian communities are a strong feature of the Little Swanport River, particularly in the lower half of the catchment and tributaries where vegetation remains. Wintle (2002) identified four assemblages of riparian species that were associated with "scour" by sediments disturbed during flood events. These assemblages supported different guilds of regenerating species, and were more diverse than other riparian assemblages, leading her to conclude that certain vegetation species, particularly herbs, rely on flood disturbance and the creation of colonisation gaps. As an example, some *Acacia* and *Hakea* species drop their seeds on the fine sediments deposited by receding flood waters, whereas the physical damage caused by flood waters and flood debris can trigger vegetative growth of woolly tea tree (*Leptospermum lanigerum*) and Oyster Bay pine (*Callitris rhomboidea*, M. Askey-Doran DPIW, *pers. comm.*).

There is considerable evidence that a variable flow regime results in a riparian vegetation community that is diverse in species richness and age (Bendix and Hupp 2000). As discussed earlier, the high flows and flood events of the flow regime are still intact and retain the capacity to regulate the extant riparian vegetation communities in the catchment. However, the low flow parts of the flow regime have been modified with current water use activities, and it is still unclear what effect this may have on riparian assemblages.

Riparian vegetation is important for trapping sediments, filtering nutrients from rainfall runoff, contributing woody debris and organic material to the river, and modulating water temperature. The riparian vegetation in the upper part of the catchment has been predominantly cleared for agriculture, and has either been replaced by introduced species, or there is no riparian vegetation at all. The clearance of riparian vegetation, combined with the modification of low flows, potentially provides more favourable conditions for introduced species and may explain their preponderance in these areas.

Geomorphic Zone 1

As described earlier in the geomorphic characterisation of the catchment, much of the terrestrial vegetation in this zone has been cleared for agriculture, particularly around the uppermost Little Swanport River and Eastern Marshes Rivulet. This has left a combination of pastoral grasses, native grasses such as *Themeda triandra* (kangaroo grass) and *Poa labillardieri* (silver tussock), introduced species such as *Ulex europaeus* (gorse), and small remnant patches of *E. globulus* (blue gum) and *E. viminalis viminalis* (white gum) in these areas (Appendix 1 - Table 1). The CFEV database describes the tree assemblage in this zone as being dry and wet sclerophyll forest and grassy woodlands of the lower midlands. This assemblage may also have some heathy understoreys on more siliceous substrates and species such as *E. tenuiramis* (silver peppermint), *Leptospermum scoparium* and *Pomaderris pilifera*.

There are permanent pools in this zone (for example, on Eastern Marshes Rivulet) which support the growth of aquatic vascular plants (macrophytes) including *Myriophyllum* spp. (water milfoil), *Juncus* spp., *Isolepis fluitans* (floating club-rush), *Eleocharis sphacelata* (tall spike-rush), *Schoenus apogon* (fluke bog-rush), *Villarsia reniformis*, and *Potamogeton tricarinatus* (floating pondweed), as well as algal species such as *Chara* sp. and *Nitella* sp.

Other areas in this zone, namely Green Tier Creek and Rocka Rivulet, are less disturbed and have more abundant an diverse riparian vegetation communities. The lagoon areas on Green Tier Creek are vegetated with native grasses including *Poa labillardieri*, *Austrodanthonia* spp. (wallaby grass), *Austrostipa* spp. (spear grass) and *Ehrharta stipoides* (weeping grass), graminoids including *Lepidosperma* spp., *Carex* spp. and *Lomandra longifolia*, and some patchy open *Eucalyptus viminalis viminalis*, *E. amygdalina* (black peppermint) and *E. ovata* (swamp gum) woodland (Williams and Potts 1996, Wintle 2002). Further upstream, the riparian vegetation includes *Pteridium esculentum* (bracken fern), and herbs such as *Dichondra repens* and *Acaena novae-zelandiae* (Wintle 2002). There is also a range of shrubs and trees including *Leptospermum lanigerum* (woolly tea-tree), *Acacia verticillata* (prickly mimosa) and *Bursaria spinosa* (prickly box). The upland chain-of-lagoons area on Rocka Rivulet also supports dense *Leptospermum lanigerum* stands which include *Acacia* species, *Banksia marginata* and *Callistemon pallidus* (bottle-brush), with a sclerophyll overstorey in which *Eucalyptus ovata*, *E. amygdalina*, *E. delegatensis* and *E. brookeriana* are also present (M. Askey-Doran DPIW, *pers. comm.*; (Williams and Potts 1996, Wintle 2002).

Geomorphic Zone 2

There has been relatively extensive clearing of vegetation for agriculture through this zone and the riparian vegetation is in relatively poor condition; some river reaches are unvegetated. The CFEV database describes the river reaches through this area as being characterised as lower midlands grasslands with some dry sclerophyll woodland and forest, mainly on Triassic sedimentary rocks in upland areas (Appendix 1 - Table 2). There are numerous introduced riparian species throughout this zone such as *Ulex europaeus*, *Crataegus monogyna* and *Rosa rubiginosa* (sweet briar), as well as remnant patches of native grasses including *Themeda triandra* and *Poa labillardieri*, herbs such as *Acaena novae-zelandiae* and *Geranium potentilloides*, and trees such as *Acacia melanoxylon* and *Bursaria spinosa* (Wintle 2002). The sclerophyll patches are predominantly characterised by *Eucalyptus pauciflora*, *E. delegatensis tasmaniensis* and *E. rodwayi*, the latter two of which are endemic (Williams and Potts 1996).

In this part of the catchment, the channel is often dry but there are some pools that persist over the summer and can support abundant macrophyte populations including *Myriophyllum* spp., *Isolepis fluitans*, *Eleocharis* spp., *Potamogeton* spp., *Juncus* spp., *Carex* spp. as well as the introduced *Typha australis* (cumbungi).

Geomorphic Zone 3

The riparian vegetation on the upstream section of this zone, at Charlie's Mount, has been modified in the past, and now comprises *Eucalyptus viminalis viminalis* open woodland with a native grass understorey of *Themeda triandra* and *Poa labillardieri* and abundant gorse. The downstream section from Pages Creek appears to have been cleared in the past, possibly at European settlement, but not developed any further, possibly because the valley sides are steeper and less accessible, thereby allowing the vegetation to regenerate (M. Askey-Doran DPIW, *pers. comm.*).

Consequently, the riparian vegetation here is more intact and consists of *E. viminalis viminalis* and *E. amygdalina* forest with an understorey including shrubs (e.g. *Acacia mearnsii*, *A. melanoxylon*, *Bursaria spinosa* and *Leptospermum lanigerum*), native grasses (e.g. *Poa labillardieri* and *Austrostipa* spp.), graminoids (e.g. *Juncus* spp., *Lepidosperma* spp. and *Carex* spp.), and herbs such as *Wahlenbergia* spp. and *Dichondra repens* (Wintle 2002) (Appendix 1 - Table 3). However, the presence of introduced species such as *Ulex europaeus* (gorse) through this zone is testament to previous land use disturbance. The CFEV database describes the tree assemblage characteristic of this zone as Derwent valley lowland dry sclerophyll, but lacking elements such as Oyster Bay pine and *Leptospermum grandiflorum*. This tree assemblage is found in the dry insolated aspects of the Derwent valley and lower midlands through to the Eastern Tiers.

The partially-confined geomorphic nature of this zone has created a series of cobble bars and riffles with some bedrock control, interspersed with large pools. Finer sediments are deposited in these pools and can support extensive macrophyte beds comprising *Myriophyllum* spp., *Eleocharis* spp., *Baumea* spp., *Isolepis fluitans* and *Carex* spp., amongst others. In some places, this sediment trapping has provided enough sediment for riparian plants such as *Leptospermum lanigerum* and *Acacia mucronata* to take hold during the drier periods and create midstream "islands".

Geomorphic Zone 4

The vegetation throughout this reach is in relatively good condition, contributing a good source of wood for instream physical diversity. The riparian vegetation community comprises many endemic and native species and very few weeds, although the uppermost part has some willow and gorse which have invaded from the upper, more modified reaches of the Little Swanport River (Appendix 1 - Table 4). The high species diversity of the riparian vegetation community in this zone is influenced by flood disturbance history, and thus the high hydrological variability of the catchment (Wintle 2002).

The overstorey consists of predominantly *E. amygdalina* and *E. viminalis viminalis* forest, although *E. pulchella* is also present and the upper slopes include *E. brookeriana* and *E. dalyrmpleana* (Williams and Potts 1996). The characteristic tree assemblage of this region is described by the CFEV database as being east coast lowland dry sclerophyll with Oyster Bay pine (*Callitris rhomboidea*), occurring on the coastal flanks of the Eastern Tiers south of Bicheno. There is a wide variety of trees and shrubs, including *Banksia marginata*, *Micrantheum hexandrum*, *Notolaea ligustrina* (native olive) and *Leptospermum lanigerum* (Wintle 2002), and the understorey includes grasses (e.g. *Poa labillardieri* and *Ehrhata stipoides*), graminoids (e.g. *Carex* spp. and *Lomandra longifolia*) and herbs (e.g. *Oxalis prerennans* and *Acaena novae-zelandiae*). There are also ferns (e.g. *Hymenophyllumci* spp., *Blechnum wattsii* and *Pteridium esculentum*), a climber (*Clematis aristata*) and orchids (*Pterostylis* spp.) present in this zone (Wintle 2002).

Some of the runs and pools in this zone support small populations of aquatic macrophytes such as *Myriophyllum pedunculatum* and *Triglochin procera*, particularly in the depositional areas or between cobbles and boulders where finer sediments collect, and can support high algal biomass during the warmer months.

Summary and conclusions

The riparian vegetation within the catchment is strongly related to soil type and land use, and agricultural activities have contributed to riparian vegetation communities being in poorer condition in the upper part of the catchment. In the lower catchment, it appears flood disturbance has helped to maintain the successional status and composition of riparian vegetation communities, and that the diversity of these communities is related to the high hydrological variability of the flow regime.

Across the catchment, dry sclerophyll woodland is generally the dominant tree assemblage, with an mid-storey of native shrubs, herbs and grasses, although there are a significant number of introduced species present particularly in the upper catchment. Pools that retain water all year round often support diverse and abundant aquatic vegetation.