4. Water Quality Assessment

Monitoring of water quality in the Little Swanport catchment was undertaken at 25 sites. Chapter 1 provides a detailed outline of site locations, the water quality parameters that were assessed and the methodology for sample collection and data analysis. This chapter reports on these data.

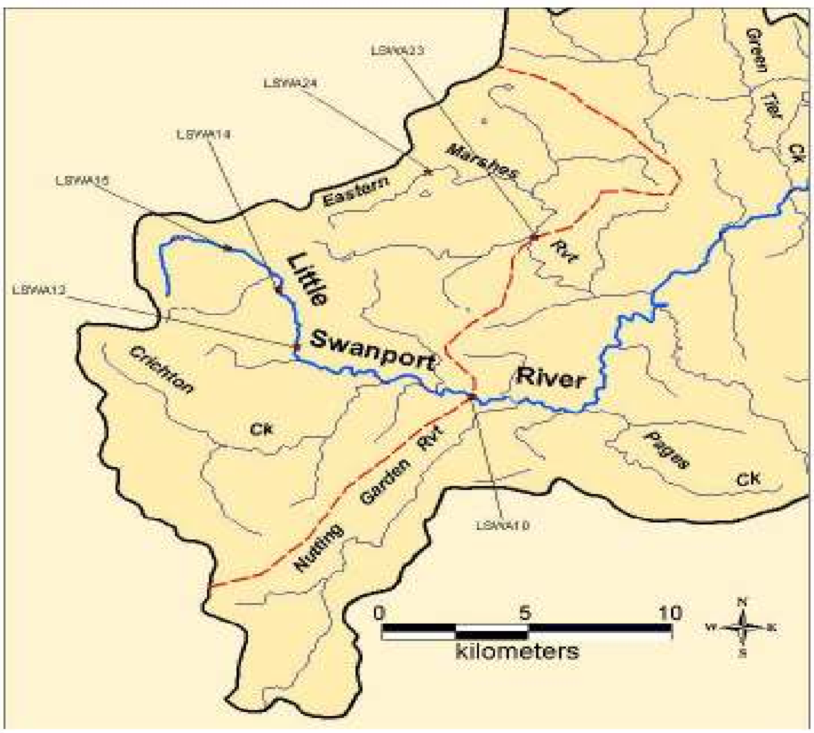
To allow the data to be displayed and discussed in a spatially relevant manner, and one that is consistent with the catchment characterisations that have been outlined in Chapter 2, the results of water quality monitoring are presented in three sections: upper catchment, middle catchment and lower catchment. These broadly align with the geomorphic zones 1&2, 3&4 and 4 respectively, as outlined in section 3 of Chapter 2. While maintaining this structure is useful for reporting purposes, it must be recognised that land-use and water management is also a major factor that influences water quality and has a degree of independence from the characterisations discussed in Chapter 2.

4.1 Water quality of the upper catchment

General trends in monthly water quality data for the upper catchment are presented below. Data for turbidity, electrical conductivity and dissolved oxygen are presented as box plots, while temperature and in-stream pH data is shown in tables of summary statistics. In addition graphs of monthly data and modelled flow for the lower site in the upper catchment, Little Swanport River at Swanston Rd (LSWA10), are shown to illustrate water quality at the exit point of the upper catchment. Continuous water quality data for turbidity, temperature, conductivity, dissolved oxygen and pH, from a multi-probe installation at LSWA10, is presented with modelled flow data in section 4.1.3.

4.1.1 Site Descriptions

Water quality monitoring within the upper catchment includes site on Crichton Creek, upper Eastern Marshes Rivulet and the Little Swanport River above the Swanston Road (Figure 21). Both Crichton Creek and the upper Little Swanport River fall within geomorphic Zone 2 (mobile zone) which is dominated by a sandstone/mudstone geology. The upper catchment of Eastern Marshes (upstream of and including Eastern Marshes at Manning Road ford - LSWA23) falls within geomorphic Zone 1 (uplands chain-of-lagoons), and consists of flat headwater plains with a dolerite geology. Upstream of Crichton Creek, the Little Swanport River courses through a short section near Charlies Mount defined as geomorphic Zone 3 (partly confined) and is controlled by a dolerite geology. With the exception of the section at Charlies Mount, where the riparian and surrounding vegetation is largely intact, upper catchment riparian and surrounding vegetation has been extensively cleared for grazing and the Little Swanport River and its tributaries are subject to stock intrusion. The upper catchment is strongly ephemeral in nature, has a low gradient and is characterised by fine riverbed sediments.



LSWA10 – Little Swanport River at Swanston Rd
LSWA12 – Little Swanport River at lower Inglewood Rd
LSWA14 – Little Swanport River at upper Inglewood Rd
LSWA15 – Little Swanport River above 'Longacres'
LSWA23 – Eastern Marshes Rivulet at Manning Rd
LSWA24 – Eastern Marshes Rivulet at Lemont Rd
LSWA32 – Crichton Creek at Inglewood Rd

Figure 21: Location of water quality monitoring sites in the upper catchment of the Little Swanport River system.

Crichton Creek

Crichton Creek is an ephemeral tributary, which joins the Little Swanport River below the partly confined section at Charlies Mount and above Swanston Road (LSWA10). One site on Crichton Creek (Crichton Creek at Inglewood Road - LSWA32) was included in this study (Plate 6). This site is immediately upstream of the confluence of Crichton Creek and the Little Swanport River. At various times throughout the study Crichton Creek ceased to flow. Riparian vegetation has been extensively cleared from Crichton Creek along its length and it is also subject to stock access.

Plate 6: Crichton Creek at Inglewood Road (LSWA32), at high flow and dry.

Eastern Marshes Rivulet

Two sites on Eastern Marshes Rivulet have been included in the upper catchment; Eastern Marshes at Manning Road Ford (LSWA23) and Eastern Marshes at Lemont Road (LSWA24). Below LSWA23, Eastern Marshes Rivulet flows through a shallow valley of native grasses before entering a narrow gorge and joining the Little Swanport River. Almost all land use impacts on this stream occur above this site. This part of the catchment has been almost entirely cleared, with little or no riparian or surrounding vegetation and unimpeded stock access to the stream (Plate 7). The associated lagoon complex has also been cut and drained.

Cullens Creek, draining a catchment largely dominated by native grasses and remanent vegetation, enters immediately above LSWA23. Logging roads were constructed over both Eastern Marshes Rivulet and Cullens Creek (see Plate 8) during winter 2004. As subsequent sampling at this site was conducted at low flow, the effect of this construction is not apparent in the water quality data, however it is likely to have an impact during periods of high rainfall due to soil disturbance and road drainage. LSWA24 is in the upper reaches of Eastern Marshes Rivulet. The stream at this point has been channelised and throughout the study generally had very low flow or was pooled. The stream flows through pasture, has no riparian vegetation and is open to stock. Marshes upstream of this site have been drained.

Plate 7: Eastern Marshes Rivulet at Lemont Road (LSWA24), dry and in high flow

Plate 8: Eastern Marshes Rivulet at Manning Road Ford (LSWA23) at low and high flow, the logging road was constructed during winter 2004.

Little Swanport River

Four sites were monitored on the upper reaches of the Little Swanport River; Little Swanport above 'Longacres' (LSWA15), Little Swanport at 1st Inglewood Road Bridge (LSWA14), Little Swanport at second Inglewood Road bridge (LSWA12) and Little Swanport at Swanston Road (LSWA10). The uppermost site, LSWA15, is below Ashgrove Lagoon, a dam on the main channel, and the river at this site flowed infrequently. Downstream sites, LSWA14 and LSWA12, also experience periods of no flow, although on a less frequent basis. At LSWA10, flow was more consistent although some periods of no flow were observed. The river at this site consists of a series of pools, which appear to be spring fed. Throughout this section the river is subject to stock access and has little or no natural riparian vegetation. Land use is predominantly grazing with some minor cropping, remanent vegetation remains on areas of higher relief and within the partly confined section of the Little Swanport River near Charlies Mount.

Plate 9: Little Swanport River above 'Longacres' (LSWA15), upstream view (left) and downstream.

Plate 10: Little Swanport River at upper Inglewood Road bridge (LSWA14), dry and in high flow.

Plate 11: Little Swanport River at lower Inglewood Road (LSWA12), in low and high flow.

Plate 12: Little Swanport River at Swanston Road (LSWA10) in low and high flow.

4.1.2 Monthly Sampling

Turbidity

Turbidity in flowing water is an indicator of the amount of suspended material being transported by the river at the time of sampling. The suspended material consists of both organic (plant material, algae) and/or inorganic (clay, silt etc) materials.

Results from monthly turbidity sampling for the upper catchment (Figure 22) show that median turbidity values at all sites are low (below 5 NTU), with the exception of Eastern Marshes at Lemont Rd (LSWA24), which had a median turbidity of 5.69 NTU. The ANZECC guideline for the turbidity of drinking water is 5 NTU. These values reflect the fact that throughout the survey these sites were generally observed to have low flow or were ponding. Under these conditions there is very little input of suspended material from stream banks and in very low flows material drops out of suspension. Higher turbidity levels were observed occasionally at low flow or at ponded sites, and these can be linked to either summer algal production or re-suspension through disturbance. All of the sites in the upper catchment are open to stock.

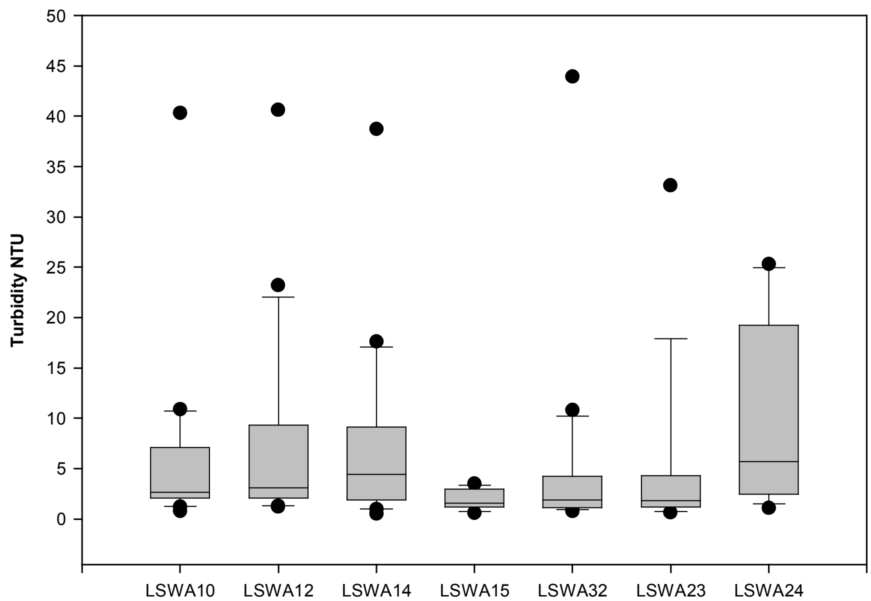


Figure 22: Statistics of monthly turbidity data for the upper catchment of the Little Swanport River.

During periods of higher flow, turbidity levels rise dramatically as sediment from stream banks and overland runoff enters the stream. Maximum turbidity levels at all sites, with the exception of Eastern Marshes at Lemont Rd. (LSWA24), were recorded during a high flow event in August 2003. Turbidity at all sites exceeded 30 NTU, with Crichton Creek and the lower 2 sites on the Little Swanport River (LSWA10 and LSWA12) exceeding 40 NTU. The elevated turbidity levels in the upper catchment at high flow are indicative of a highly disturbed system. Much of the riparian vegetation in the upper catchment has been removed and can no longer stabilise riverbanks or act as a trap for sediment carried by overland runoff. The absence of riparian vegetation increases the susceptibility of stream banks to erosion, particularly in high flow. There is a high level of disturbance from stock throughout the catchment. Stock access results in erosion of stream banks, in addition to disturbance of stream substrate. The low turbidity levels recorded at Little Swanport above 'Longacres' (LSWA15) is probably due to the dam at Ashgrove Lagoon acting as a sediment sink and reducing the transport from the catchment above except in very high flow.

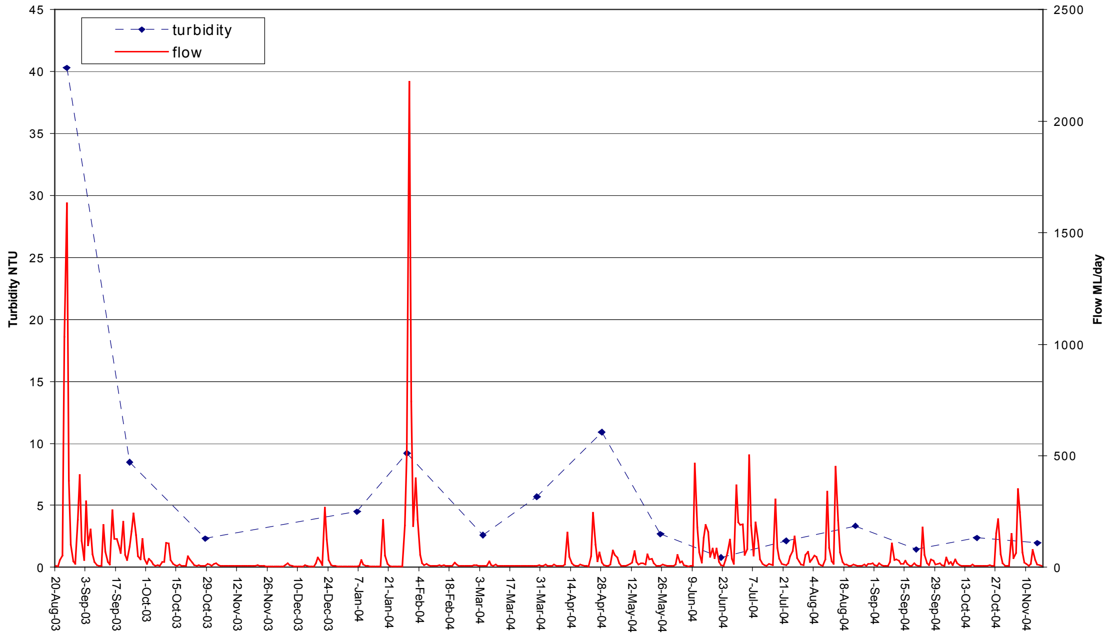


Figure 23: Monthly turbidity results and modelled flow at Little Swanport River at Swanston Rd (LSWA10).

Electrical Conductivity

Electrical conductivity in upland streams is closely related to catchment geology, and the influence of groundwater. In some specific catchments with a naturally high geological salt content, or where salt content is strongly influenced by marine aerosols, surface water conductivity can naturally be quite high. The Little Swanport catchment would appear to have a naturally elevated salt content, however salt levels are also likely to be strongly influenced by land use.

In the upper catchment median conductivity values exceed 1400 µS/cm at all sites (Figure 24). In most catchments, riverine conductivity generally increases in a downstream direction, however, studies from the Murray-Darling Basin (Murray -Darling Basin Ministerial Council 1999) have found higher conductivity in tributaries. Within both the Little Swanport River and Eastern Marshes Rivulet, conductivity increases towards the top of the catchment. This trend was also observed for the upper tributaries of the both the Coal and Jordan catchments (DPIWE 2003a and 2004b). Conductivity in the upper catchment would appear to be strongly related to groundwater where surface flow is increasingly ephemeral in nature. The increasing proportion of Triassic marine sediments in the upper catchment may also explain the upward trend in conductivity values. While there may be naturally elevated salt levels in the upper catchment, the extensive land clearing in this part of the catchment is likely to have increased groundwater salt inputs. Conductivity at all sites was highest during periods of low flow due to the increasing influence of these saline groundwaters and was significantly lower during periods following rainfall, which increased surface runoff and dilution (Figure 25).

Studies have suggested that if conductivity in surface waters exceeds 1500 µS/cm, direct adverse biological effects are likely to occur in a river, stream and wetland ecosystems, with many aquatic macrophytes and invertebrate fauna effected by salt at these concentrations (Murray-Darling Basin Commission, 1999). Salinity of more than 700 µS/cm is unsuitable for horticultural application, while levels above 800 µS/cm can negatively impact on tree crops (Murray-Darling Basin Ministerial Council 1987).

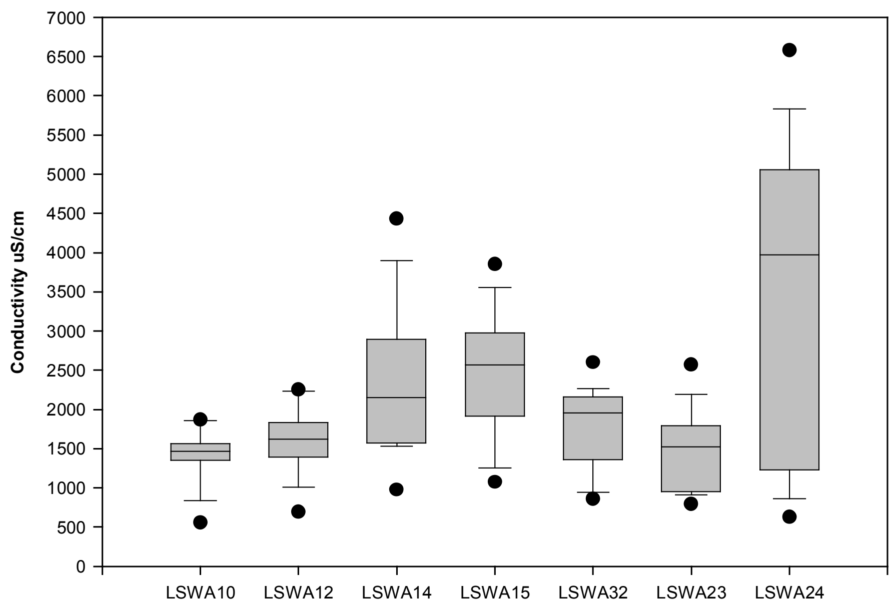


Figure 24: Statistics of monthly conductivity data for the upper catchment of the Little Swanport River.

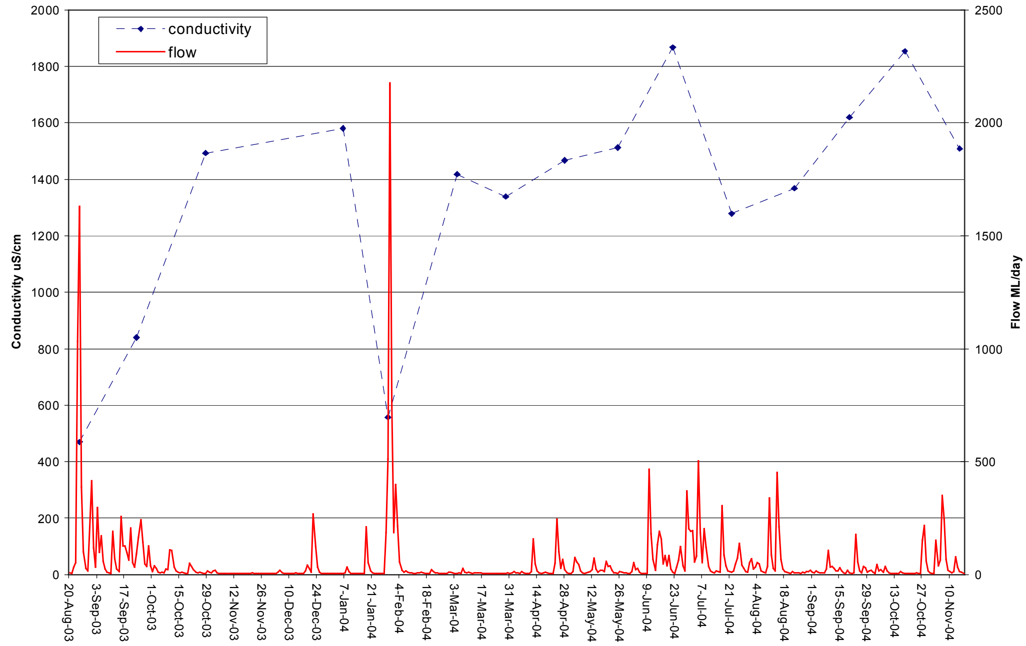


Figure 25: Monthly conductivity results and modelled flow at Little Swanport River at Swanston Rd (LSWA10).

Dissolved Oxygen

Dissolved oxygen (DO) is a useful indicator of the health of aquatic systems. In waters that are not influenced by anthropogenic activities there is a relationship between respiration, photosynthesis and diffusion, which results in regular, hourly changes in DO concentrations. As a result, the levels of dissolved oxygen recorded during routine monthly monitoring are generally not representative of the range of oxygen that can occur at a site, but rather provide only an indication of dissolved oxygen levels that occur during daylight hours. Unnatural organic enrichment of waterways often creates an imbalance to the system and can result in extremes in DO generation. Low oxygen concentrations can often be the first sign of stress or degradation and should be prevented where possible (ANZECC, 2000). Respiration at night often results in a lowering of DO as a result of the consumption of oxygen by biochemical processes. Low DO has an adverse effect on many aquatic organisms that depend upon oxygen in water for efficient functioning. Furthermore, existing problems may be exacerbated if surface layers of sediments become anoxic, resulting in reducing conditions in sediments and the release of previously bound nutrients and toxicants (ANZECC, 2000). However, care needs to be taken when using DO as an indicator of water quality as concentrations can fluctuate widely over a 24-hour period. During monitoring in the Little Swanport catchment, readings were generally taken at the same time of day for a given site, however there is some variation at all sites.

ANZECC (2000) recommends guidelines for dissolved oxygen in slightly disturbed streams in the south east of Australia. It suggests a lower limit of 90% and an upper limit of 110% saturation. Even in highly modified ecosystems, it suggests that DO should not be permitted to fall below 60% saturation, determined over at least one diurnal cycle (ANZECC, 2000).

Dissolved oxygen data measured on a monthly basis using hand held instruments is displayed in Figure 26. Results show that for most sites in the upper catchment, median levels of dissolved oxygen fall within the 90-110% range. The results also show that all sites in the upper catchment are susceptible to large variations in levels of dissolved oxygen. In particular, the lower three sites on the Little Swanport River and sites on Eastern Marshes Rivulet showed these large variations. The largest variations were recorded at LSWA14 where very high values were recorded as well as almost total depletion. In general, the results for dissolved oxygen are a reflection of the ephemeral nature of the upper catchment where ponded water is susceptible to stagnation. However organic enrichment may also be a factor, particularly at LSWA14, which was most severely degraded by stock trampling.

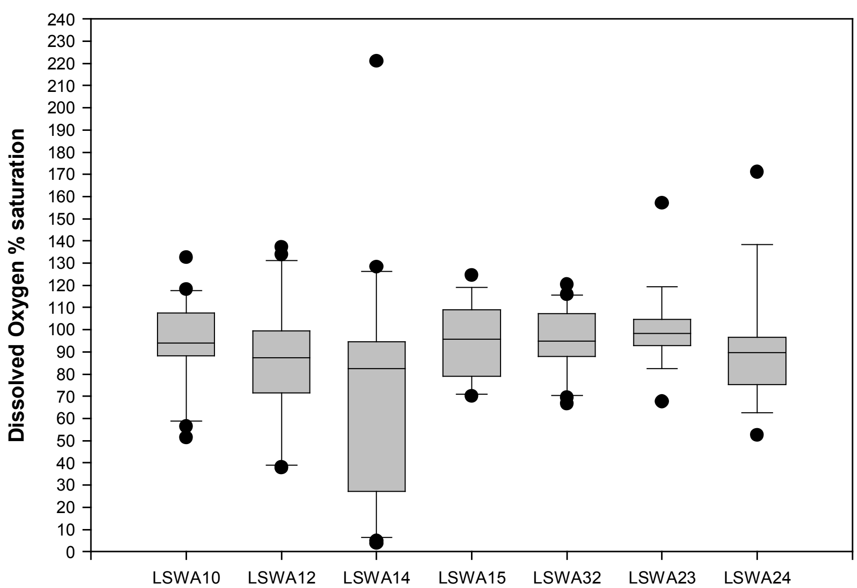


Figure 26: Statistics of monthly dissolved oxygen data for the upper catchment of the Little Swanport River.

Temperature

The functioning of aquatic ecosystems is closely regulated by temperature. For example, breeding and migration of many aquatic organisms are cued by changes in water temperature (Boulton and Brock, 1999). Like dissolved oxygen, temperature changes occur naturally both diurnally and seasonally and in response to changes in flow. Water temperature is strongly correlated to air temperature, particularly in headwater streams and at median and below median flows (Webb et. al., 2003). Within the upper catchment, the major impact on natural temperature conditions is the clearing of riparian vegetation. Riparian vegetation moderates in-stream water temperature fluctuations by providing shade and cover, thereby absorbing radiation, an effect particularly noticeable on cloudless summer days (Rutherford et. al., 2004). Riparian vegetation may also moderate daily minimum temperatures by insulating the stream and offsetting overnight radiation loss from the stream (Rutherford et. al., 1997)

As temperature was recorded at different times at different sites, it is problematic to make comparisons between sites. High maximum temperatures were recorded at the three lower sites on the Little Swanport River (Table 12), indicating that high temperatures may have an impact through the upper reaches of the Little Swanport River. The impact of riparian vegetation on temperature can be seen in the higher median temperature at Little Swanport River upper Inglewood Road (LSWA14) compared to Little Swanport River lower Inglewood Road (LSWA12). There is no riparian vegetation at LSWA14, while there is some sparse riparian vegetation at LSWA12. These two sites were consistently sampled within 30 minutes of each other. It should be noted that Little Swanport River above 'Longacres' (LSWA15) and Eastern Marshes at Lemont Road (LSWA24) were sampled less often due to a lack of water.

Table 12: Summary statistics for monthly temperature data in the upper catchment of the Little Swanport River

	Little Swanport River at Swanston Road (LSWA10)	Little Swanport River at lower Inglewood Road (LSWA12)	Little Swanport River at upper Inglewood Road (LSWA14)	Little Swanport River above 'Longacres' (LSWA15)	Crichton Creek at Inglewood Road (LSWA32)	Eastern Marshes Rivulet at Manning Road (LSWA23)	Eastern Marshes Rivulet at Lemont Road (LSWA24)
Median	10.6	10.7	12.75	9.9	16.0	12.1	14.7
Maximum	26.0	25.6	24.9	14.8	21.6	18.6	20.7
Minimum	4.4	3.7	4.2	3.4	5.8	5.9	4.2
Samples	16	16	16	11	15	11	15

In-stream pH

In-stream pH values are strongly influenced by a variety of factors relating to catchment geology, soil chemistry, vegetation and land use practices. The degree to which these factors affect pH and its buffering capacity against changing environmental conditions are inter-related with levels of acidity and alkalinity (UNESCO, 1992). Waters of low alkalinity (<24m/L as $CaCO_3$) have a lower buffering capacity and are therefore more susceptible to fluctuations in pH. Biological and atmospheric processes can influence pH levels and how they fluctuate (UNESCO, 1992). Thus, pH levels can vary both seasonally and diurnally depending upon environmental conditions. Changes in pH can be important, as they affect the concentration and toxicity of some chemical substances (eg. ammonia, heavy metals) and the ionic and osmotic balance of aquatic organisms.

The results from monthly sampling for in-stream pH in the upper catchment show that there is very little variation of median, maximum and minimum values between sites. Waters in the upper catchment are generally alkaline with median values between 7.5 and 8.0. The greatest variation in pH was recorded at Little Swanport River at upper Inglewood Road (LSWA14), a highly modified site. The maximum value at this site of 10.16 was associated with supersaturation of dissolved oxygen. Environmental pH is closely controlled by the balance of carbon dioxide, carbonate and bicarbonate ions (UNESCO, 1992), and these are often influenced by primary production in rivers and reflect the closely the changes in dissolved oxygen. Variability of pH at LSWA14 is likely to be a reflection of variable dissolved oxygen. Minimum values recorded at all sites, except Little Swanport River above 'Longacres' (LSWA15) and Eastern Marshes at Lemont Road (LSWA24), which was not sampled, were recorded during the high flow event in August 2003. During this event waters throughout the upper catchment became more neutral or acidic. Summary statistics of monthly in-steam pH for the upper catchment are given in Table 13.

Table 13: Summary statistics for monthly in-stream pH data in the upper catchment of the Little Swanport River

	Little Swanport River at Swanston Road (LSWA10)	Little Swanport River at lower Inglewood Road (LSWA12)	Little Swanport River at upper Inglewood Road (LSWA14)	Little Swanport River above 'Longacres' (LSWA15)	Crichton Creek at Inglewood Road (LSWA32)	Eastern Marshes Rivulet at Manning Road (LSWA23)	Eastern Marshes Rivulet at Lemont Road (LSWA24)
Median	7.84	7.86	7.62	7.98	7.93	7.63	7.96
Maximum	8.38	8.32	10.16	8.2	8.26	8.78	8.38
Minimum	7.12	7.27	6.55	7.71	7.02	7.18	6.28
Samples	16	16	16	11	15	11	16

4.1.3 Nutrients

Excess nutrients in surface waters can impact on ecosystems directly and indirectly. One of the most common problems is the stimulation of growth of algae (including potentially toxic blue-green algae) and nuisance plants that can dominate and change the structure of an aquatic ecosystem. The most bioavailable forms of nitrogen and phosphorus are ammonia (NH_3^+), nitrate (NO_3^-) and dissolved reactive phosphorus (ANZECC, 2000). The concentrations of nutrients in water draining agricultural areas can be quite variable and may be heavily impacted by specific activities (eg. fertiliser applications, pasture drainage, stock access, etc) or site condition (eg. river-bank erosion, silt deposition, etc).

Three sites in the upper catchment were sampled for nutrients on a monthly basis, Little Swanport River at Swanston Road (LSWA10), Little Swanport River upper Inglewood Road (LSWA14) and Crichton Creek at Inglewood Road (LSWA32).

Total Nitrogen

Total nitrogen in environmental waters is the sum of organic nitrogen, nitrate nitrogen (NO_3/N) and nitrite nitrogen (NO_2/N), although NO_2/N is normally detected at only very low concentrations unless there is some local form of effluent entering the waterway. Nitrogen in natural environments is generally derived from the atmosphere and incorporated into organic forms through the process of nitrogen fixation by plants. From then on there is a multitude of complex pathways by which nitrogen is converted to ammonia, nitrate and other forms of nitrogen (Nitrogen Cycle). Nitrogen in waterways is also influenced by human activities such as intensive animal husbandry, sewage effluent treatment discharges and agricultural fertiliser application. All these activities have the potential to increase substantially the concentrations of nitrogen species in rivers and streams. Total nitrogen concentrations can vary from as low as 100-200 µg/L in pristine streams, to in excess of 10,000 µg/L in heavily polluted rivers (ANZECC, 2000). The ANZECC total nitrogen guideline for the protection of aquatic ecosystems in Tasmanian rivers is 0.48 mg/L (480 µg/L). Concentrations in excess of this value indicate a potential risk to the aquatic environment.

Data for monthly total nitrogen is presented in Figure 27 and Figure 28. The maximum value at LSWA14 of 3.49 mg/L has been removed for graphic purposes. Median total nitrogen concentrations at all sites exceeded the 0.48 mg/L level recommended by ANZECC (2000). The two highest values from Little Swanport River at Swanston Road (2.49 mg/L and 1.19 mg/L) were recorded during a high flow event and after rain. The two highest values recorded at Little

Swanport River upper Inglewood Road (3.49 mg/L and 2.44 mg/L) and the maximum value from Crichton Creek (2.8 mg/L) were recorded during periods of low to very low flow indicating the susceptibility of these sites to organic pollution, most likely from stock access. Total nitrogen concentrations in the upper catchment are a reflection of site specific impacts at low flow, particularly from stock, where concentrations may be very high, and diffuse inputs during rain/flow events resulting in elevated levels throughout the catchment. The latter process is particularly relevant to Little Swanport River at Swanston Road, where elevated levels of total nitrogen were associated with periods of high flow.

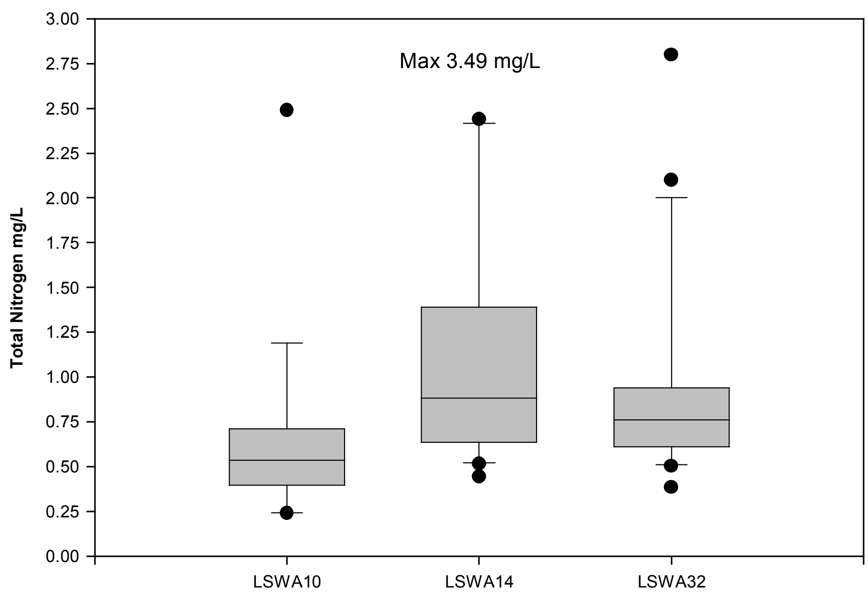


Figure 27: Statistics of monthly total nitrogen data for the upper catchment of the Little Swanport River.

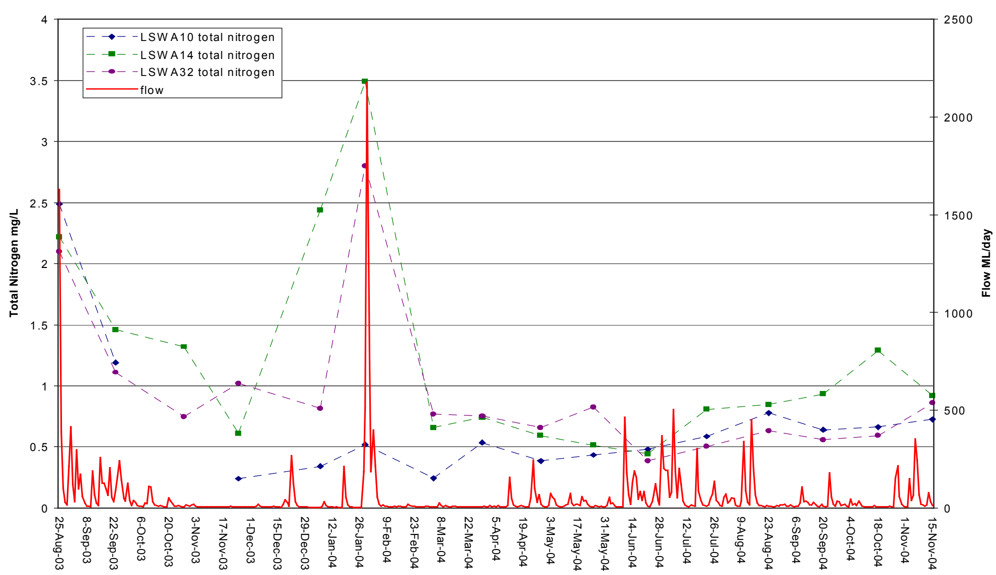


Figure 28: Upper catchment monthly total nitrogen with modelled flow at Little Swanport River at Swanston Rd.

Nitrate and Nitrite

Nitrate Nitrogen (NO_3/N) is a soluble form of nitrogen and passes easily from soils into groundwater where it can influence surface water concentrations during baseflow conditions. Natural sources of NO_3/N originate from geological processes and the breakdown of plant and animal material and in rural environments from the use of inorganic fertilisers and increased levels of animal and plant wastes (UNESCO, 1992). Land clearing for pasture and cropping can increase soil aeration and enhance the action of nitrifying bacteria, further increasing soil NO_3/N concentrations. Nitrate often varies on a seasonal basis, with higher concentrations generally occurring in winter, when NO_3/N is leached from the soil profile by pore-water movement (Kladivko, *et al.,* 1991) and lower plant uptake (Wright, *et al.*, 1991).

Nitrate concentrations, and the proportion of total nitrogen occurring as nitrate, are usually higher in industrial, urban and agriculturally developed areas (Harris, 2001). Nitrate concentration often shows a complex pattern of behaviour with changing flows in rivers. As streamflow increases following rainfall, the influence from point sources decrease as they become diluted, however diffuse sources of NO_3/N from agricultural land may result in temporarily higher concentrations. During the low flows of summer, in-stream processes often decrease NO_3/N concentrations by denitrification (Neale, 2001).

ANZECC (2000) recommends that oxides of nitrogen should not exceed 0.190 mg/L for upland streams in south eastern Australia. Results from monthly sampling in the upper catchment are presented in Figure 29 (the maximum value of 1.84 mg/L from Crichton Creek has been removed for graphical purposes). Median values at all sites was well below the ANZECC guideline, however all sites appear to be susceptible to periodic episodes of very high levels of nitrate, well in excess of this guideline. While all sites showed elevated levels during the high flow event sampled in August 2003, highest concentrations were found sites at both Little Swanport River at upper Inglewood Road and Crichton Creek during periods of low flow when trace rainfall had occurred preceding sampling. It would seem likely that nitrate concentrations are driven by the same mechanisms described for the Coal and Jordan River catchments (DPIWE 2003a and 2003b). Increased nitrate concentrations, through infiltration and groundwater inputs, are evident immediately preceding a flow event, followed by a subsequent decline in concentration, as nitrate is flushed through the soil profile and is diluted by increased flow.

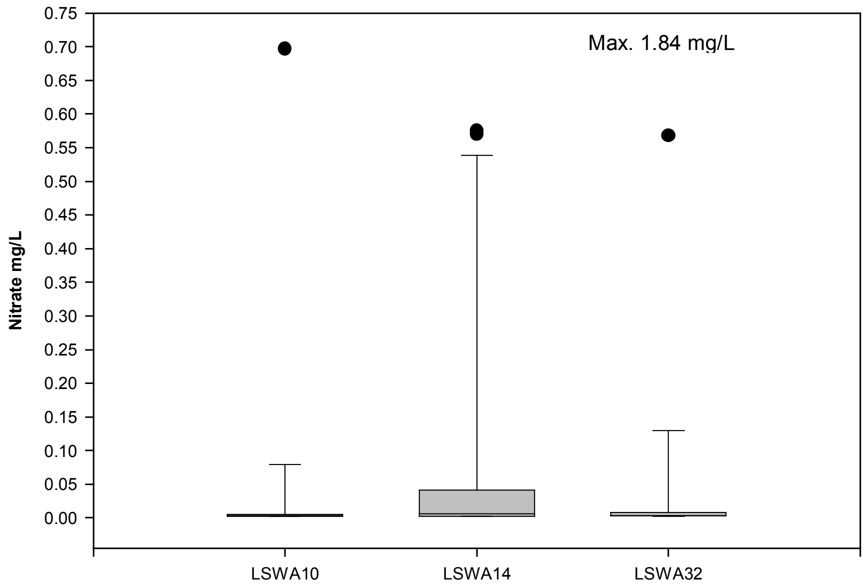


Figure 29: Statistics of monthly nitrate data for the upper catchment of the Little Swanport River.

Ammonia

Ammonia (NH_3/N) naturally occurs in surface water as a result of the breakdown of organic and inorganic materials and excretion from biota. High concentrations NH_3/N can be an indicator of organic pollution. The toxicity of ammonia to aquatic life increases with decreases in dissolved oxygen concentrations and pH (UNESCO, 1992). ANZECC (2000) recommends that at a pH of 8 NH_3/N concentrations should not exceed 0.9 mg/L in order to protect ecosystems that are 'moderately disturbed'.

All monthly concentrations of ammonia recorded for the upper catchment were well below the ANZECC guideline. Median values at all three sites were below 0.01 mg/L, and a maximum value of 0.297 mg/L was recorded at Little Swanport River upper Inglewood Road.

Total Phosphorous and Dissolved Reactive Phosphorous

Phosphorus is one of the nutrients essential for growth of aquatic plants and animals, and is often the underlying factor driving ecosystem productivity. However, in surface waters phosphorus is normally present at very low concentrations and is usually the nutrient that limits the growth of algae. When it is present in excess, it can trigger algal blooms, a feature of eutrophication. Although algae and aquatic plants generally require phosphorus in its dissolved form, once present in a waterway it can change between dissolved and particulate forms depending on environmental conditions and biochemical processes (UNESCO, 1992).

Both diffuse sources (fertiliser use and stock grazing) and point sources (sewerage effluent discharge and urban runoff) can cause increased inputs of phosphorous to rivers, lakes and streams. Phosphorous is normally present attached to organic and inorganic particulate material and can often be related to turbidity levels. Total phosphorous (TP) concentrations can vary from less than 0.001 mg/L in small near-pristine mountain streams to over 1 mg/L in heavily polluted rivers (ANZECC, 2000). It is recommended that 0.013 mg/L be used as the default trigger value for TP concentrations in Tasmanian rivers and streams.

Monthly results for TP are presented in Figure 30. Median values for Little Swanport River at Swanston Road (0.01 mg/L) and Crichton Creek at Inglewood Road (0.01mg/L) were both below the ANZECC guideline, with the median value for Little Swanport at upper Inglewood Road (0.02 mg/L) above the guideline value. The maximum values for LSWA10 (0.11 mg/L) and LSWA32 (0.09 mg/L) both occurred during the high flow event of August 2003. The very high maximum value for Little Swanport River at upper Inglewood Road (0.78 mg/L) occurred at low flow after rainfall when elevated levels of total and dissolved nitrogen were also recorded. This is likely to be a reflection of site specific factors at this location, which is severely degraded and had higher and more variable TP concentrations throughout the survey.

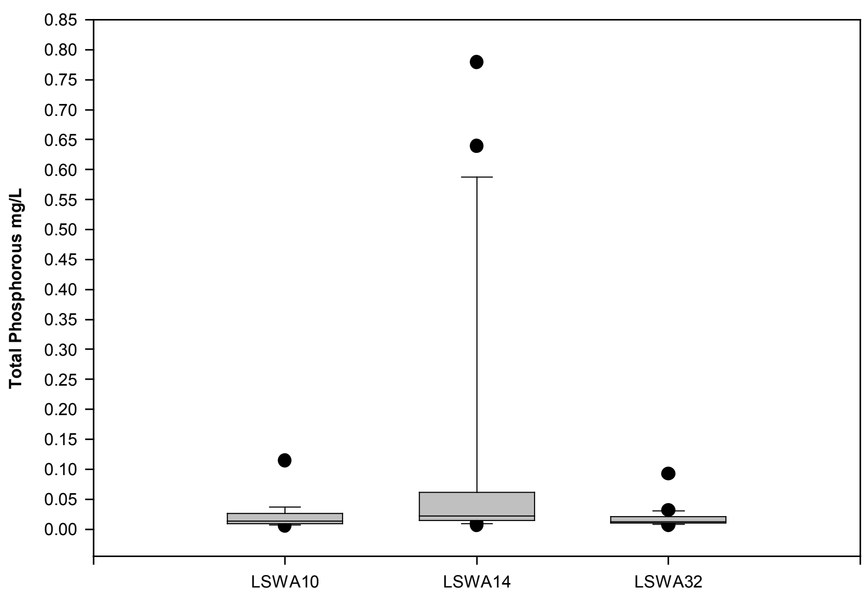


Figure 30: Statistics of monthly total phosphorous data for the upper catchment of the Little Swanport River.

4.1.4 Continuous Water Quality

A multi-probe was installed at LSWA10 on the Little Swanport River at Swanston Road from 28 April 2004 to 18 November 2004. Water temperature, electrical conductivity, turbidity, pH and dissolved oxygen were recorded at half hourly intervals. Data has been quality coded and edited using monthly spot samples. Data classified as poor quality (>20% error in comparison to spot sample) has been removed. At this site a flow of 700 ML/day can be expected once every 6 months, a flow of 1000 ML/day annually. The maximum modelled flow (see below) to occur during the study was 502 ML/day.

Parameter values used in the interpretation of continuous water quality data are used as a general guide only and are not intended to be used as absolute indicators of the ecological impacts of water quality at a given site. Continuous water quality data presented in this report is also short term in nature, it cannot be used to determine seasonal trends, and is used only to provide some indication of some general water quality characteristics at each site.

Modelled flow is also presented in this section. It is included as an aid to the interpretation and presentation of the continuous water quality data and to provide some context as to the magnitude of a given flow associated with changes in water quality. The flow data is derived from a rainfall/runoff model that was developed to aid with water management planning for the catchment (SKM, 2004). This model is based on long term rainfall data and is more accurate in modelling a long term flow record rather than the short term records presented here. In addition, the model provides flow for the lower gauging station, flow for upstream sites is extrapolated using the proportion of catchment area above a given site. There may be some deviation between the modelled flow and the actual flow at the scale presented, as rainfall across the catchment is often variable. Rainfall that produces a given flow at the lower gauging station may not fall evenly across the catchment and therefore flow at upstream sites may not always be proportional to catchment area. There is good agreement, however, between the modelled flow hydrographs and the level hydrograph at the upper gauging station.

Turbidity

Turbidity at this site over the period of record was generally low (Figure 31), with a median turbidity of 1.5 NTU. Turbidity was below 5 NTU for 84% of the period of record. It is apparent, however, that peaks in flow through the upper Little Swanport River can produce high turbidity, with maximum turbidity of 79.4 NTU recorded during a period of elevated flow in August. A subsequent flow event of greater magnitude immediately following this produced a maximum turbidity of 33 NTU, indicating the importance of preceding flow/runoff conditions in determining the amount of sediment transported by any given event.

Electrical Conductivity

While current understanding of the impacts of salinity on freshwater biota is limited, there is a general acceptance that freshwater ecosystems experience little ecological stress when conductivity is below 1500 µS/cm (Horrigan et.al., 2005, Nielson et. al., 2003, Hart et.al., 1991). However sub-lethal effects on a range of biota may occur below this level, leading to long term changes in biological composition (Nielson et. al., 2003, Hart et. al., 1990). For example, changes in invertebrate community composition can be expected to occur above 800 µS/cm in some systems (Horrigan et. al., 2005). The impact of conductivity on aquatic flora and fauna is also likely to have a greater impact on early life stages (James et. al., 2003), and this has not been extensively studied. It has been recommended that water with conductivity in excess of 800 µS/cm should not be used for crop irrigation (Hamlet A.G., 2002).

Confirming data collected during the monthly sampling, conductivity at this site is high (Figure 32), with a median value of 1592 µS/cm and maximum and minimum values of 2016 µS/cm and 687 µS/cm. During periods of baseflow, groundwater inputs appears to control conductivity, and conductivity remained constant or exhibited a steady increase during prolonged periods of low flow. Conductivity often fell substantially with increased flow but tended to return to previous levels after only a very short interval, as groundwater again became the dominant influence on conductivity. During winter, conductivity was generally lower as a result of increased rainfall and stream flow. Conductivity at this site exceeded 800 µS/cm for at least 98% of the record and exceeded 1500µS/cm for 64% of the time period where good data was obtained.

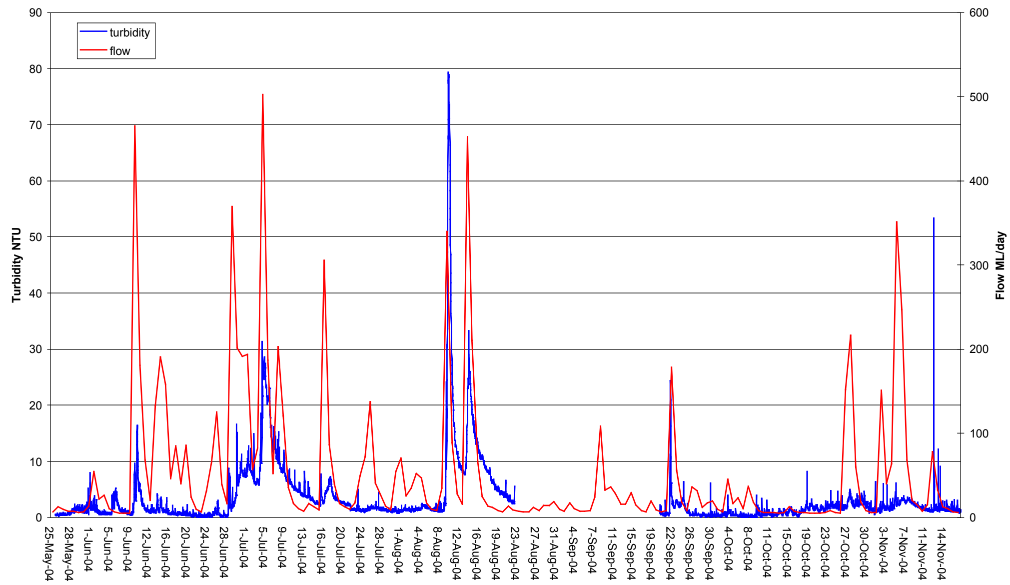


Figure 31: Continuous turbidity data and modelled flow at Little Swanport River at Swanston Road (LSWA10).

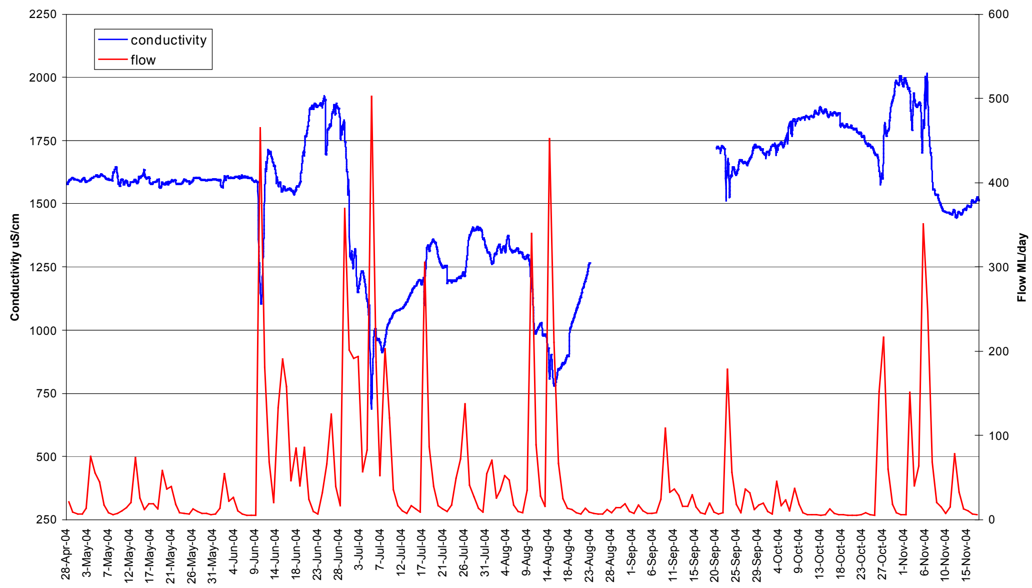


Figure 32: Continuous conductivity data and modelled flow at Little Swanport River at Swanston Road (LSWA10).

Dissolved Oxygen

Concentrations of dissolved oxygen below 5 mg/l may adversely affect the functioning and survival of biological communities (UNESCO, 1992). Dissolved oxygen was below this level for 8% of period of record (Figure 33), and fell below this level for over 12 hours on 4 separate occasions, three in June and one in November. During one period in June, dissolved oxygen was below 5 mg/L for over 72 hours. During periods of low flow, dissolved oxygen concentrations at this site may have negatively impacted on biological function. The period of record for this site does not include summer and early autumn, when low flows and higher temperatures are likely to have resulted in even low concentrations of dissolved oxygen.

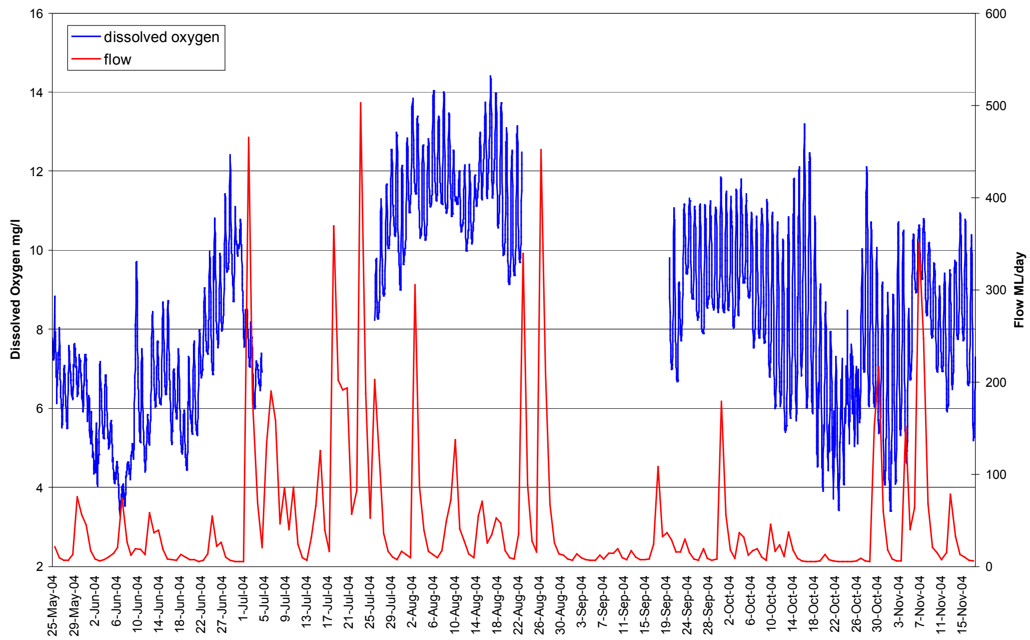


Figure 33: Continuous conductivity data and modelled flow at Little Swanport River at Swanston Road (LSWA10).

Dissolved oxygen at this site increased from generally low values recorded in May and early June as flows increased over the winter period. However, the first flow event of winter, in July 2004, resulted in a decrease in dissolved oxygen, possibly a result of increased levels of organic matter and nutrients entering the river, which probably led to increased biochemical oxygen demand (UNESCO 1992). Diurnal fluctuations in dissolved oxygen concentration tended to increase during spring, when diurnal temperature fluctuations became larger (see below) and there was likely to be an increase in primary production.

Water Temperature

Water temperature can have a direct effect on local biodiversity through the exceedance of lethal limits for biota and indirectly through changes to dissolved oxygen concentrations (Davies et.al., 2004). There are a number of methods for determining the thermal tolerances of macro-invertebrates. In Australia, an upper lethal limit for cold water mayflies has been calculated at 20.6 ^{o}C (Davies, et. al., 2004). Mayflies are particularly sensitive to temperature and are important components of invertebrate communities in rivers and this figure is used to give an indication only of the temperature at which adverse ecological effects may be expected to occur. Biota may also be effected by large diurnal variations, while temperatures close to lethal limits may also have sub-lethal effects on biological functions such as reproduction and emergence which may threaten long term survival of aquatic insects (Davies et.al., 2004, Bunn et.al., 1999).

Maximum and minimum water temperature during the period of record was 23.53 °C and 1.95 °C respectively. Temperature exceeded 21 °C on four occasions, all in the last 28 days of record. It is very likely that during the summer months, water temperatures well in excess of this would have occurred, placing significant stress on instream organisms.

The magnitude of diurnal temperature fluctuations tended to increase in October and November. This a reflection of the increase in incident light during the longer daylight hours of spring, particularly as the riparian vegetation on the southern side of the river at this site has been cleared, allowing greater exposure to light in spring and summer. Although water temperature decreases with flow, particularly in spring, this is likely to be a result of decreased air temperature associated with rain bearing cold fronts crossing the State.

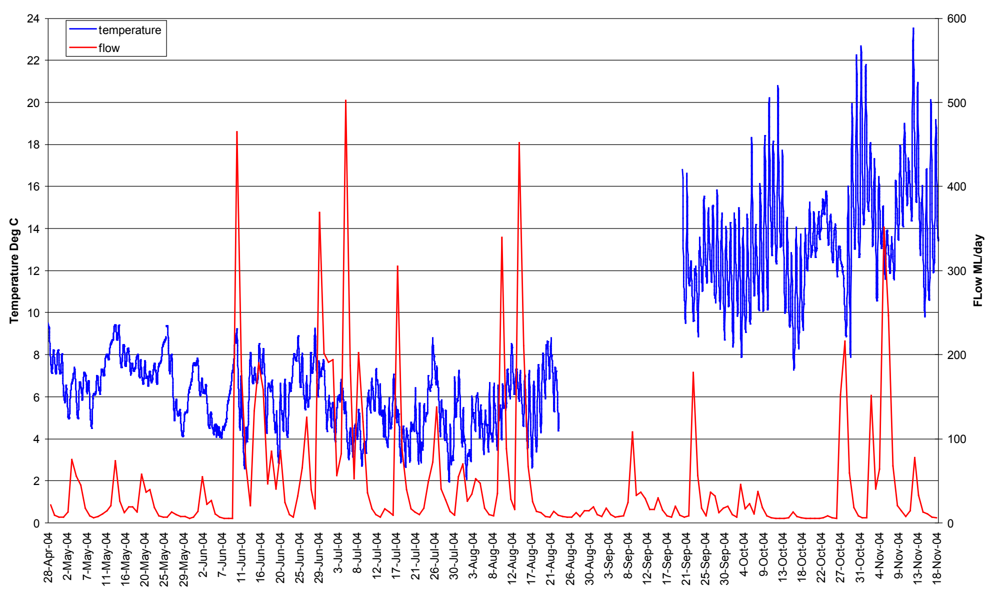


Figure 34: Continuous water temperature data and modelled flow at Little Swanport River at Swanston Road (LSWA10).

In-stream pH

In-stream pH values recorded throughout the main catchment indicate an alkaline system with medians at all sites except Rocka Rivulet and Pepper Creek above 7.5. Although ANZECC guidelines for pH in south eastern Australia are 6.5-7.5, it is generally recognised that appropriate pH guidelines should be determined on a site-specific basis and it has been recommended that pH should not vary by more than one unit (Dallas and Day 1993). Diurnal variation in pH is often related to plant photosynthesis and the uptake and release by plants of CO_2 (Jarvie et.al., 2001).

During the day, net uptake of CO_2 by plants results in an increase in pH, while respiration at night leads to an decrease.

Median pH for LSWA10 as determined from the continuous water quality data is 7.63 with a maximum and minimum of 8.29 and 7.21 respectively, and aligns reasonably well with the monthly data from this site presented in Table 13. Diurnal variations in pH follow those for temperature and dissolved oxygen. The magnitude of changes in pH over the period of record is low.

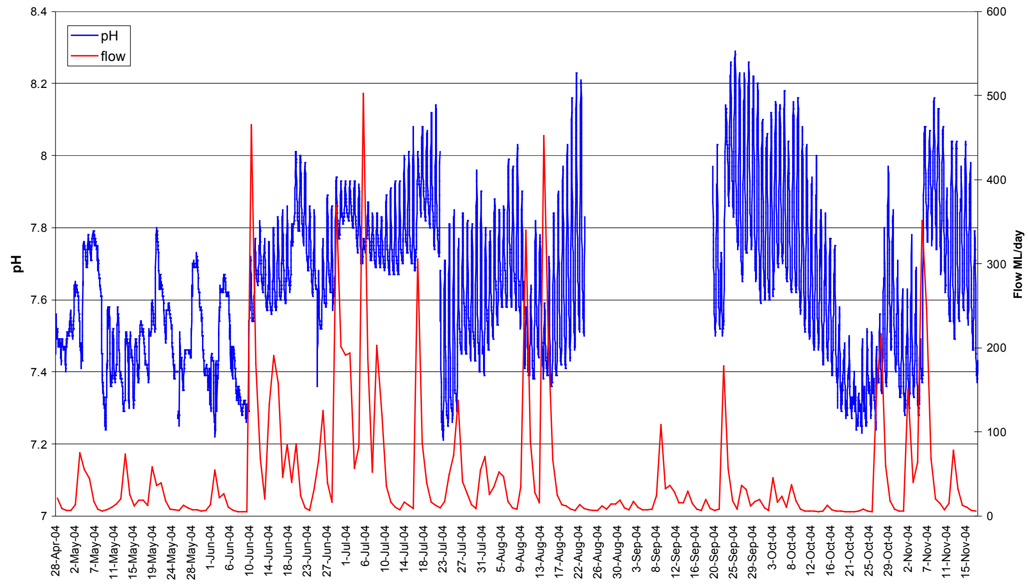


Figure 35: Continuous in-stream pH data and modelled flow at Little Swanport River at Swanston Road (LSWA10).

4.1.5 Summary

Water quality throughout the upper catchment is strongly influenced by the ephemeral nature of the hydrology and the pattern of land use within the catchment. These factors in combination result in relatively poorer water quality in this area, particularly with regard to dissolved salt.

Throughout the duration of the study, baseflow at all sites in the upper catchment was observed to be either very low or to have ceased. These conditions, combined with a lack of riparian vegetation, often result in high temperatures and large variations in dissolved oxygen. The generally low turbidity recorded throughout the upper catchment is also largely a result of low flow conditions, with high to very high turbidity recorded at all sites during periods following significant rainfall. Due to the ephemeral conditions in the upper catchment, water quality is often strongly related to local influences, as there often little or no flow between sites. During these times, groundwater has a strong influence on water quality, and throughout the upper catchment there is a very high salt content as a result of this. While the intermittent nature of the flow regime and possibly to some degree the character of the groundwater may be a natural aspect of the physical processes that operate in the upper catchment, land use has significantly altered this and is very likely to have led to the elevated conductivity of its surface water.

The primary impact of land use in the upper catchment is clearing of the riparian and surrounding vegetation. The removal of riparian vegetation results in higher in-stream temperatures which can also result in low dissolved oxygen, and increases steam bank erosion, resulting in the high turbidity observed during higher flow. Riparian vegetation also acts as a buffer for overland transportation of sediment and nutrients carried by runoff. The majority of sites in the upper catchment had high nutrient levels, particularly during periods of rainfall and runoff. Clearing of vegetation from the surrounding catchment also allows for greater transportation of nutrients and sediments through runoff, however the greatest impact is likely to be increased mobilisation of salt, which has a major impact on water quality in the upper catchment. A number of sites had extremely poor water quality at various times, with extremely high nutrient concentrations occurring as a result of local influences, most notably stock intrusion.

A study of Australian water quality data (Harris, 2001b), suggests that when land clearance exceeds 50% of a catchment, there is a sharp increase in exports of salt, suspended solids and nutrients to waterways and in some cases groundwater, and that an increases in nitrate concentrations also commonly occur. It is apparent that these impacts are occurring in the upper catchment of the Little Swanport River.