DEPARTMENT *of*
PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Tasmania

Natural Heritage Trust

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Water Quality of Rivers in the Duck River Catchment

A Report Forming Part of the Requirements for 'State of Rivers' Reporting

PART 1

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The Department of Primary Industries, Water and Environment

The Department of Primary Industries, Water and Environment provides leadership in the sustainable management and development of Tasmania's resources. The Mission of the Department is to advance Tasmania's prosperity through the sustainable development of our natural resources and the conservation of our natural and cultural heritage for the future.

The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

Executive Summary

The information contained in this report should be viewed together with the reports on river hydrology, aquatic ecology and river condition. These four reports combined form the "State of River Report ' for the Duck River drainage system.

The major findings arising from the study into water quality in the catchment are;

- Water quality data collected from waterways in the catchment prior to this study provides a useful background against which recent data can be compared. Testing of water in Deep Creek by the North West Regional Water Authority is particularly useful in demonstrating the benefits of fencing off streams to improve water quality, and future monitoring by this utility should be encouraged as this data may be a valuable indicator of long-term changes in water quality that may result from improved land management practices in this area.
- Rivers in the catchment appear to be significantly impacted by land management practices, which have resulted in much higher nutrient levels than have been recorded elsewhere in Tasmania under the 'State of Rivers' program. Nutrient concentrations were particularly high in Edith Creek, Coventry Creek and White Water Creek, and contributions from these creeks is likely to be the main cause for elevated nutrient concentrations in the lower reaches of the Duck River.
- The presence of dolomite in the catchment has an influence on the ionic characteristics of water quality in parts of the catchment, particularly in the vicinity of White Water Creek and the Duck River at Poilinna Road.
- High conductivity and nutrient concentrations in Coventry Creek is likely to be indicative of the level of impact of leachate from the area of the Blue Ribbon abattoir upstream.
- While low DO concentrations were recorded at many sites in the Duck River and its tributaries, this does not appear to not have had a deleterious affect on the health of aquatic macroinvertebrate communities, which were generally found to be within the 'A' band. This good 'health' score may be a result of nutrient enrichment.
- Nutrient export loads from the catchment are among the highest recorded in Tasmania; total phosphorus and total nitrogen export coefficients were 1.67 kg/mm/km^2 and 0.532 kg/mm/km^2 respectively. Elevated nutrient export coefficients recorded in the Duck River catchment are probably caused by a combination of factors including high rainfall, intensive dairy farming and paddock drainage, discharges of effluent from dairy sheds, bank and river bed destabilisation caused by stock access and a lack of riparian buffering.
- Poor water quality in the tributaries to Lake Mikany may pose some risk to water quality in the lake, which is the water supply for Smithton. Excessive nutrient loads and sediment from these tributaries may increase the risk of algal blooms in the lake, and interfere with water treatment at the Deep Creek plant downstream.
- Testing for faecal bacteria across the catchment showed that faecal pollution is highest in the lower catchment, particularly in the Edith Creek drainage system, where extensive open drains and a lack of riparian buffering, along with dairy shed effluent input, are likely to be the main factors leading to faecal pollution and nutrient enrichment of this creek.
- Investigations following fish kills in Scopus Creek (west of Smithton) found that the pH of the water in this small drainage system was periodically very low (<3) and was a result of the exposure of acid sulphate soils. Extraction of groundwater was assumed to

reduce the local water table sufficiently to cause the generation of acid drainage water, which when flushed into waterways resulted in fish kills and the death of other aquatic life. Better management of water extraction and monitoring of groundwater levels is seen as important if the environmental threat of acidic drainage is to be reduced. Acid sulphate soils are also likely to occur in Togari, Montagu, Harcus and the Brittens Swamp areas.

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A GLOSSARY OF TERMS

Baseflow
Flow in a stream is essentially a function of overland flow, subsurface flow and groundwater input. During periods when there is no contribution of water from precipitation, flow in a stream is composed of water from deep subsurface and groundwater sources and is termed ‘baseflow’.

Box and Whisker Plots
One common method of examining data collected at various sites is to plot the data from each site as a ‘box and whisker’ plot. These plots display the median (or the middle of the data) as a line across the inside of the box. The bottom and top edges of the box mark the first and third quartiles respectively, indicating the middle 50% of the data. The ends of the whiskers show the extremes of the data and together enclose 95% of the data.

Catchment
The land area which drains into a particular watercourse (river, stream or creek) and is a natural topographic division of the landscape. Underlying geological formations may alter the perceived catchment area suggested solely by topography (limestone caves are an example of this).

Discharge
The volume of water passing a specific point during a particular period of time. It usually refers to water flowing in a stream or drainage channel, but can also refer to waste water from industrial activities.

Diurnal Variation
‘Diurnal variation’ is a term that is used to describe the cyclical pattern of change that occurs within a daily timescale. Water temperature variation is a typical example of a parameter that varies ‘diurnally’, with lowest temperatures occurring in the hours before dawn and the highest temperatures occurring around the middle of the day. Many water quality parameters that are influenced by biological processes also tend to vary on a diurnal basis.

Dissolved Oxygen
Oxygen is essential for all forms of aquatic life and many organisms obtain this oxygen directly from the water in the dissolved form. The level of dissolved oxygen in natural waters varies with temperature, turbulence, photosynthetic activity and atmospheric pressure. Dissolved oxygen varies over 24 hour periods as well as seasonally and can range from as high as 15 mg/L to levels approaching 0 mg/L. Levels below 5 mg/L will begin to place stress on aquatic biota and below 2 mg/L will cause death of fish.

Ecosystem
An environment, the physical and chemical parameters that define it and the organisms which inhabit it.

Electrical Conductivity (EC)
Conductivity is a measure of the capacity of an aqueous solution to carry an electrical current, and depends on the presence of ions; on their total concentration, mobility and valence. Conductivity is commonly used to determine salinity and is mostly reported in microSiemens per centimetre (µS/cm) or milliSiemens per metre (mS/m) at a standard reference temperature of 25^{o} Celsius.

Eutrophication

The enrichment of surface waters with nutrients such as nitrates and phosphates, which cause nuisance blooms of aquatic plants and algae.

Export Loads / Export Coefficients
The calculation of export loads of nutrients, or any other parameter, involves using nutrient concentration data collected over a wide variety of flow conditions and from various seasons. This information, when plotted against flow at the time of collection, can reveal relationships between flow and concentration which can then be used to estimate the load of a particular nutrient leaving the catchment (estimates of export loads should be regarded as having no greater accuracy than +/- 15%).

The export coefficient (also known as the Runoff Coefficient) corrects for catchment size so that export loads from variously sized catchments can be compared. The most commonly used formula to perform this correction is;

Discharge (ML) / **Catchment Area** (km^2) = **X** ($mm.km^2$)
Total Load (kg) / **X** = **Y** ($kg\ mm^{-1}$)
Y / **Catchment Area** (km^2) = **Export Coefficient** ($kg\ mm^{-1}km^{-2}$)

Where Z is the Export Coefficient and is equivalent to Total Load (kg) / Discharge (ML).

Faecal Coliforms (also known as 'thermotolerant coliforms' - eg. *E.coli*)
Faecal coliform bacteria are a sub-group of the total coliform population that are easy to measure and are present in virtually all warm blooded animals. Although measurement of this group is favoured by the NHMRC (1996) as suitable indicators of faecal pollution, it is recognised that members of this group may not be exclusively of faecal origin. However their presence in samples implies increased risk of disease. Pathogenic bacteria are those which are considered capable of causing disease in animals.

General Ions
General ions are those mineral salts most commonly present in natural waters. They are primarily sodium, potassium, chloride, calcium, magnesium, sulphate, carbonates and bicarbonates. Their presence affects conductivity of water and concentrations variable in surface and groundwaters due to local geological, climatic and geographical conditions.

Hydrograph
A plot of flow (typically in a stream) versus time. The time base is variable so that a hydrograph can refer to a single flood event, to a combination of flood events, or alternatively to the plot of all flows over a month, year, season or any given period.

Macroinvertebrate
Invertebrate (without a backbone) animals which can be seen with the naked eye. In rivers common macroinvertebrates are insects, crustaceans, worms and snails.

Median
The middle reading, or 50^{th} percentile, of all readings taken.
i.e. Of the readings 10, 13, 9, 16 and 11
{Re-ordering these to read 9, 10, 11, 13 and 16}
The median is 11.
The **Mean** (or Average), is the sum of all values divided by the total number of readings (which in this case equals 11.8).

Nutrients

Nutrients is a broad term which encompasses elements and compounds which are required by plants and animals for growth and survival. In the area of water quality the term is generally used with only phosphorus and nitrogen species in mind, though there are many other 'nutrients' that living organisms require for survival.

pH and Alkalinity

The pH is a measure of the acidity of a solution and ranges in scale from 0 to 14 (from very acid to very alkaline). A pH value of 7 is considered 'neutral'. In natural waters, pH is generally between 6.0 and 8.5. In waters with little or no buffering capacity, pH is related to alkalinity which is controlled by concentrations of carbonates, bicarbonates and hydroxides in the water. Waters of low alkalinity (< 24 ml/L as CaCO3) have a low buffering capacity and are susceptible to changes in pH from outside sources.

Riparian Vegetation

Riparian vegetation are plants (trees, shrubs, ground covers and grasses) which grow on the banks and floodplains of rivers. A 'healthy' riparian zone is characterised by a homogeneous mix of plant species (usually native to the area) of various ages. This zone is important in protecting water quality and sustaining the aquatic life of rivers.

Suspended Solids

Suspended solids are typically comprised of clay, silt, fine particulate organic and inorganic matter and microscopic organisms. Suspended solids are that fraction which will not pass through a 0.45μm filter and as such corresponds to non-filterable residues. It is this fraction which tends to contribute most to the turbidity of water.

Total Kjeldahl Nitrogen (TKN)

The Kjeldahl method determines nitrogen in water and is dominated by the organic and ammoniacal forms. It is commonly used to determine the organic fraction of nitrogen in samples and when the ammonia nitrogen is not removed, the term 'kjeldahl nitrogen' is applied. If the ammonia nitrogen is determined separately, 'organic nitrogen' can be calculated by difference.

Total Nitrogen (TN)

Nitrogen in natural waters occurs as Nitrate, Nitrite, Ammonia and complex organic compounds. Total nitrogen concentration in water can be analysed for directly or through the determination of all of these components. In this report, Total Nitrogen has been calculated as the sum of Nitrate-N + Nitrite-N + TKN.

Total Phosphorus (TP)

Like nitrogen, phosphorus is an essential nutrient for living organisms and exists in water as both dissolved and particulate forms. Total phosphorus can be analysed directly, and includes both forms. Dissolved phosphorus mostly occurs as orthophosphates, polyphosphates and organic phosphates.

Turbidity

Turbidity in water is caused by suspended material such as clay, silt, finely divided organic and inorganic matter, soluble coloured compounds and plankton and microscopic organisms. Turbidity is an expression of the optical properties that cause light to be scattered and absorbed rather than transmitted in a straight line through the water. Standard units for turbidity are 'nephelometric turbidity units' (NTU's) standardised against Formazin solution.

Units and Conversions

mg/L = milligrams per litre (1000 milligrams per gram)
μg/L = micrograms per litre (1000 micrograms per milligram)
e.g. 1000 μg/L = 1 mg/L
μS/cm = Microsiemens per centimeter
m^3s^{-1} = cubic metre per second (commonly referred to as a 'cumec')
ML = 1 million litres (referred to as a 'megalitre')

Acronyms

ANZECC - Australian and New Zealand Environment and Conservation Council
ARMCANZ - Agricultural and Resource Management Council of Australia and New Zealand
DPIWE - Department of Primary Industries, Water and Environment
DPIF - Department of Primary Industry and Fisheries (replaced by DPIWE)
DCHS - Department of Community and Health Services
NHMRC - National Health and Medical Research Council
NHT – Natural Heritage Trust (formerly the National Landcare Program)
RWSC - Rivers and Water Supply Commission
NWRWA – North West Regional Water Authority

B SUMMARY OF NATIONAL GUIDELINES FOR WATER QUALITY

Australian Water Quality Guidelines as per ANZECC (2000)

As part of a National strategy to 'pursue the sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development' the Australian and New Zealand Environment and Conservation Council (ANZECC) has been developing guidelines for water quality for a range of Australian waters. Since 1992, a document titled 'Australian Water Quality Guidelines For Fresh and Marine Waters (1992) ' has been available for use as a reference tool for catchment management plans and policies. Since 1995, these guidelines have been under review and have now been superseded by new and more rigorous guidelines (ANZECC, 2000). Where possible, these new guidelines have had a more regional focus. This new approach has changed the emphasis of guideline setting, suggesting a 'risk assessment' approach which utilises the concept of increased risk with increasing departure from 'safe' levels.

The revised guidelines also restate the principle that guidelines are only to be used in the absence of local data, and that where local data can be obtained, they should be used to develop local water quality standards. For some water quality parameters, this approach has been taken, with data from Tasmanian systems (where available) being used to develop guidelines for use within Tasmania. In the National document, Tasmanian rivers have been broadly classified as upland or alpine rivers, as available data at the time was from upland river systems only. However it is important to note that some of the North West river systems originate below the 150m classification level for upland systems and can therefore be classified as lowland rivers.

Table 1. Trigger Levels for Nutrients, pH and Dissolved Oxygen (ANZECC 2000).

Ecosystem Type	TP (μg/L)	FRP (μg/L)	TN (μg/L)	NOx (μg/L)	pH	DO (%sat)
Lowland River	50	20	500	40	6.5 - 8.0	<85 & >110
Upland River	13	5	480	190	6.5 to 7.5	<90 & >110
Lakes and Reservoirs	10	5	350	10	6.5 to 8.0	<90 & >110

Table 2. Trigger Levels for Conductivity and Turbidity (ANZECC 2000).

Ecosystem type	Salinity (μScm^{-1})	Explanatory notes
Lowland Rivers	125-2200	Lowland rivers may have higher conductivity during low flow periods and if the system receives saline groundwater inputs. Low values are found in eastern highlands of Victoria (125μScm^{-1}) and higher values in western lowlands and northern plains of Vic (2200 μScm^{-1}), NSW coastal rivers are typically in the range 200-300 μScm^{-1}.
Upland Rivers	30–350	Conductivity in upland streams will vary depending upon catchment geology. Low values found in Victorian alpine regions (30 μScm^{-1}) and eastern highlands (55 μScm^{-1}), high value (350 μScm^{-1}) in NSW rivers. Tasmanian rivers mid-range (90 μScm^{-1}).
Lakes/ Reservoirs	20–30	Conductivity in lakes and reservoirs are generally low, but will vary depending upon catchment geology. Values provided are typical of Tasmanian lakes and reservoirs.

Ecosystem type	Turbidity (NTU)	Explanatory notes
Lowland Rivers	6-50	Turbidity in lowland rivers can be extremely variable. Values at the low end of the range would be found in rivers flowing through well-vegetated catchments and at low flows. Values at the high end of the range would be found in rivers draining slightly disturbed catchments and in many rivers at high flows.
Upland Rivers	2–25	Most good condition upland streams have low turbidity. High values may be observed during high flow events.
Lakes & Reservoirs	1–20	Most deep lakes and reservoirs have low turbidity. However shallow lakes and reservoirs may have higher natural turbidity due to wind-induced resuspension of sediments. Lakes and reservoirs in catchment with highly dispersable soils will have high turbidity.

4. Proposed Microbiological Guidelines

Primary contact

The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed:

- *150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL);*
- *35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL).*

Pathogenic free-living protozoans should be absent from bodies of fresh water. (It is not necessary to analyse water for these pathogens unless the temperature is greater than 24°C.)

Secondary contact

The median bacterial content in fresh and marine waters should not exceed:

- *1000 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms/100 mL);*
- *230 enterococci organisms/100 mL (maximum number in any one sample 450–700 organisms/100 mL).*

National Health and Medical Research Council - Drinking Water

For drinking water, guidelines published by the National Health and Medical Research Council (NHMRC, 1996) suggest that no thermotolerant coliforms (eg *E. coli*) should be present in water used for drinking.

Water Quality of Rivers in the Duck Catchment

1 Historical Data

DPIWE Water Quality Database

There is minimal historical water quality data available from the State water quality database for rivers and streams in the Duck catchment. The water quality data that is stored on the State database appears to have been collected in an ad hoc manner as part of routine stream gauging activities or as part of specific short-term investigations. One such dataset relates to faecal coliforms at selected sites in the catchment. These data were collected by the Rivers and Waters Supply Commission (RWSC) in the early 1990's, to determine the impact of dairy shed effluent on coliform levels in rivers and streams in the catchment

The database also contains some data from Deep Creek that was recorded to assist with the treatment process for the supply of domestic water to Smithton. While the State database does contain some historical data from this source (Table 1.1), a significant amount of additional data (in the form of daily time series) was provided by the North West Regional Water Authority. These data will be presented and discussed later in the section.

Some broad inferences can be made from the data extracted from the State database. The data in Table 1.1, shows that iron levels in Deep Creek are generally high, with a maximum recorded concentration of 10.7 mg/L and an average of 2.51 mg/L. Iron concentrations of this magnitude are likely to have a noticeable impact on the taste of the water (NHMRC guidelines value for iron is 0.3 mg/L).

Table 1.1: Statistical summary of historical water quality – Deep Creek at Smithton Water Supply Intake (Hydrol 1126).

DEEP CREEK					
Parameter	**n**	**Mean**	**Max**	**Min**	**Unit**
Albuminoid Ammonia	7	0.34	0.46	0.24	mg/L
Bacteria Agar 22/72	8	3667.5	20000	540	count
Bacteria Agar 37/24	8	495.5	2200	34	count
Biochemical Oxygen D	8	1.64	3.9	0.5	mg/L
Boron as B	8	0.07	0.1	0.02	mg/L
Calcium (Total) as C	8	5.74	7.8	4	mg/L
Confirmed Faecal Str	8	71.5	310	6	mg/L
Filt Resid (103-105)	31	110.3	145	91	mg/L
Fluoride as F	8	0.02	0.05	0.003	mg/L
Free Ammonia as NH_3	8	0.17	0.24	0.14	mg/L
Free Chlorine	9	33.4	51	24.2	mg/L
Iron (Total) as Fe	8	2.51	10.7	0.99	mg/L
Lab Cond @ TRef 20	7	168.71	250	120	mg/L
Magnesium (Total) as Mg	13	3.19	6.8	0.01	mg/L
Mercury (Total) as H	6	0.11	0.2	0.1	mg/L
Nitrate as N	8	0.34	0.88	0.002	mg/L
Nitrite as N	8	0.01	0.05	0.002	mg/L
Potassium (Total) as K	8	1.24	2	0.27	mg/L
Silica as SiO_2	8	5.16	6.6	3.4	mg/L
Sodium (Total) as Na	8	17.38	20	9	mg/L
Tot Coliform 100 ml	8	975	4200	70	csu/100ml
Total Hardness ($CaCO_3$)	7	33.14	46	18	mg/L
Total Phosphate	8	0.02	0.03	0.01	mg/L

The data in Table 1.1 also shows that the water of Deep Creek (which originates from Lake Mikany) is relatively dilute, with moderately low conductivity, hardness and low concentrations of dissolved salts such as sodium, calcium and magnesium. These data shows that water in Deep Creek is more typical of ambient waters elsewhere along the north-west coast of Tasmania (Fuller & Katona, 1993).

The data for biochemical oxygen demand (BOD) suggests that there is a relatively low organic load entering the stream, although when data on dissolved oxygen concentration in the water is examined (Figure 1.1), it is apparent that there may be some factors leading to periodic oxygen depletion at the site. The weir pond at this site is prone to invasion by the introduced aquatic weed Cumbungi (*Typha* spp), and this can trap sediment and encourage local decomposition, which reduces oxygen concentrations in the water column. The bacterial data suggest that there is a fairly high population inhabiting the pond, although the composition of this community is not known and may not necessarily be of faecal origin.

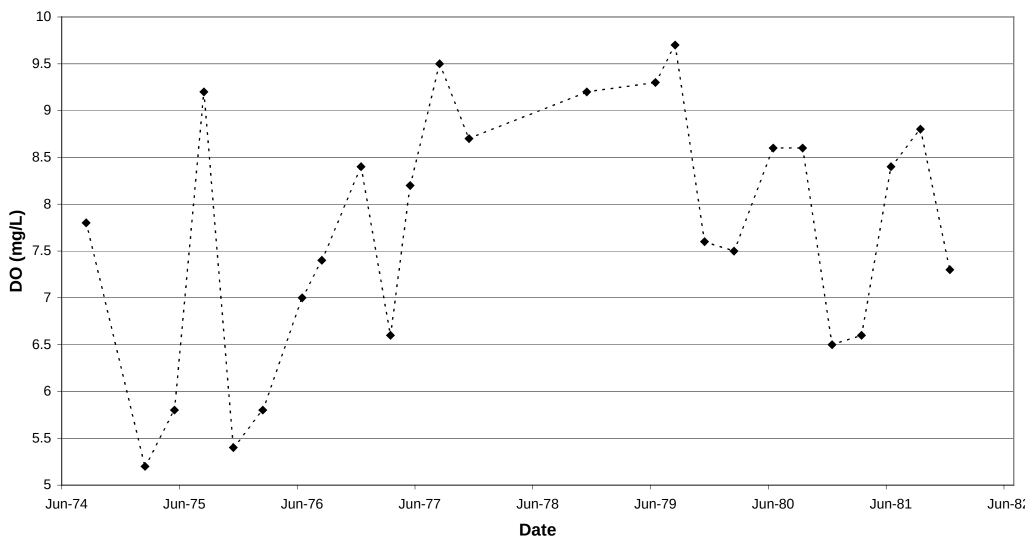

Figure 1.1: Variation in dissolved oxygen concentration between 1974-1982 at site 1126 (Deep Creek Water Supply Intake).

The major nutrient data (phosphate and nitrate) also suggest that there may be periodic inflows of nutrient-rich water and this may facilitate the growth of nuisance aquatic plants and periphyton in the pond. Through photosynthesis and respiration processes, excessive growth of these plants can also heavily influence concentrations of oxygen in the water.

Some comparative data is available from the Duck River at site 14214 (upstream Scotchtown Rd). Although not coincident with the data collected from the site on Deep Creek, these additional data can be used to compare 'average' conditions at the two sites. Figures 1.2 - 1.6 are boxplot representations of the data for apparent colour, Hellige turbidity, suspended solids and pH, and show the range and medians of the data from each of the sites [an explanation of what is represented by boxplots is given in the Glossary].

The boxplots show that while the overall range of the data for most parameters tends to be greater at site 1126, in most cases the median at the Duck River site (14214) is higher than at Deep Creek. This is especially noticeable for turbidity and suspended solids, which indicates that the Duck River carries a greater load of suspended sediment. The pH at both sites is the same, being slightly alkaline (median pH ~ 7.2).

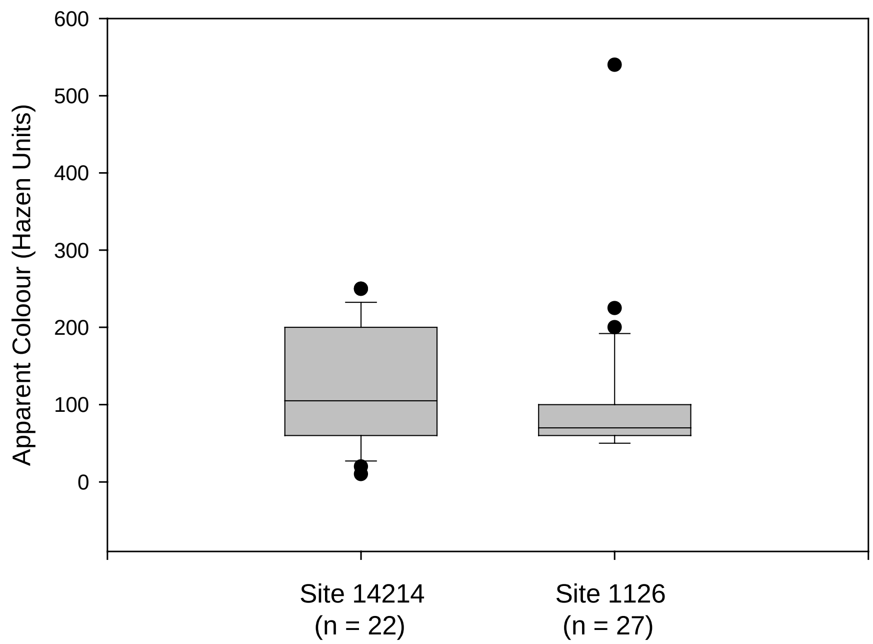

Figure 1.2: Summary statistics of apparent colour as recorded at site 14214 (Duck River upstream Scotchtown Rd) and site 1126 (Deep Creek at Water Supply Intake) between 1974-1989.

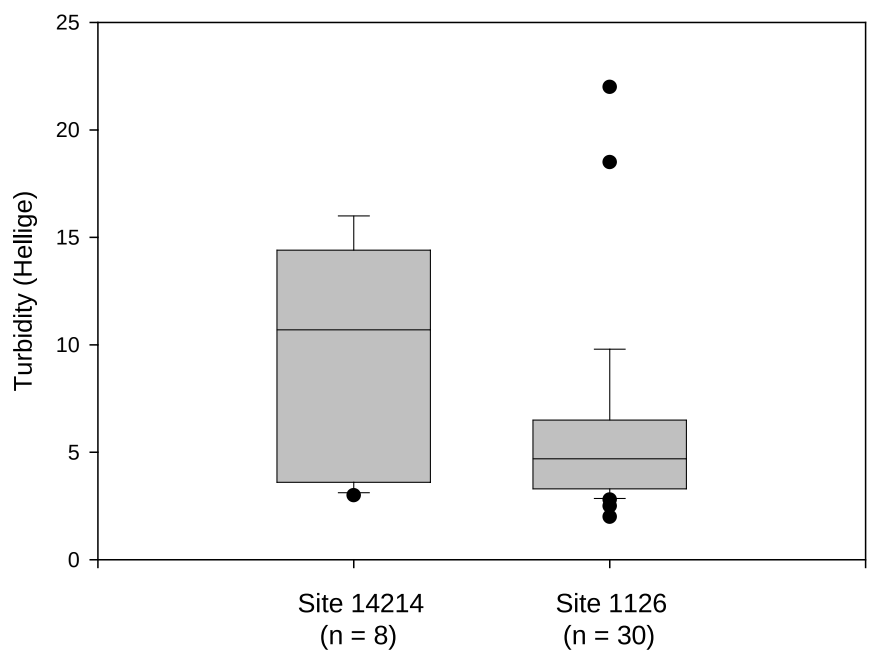

Figure 1.3: Summary statistics of Hellige turbidity as recorded at site 14214 (Duck River upstream Scotchtown Rd) and site 1126 (Deep Creek at Water Supply Intake) between 1974-1986.

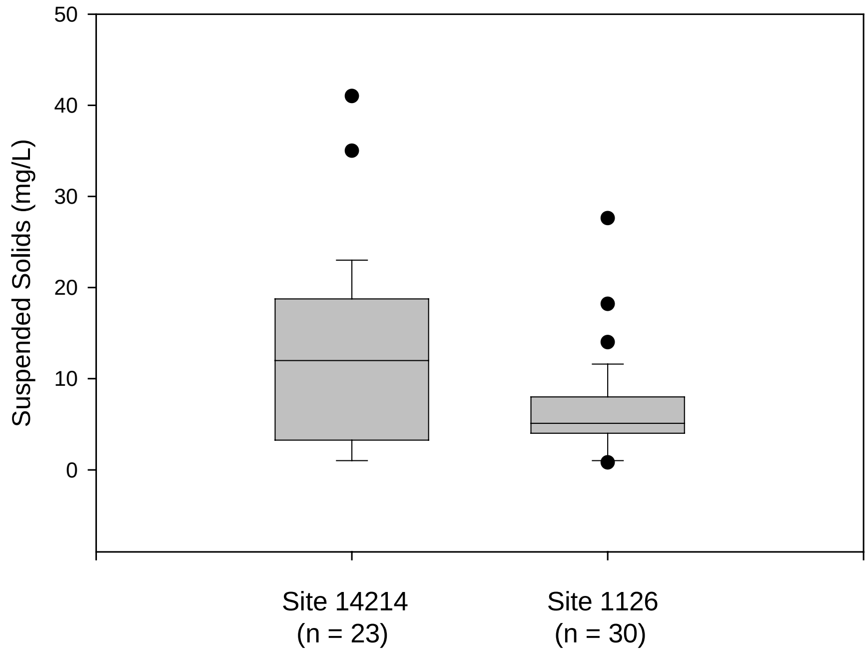

Figure 1.4: Summary statistics of suspended solids as recorded at site 14214 (Duck River upstream Scotchtown Rd) and site 1126 (Deep Creek at Water Supply Intake) between 1974-1989.

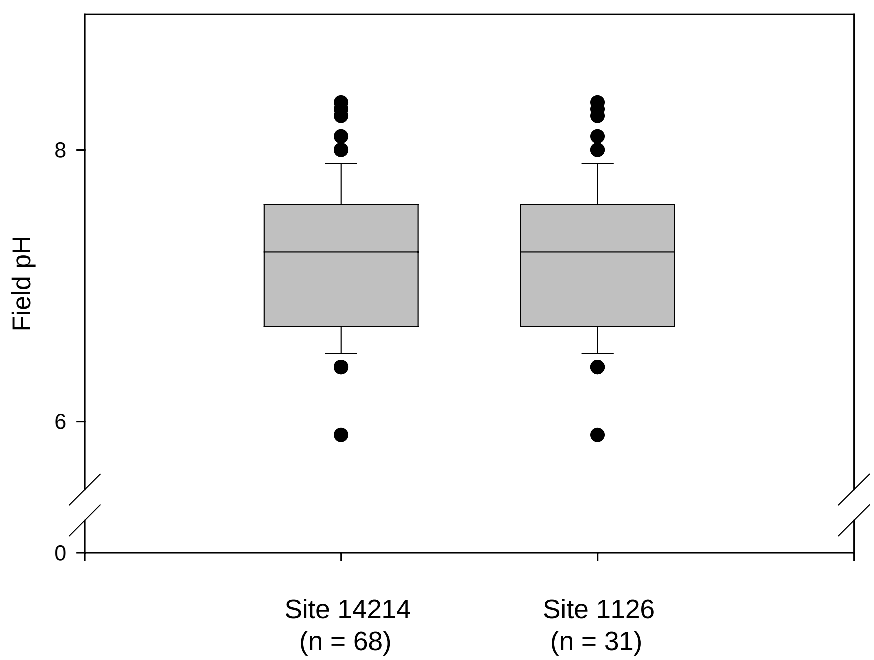

Figure 1.5: Summary statistics of field pH as recorded at site 14214 (Duck River upstream Scotchtown Rd) and site 1126 (Deep Creek at Water Supply Intake) between 1974-1989.

Other data from site 14214 are summarised below in Table 1.2. These data show that conductivity in the Duck River is significantly higher than at Deep Creek, with values ranging from 300 – 650 µS.cm^{-1}. This is also reflected in the values for filterable residues, which is an old nomenclature for what is essentially 'total dissolved solids'.

Table 1.2: Statistical summary of historical water quality – Duck River at Scotchtown Rd (Hydrol 14214)

DUCK RIVER UPSTREAM SCOTCHTOWN ROAD					
Parameter	n	Mean	Max	Min	Unit
Field Cond @ TRef 20	35	348.31	655	153	uS/cm (20 TRef)
Field Cond @ TRef 25	13	303.92	439	130	uS/cm (25 TRef)
Filt Resid (103-105)	22	207.14	330	104	mg/L
Redox Europe Stnd Ox	5	75.6	156	34	mv
Water temperature	138	12.4	20	5	Degrees C
Thermotolerant colif	18	419	1140	24	cfu/100 ml

The data for water temperature is displayed as a time series in Figure 1.6, and shows the broad seasonal and inter-annual range at this site. Because of the small size of the river, this is likely to reflect local climatic variation in the region.

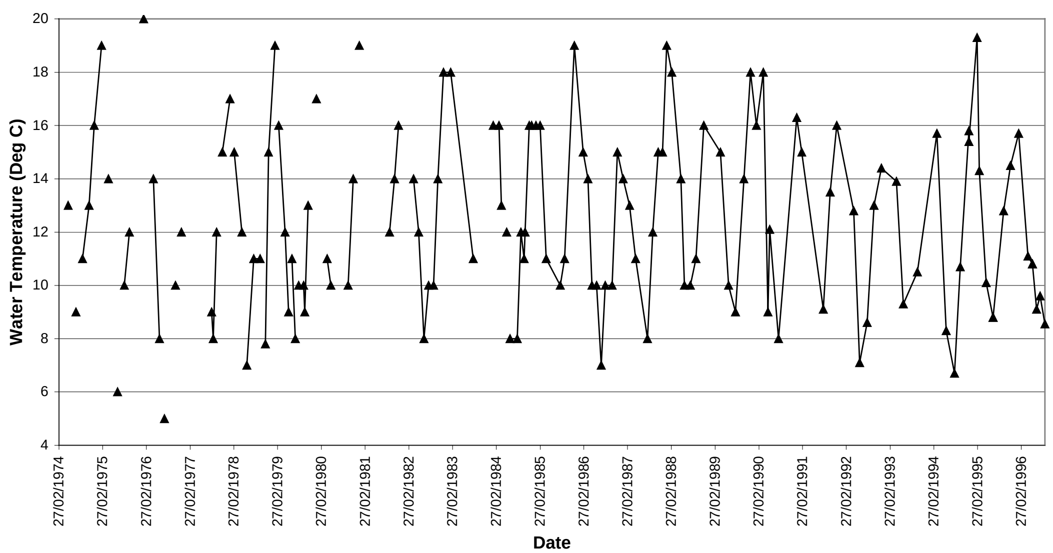

Figure 1.6: Water temperature data recorded at site 14214 (Duck River u/s Scotchtown Rd) during site visits between 1974 – 1997 to maintain the streamflow monitoring station.

The data on thermotolerant coliforms at site 14214 can also be compared with data collected simultaneously at other sites in the catchment (see Table 1.3a-f). These have been graphically represented by boxplots in Figure 1.7. The sites have been represented from left to right in approximate order from top to bottom of the catchment, and it shows that sites lower in the catchment generally have higher levels of faecal pollution. The two sites with highest concentrations of coliforms are drains in the Scopus Creek area, where there is intensive dairy farming.

Table 1.3a-f: Statistical summary of historical water quality for sites in the Duck catchment (Hydrol sites: 14244; 14232; 14251; 14255; 14239; and 14214).

DUCK RIVER AT ROGER RIVER (DAIRY) (14244)					
Parameter	n	Mean	Max	Min	Unit
Thermotolerant coliforms	15	223.53	4000	10	cfu/100 ml

SCOPUS CREEK AT MONTAGU ROAD (14232)					
Parameter	n	Mean	Max	Min	Unit
Thermotolerant coliforms	13	1590.54	4000	190	cfu/100 ml

BOLDUAN'S DRAIN AT SCOPUS (14251)					
Parameter	n	Mean	Max	Min	Unit
Thermotolerant coliforms	3	1305	8000	40	cfu/100 ml

EDITH CREEK AT EDITH CREEK (14255)					
Parameter	n	Mean	Max	Min	Unit
Thermotolerant coliforms	10	1010.38	4000	48	cfu/100 ml

ROGER RIVER AT BUFFS ROAD (14239)					
Parameter	n	Mean	Max	Min	Unit
Thermotolerant coliforms	13	94.92	496	4	cfu/100 ml

SEDGY CREEK AT BASS HIGHWAY (14214)					
Parameter	n	Mean	Max	Min	Unit
Thermotolerant coliforms	16	516.19	4000	30	cfu/100 ml

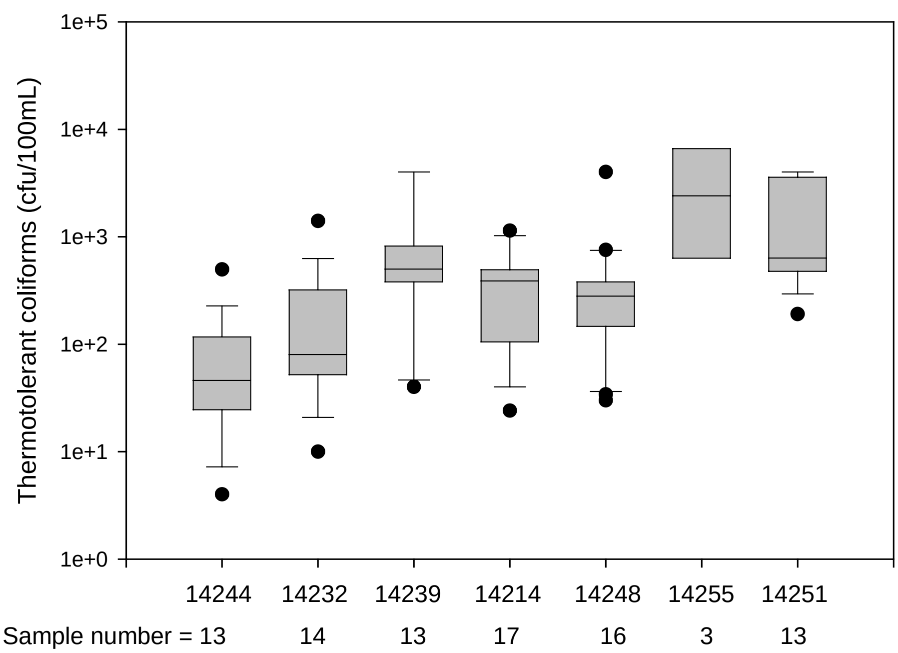

Figure 1.7: Summary statistics for thermotolerant coliforms at 7 sites in the Duck catchment (listed in Table 1.3 above), sampled by RWSC between 1993-94.

North West Regional Water Authority

Water quality monitoring at the Deep Creek water supply pond has been carried out intensively since the 1980's by the North West Regional Water Authority, which manages the treated water supply for Smithton. While this water originates from Lake Mikany, the point of extraction for treatment is from a site on Deep Creek some 4km downstream. Along with land drainage activities that occur in this area, stock access to this stretch of creek has the potential to impact on the quality of raw water, so the record of testing by the water authority only provides a picture of the ambient quality of water in this lower portion of Deep Creek.

The following time series plots cover the period between April 1985 and April 1999 and present data on the main parameters the water authority monitors to aid in the treatment of water for Smithton (water temperature, alkalinity, colour, turbidity and pH). The time series for temperature, alkalinity, and to a lesser extent colour, all show distinct annual patterns of variation. Water temperature (Figure 1.8) generally reaches a maximum of about 21°C in February each year, and is at its coldest (around 7 °C) in late July. The highest recorded water temperature (23 °C) occurred in January 1998. The coldest water temperature (1.5 °C) was recorded during a cold snap in late May of 1987.

Regression analysis was undertaken of the de-seasonalised data covering 1985 – 1989. It showed that during this period average water temperature increased by almost 1.5 °C, however statistical comparison of this record with that covering 1996-1999 showed no significant difference in mean water temperature.

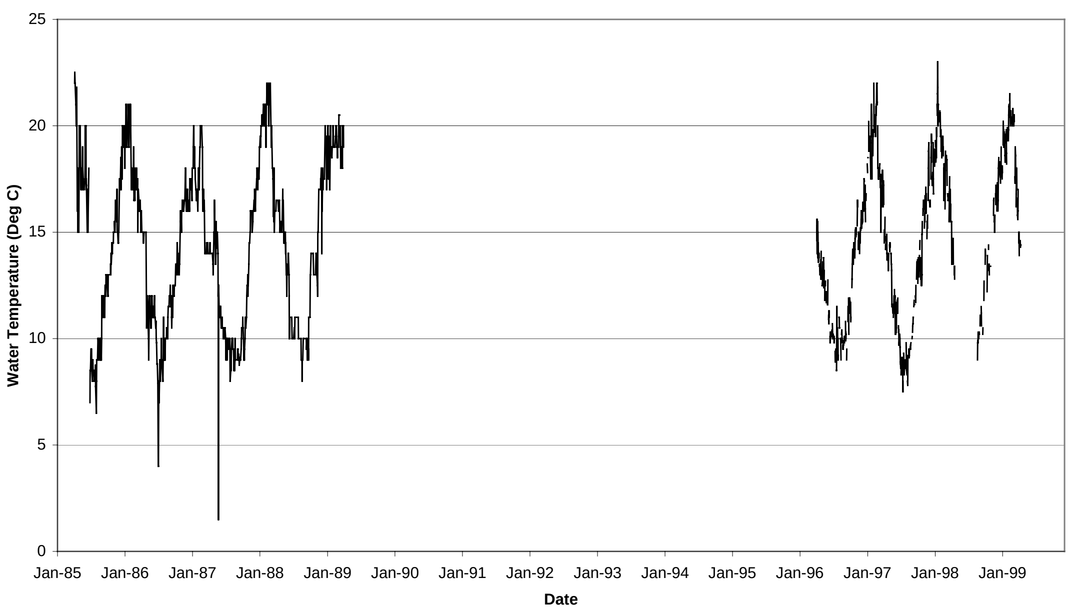

Figure 1.8: Water temperature at Deep Creek water supply intake pond (data kindly supplied by the North West Regional Water Authority).

Alkalinity in Deep Creek also shows that while alkalinity in the creek is quite low (15-35 mg/L) there is a clear seasonal pattern of change (Figure 1.9). Highest alkalinity generally occurs around April/May (the end of the 'dry' season) and lowest alkalinity is found in the early months of spring (October/November) when water is most dilute. There is no evidence of any temporal change in alkalinity at this site.

The time series for data for colour (expressed here as Total Colour Units) also shows clear seasonal variation (Figure 1.10), with lowest values occurring in late autumn and highest values recorded during the high flows of winter (June/July). The data in Figure 1.10 appears to suggest that there was a significant improvement in colour between 1989 and 1996 (during which no monitoring data is available). While this may have been due to reduced stock access to the creek during this time, it may also be due to a change in measurement procedures, with different instrumentation being used to measure colour in the latter period. This cannot be confirmed.

The seasonal pattern that characterises alkalinity and colour is much less distinct in the time series for turbidity (Figure 1.11), and is almost totally absent in the time series plot for pH (Figure 1.12). The turbidity data is characterised by frequent spikes, especially during the early years of monitoring in the 1980's. Between July 1985 and September 1986 the trace is affected by frequent, but brief periods when turbidity increased from the baseline of about 3NTU to 15NTU or more. While some of this spiking may be due to local rainfall events causing flushes of 'dirty' water in the creek downstream from Lake Mikany, it is more likely that stock access to the creek is the main cause of these turbidity events, especially during the summer months when conditions are dry and stock are more likely to stand in the creek to drink and obtain shade. Following September 1986 these periodic events disappear from the record, with the exception of those that occur during high stream flows. The most likely explanation for this improvement is fencing of the creek that commenced in the late 1980's following concerns about the intermittently poor water quality of Smithton water supply. This fencing has only recently been completed (pers comm. David Krushka, DPIWE).

Another potential influence on turbidity in the lower part of Deep Creek is the White Hills quarry, which was operated by the Circular Head Council in the 1980's to supply road gravel. This is located less than 2 km upstream of the water treatment plant on Deep Creek and drainage from the quarry was thought to cause periodic problems at the plant. This quarry was closed and the site rehabilitated in the early 1990's.

The trace for laboratory pH (as measured on site at the water treatment plant) is plotted in Figure 1.12. The trace shows that pH in Deep Creek appears to have changed between 1989 and 1996, increasing from an average of around 6.6 to approximately 7 (neutral). As was mentioned for the data on colour, this change is likely to be due to the introduction of new equipment rather than any real change in environmental pH. None of the data for ionic composition presented in Table 1.4 indicates that this change is due to actual alteration in the quality of water in Deep Creek. However, no confirmation of a change in instrumentation could be obtained.

In addition to the near-continuous water quality data discussed above, the NWRWA also collected bottled water samples for more comprehensive laboratory-based chemical analyses. These data, covering the period November 1984 to January 1993, are given in Table 1.4, along with guideline values for drinking water suggested under the National Health & Medical Research Council 'Drinking Water Guidelines' (NHMRC, 1996). The table shows that the only parameter of concern for this water supply is the iron concentration, which exceeded the guideline value of 0.3mg/L on all sampling occasions. The average iron concentration (at 0.85mg/L) is almost three times the NHMRC guideline value, and while this is not a health concern, iron at this concentration is highly likely to influence the taste of the treated water and may stain laundry.

The only other parameter exceeding NHMRC guidelines is total aluminium, which was recorded at 0.253 mg/L and 0.49 mg/L in September of 1991 and 1992 respectively. These data were recorded during higher flows and are likely to reflect the level of sediment in the water column, particularly clay minerals, which naturally contain high levels of aluminium. The water treatment process is designed to remove these particles.

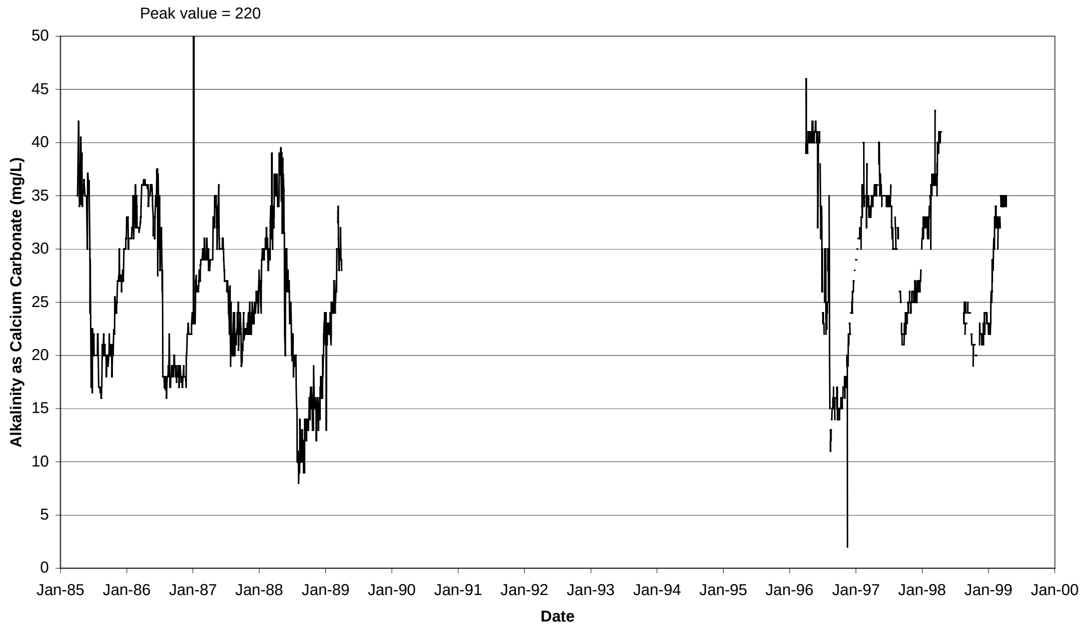

Figure 1.9: Alkalinity at Deep Creek water supply intake pond (data kindly supplied by the North West Regional Water Authority).

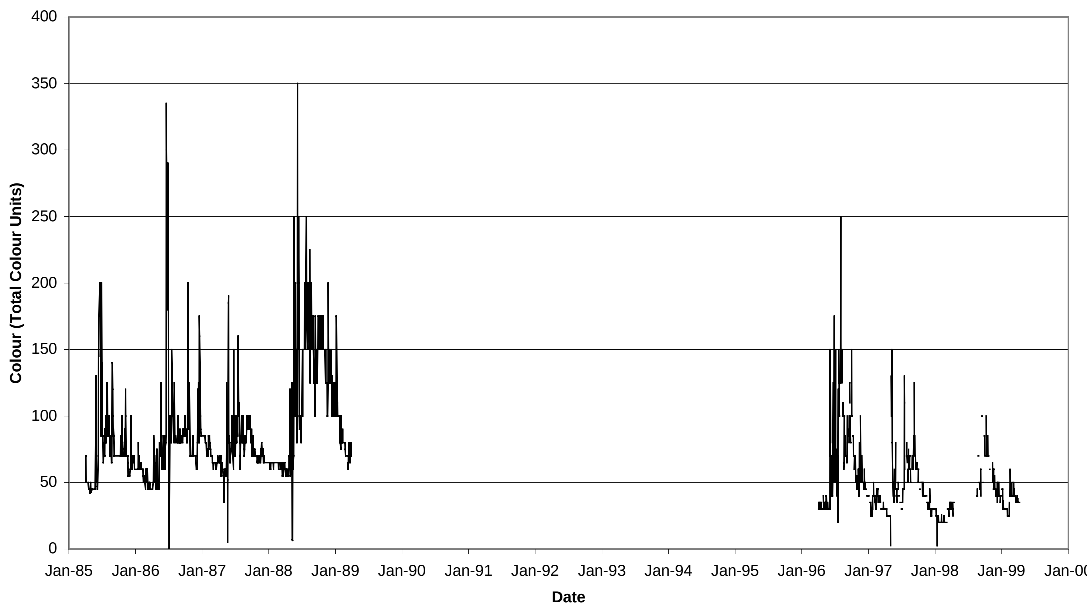

Figure 1.10: Total colour at Deep Creek water supply intake pond (data kindly supplied by the North West Regional Water Authority).

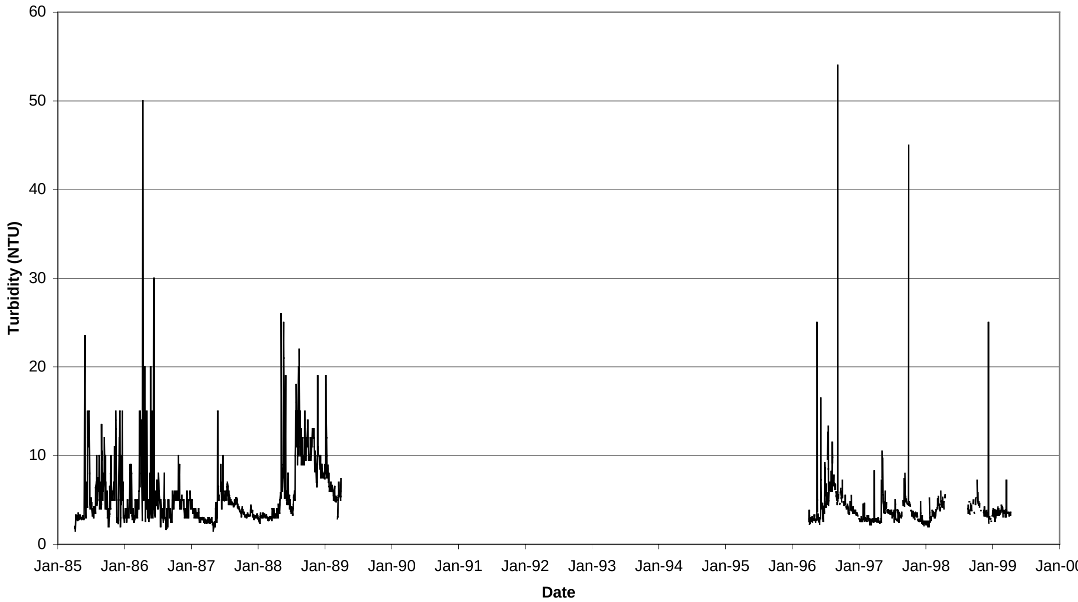

Figure 1.11: Nephelometric turbidity at Deep Creek water supply intake pond (data kindly supplied by the North West Regional Water Authority).

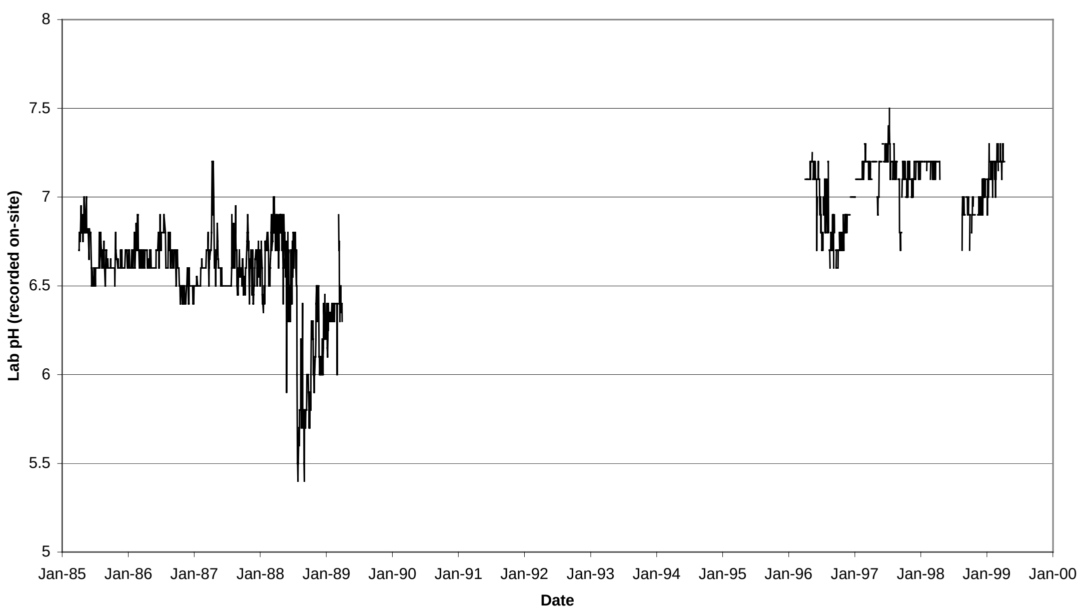

Figure 1.12: Laboratory pH (recorded on-site) at Deep Creek water supply intake pond (data kindly supplied by the North West Regional Water Authority).

Table 1.4: Data on the quality of raw water from Deep Creek from chemical analyses undertaken by the North West Regional Water Authority between 1984 and 1993.

DEEP CREEK - RAW WATER		NHMRC	Nov	Jul	Jan	Jun	Sep	Dec	Sep	Jan	May	Sep	Jan
	UNITS	Values	1984	1985	1986	1986	1986	1990	1991	1992	1992	1992	1993
Conductivity	uS/cm	400 *		130	158	156	133	165	152	176	181	150	171
TDS (by EC)	mg/L	1000	235		154	146	160	90	83	97	99	82	94
GENERAL IONS													
Calcium	mg/L	100*	3.8	4.7	5.9	6.4	8.3	4	4	4.9		3.1	
Magnesium	mg/L	30*	4	6.9	5.5	7.3	3.6	5	4	5.3		4.1	
Sodium	mg/L	300	8.3	27	20	26	21	17	18	18		19	
Bicarbonate	mg/L	NR						34	21	38		26	
Sulphate	mg/L	400	16	18	6	12	11	3	7	5		7	
Chloride	mg/L	400	28	32	28	34	28	28	30	28		24	
Hardness as CaCO3	mg/L	500		42	39	48	35	29	26	34		25	
Alkalinity (as CaCO3)	mg/L	NR		25	31	35	19	28	17	31		21	
NUTRIENTS													
TKN as N	mg/L	1 *						0.36	0.46	0.54		0.52	
Nitrate + Nitrite as N	mg/L	10	<0.1	<0.1	<1.0	<1.0	<10	0.16	0.59	0.08	0.23	0.51	0.13
Phosphate - Total as P	mg/L	NR	0.006	0.002	0.02		0.011	38	0.025	0.018		0.05	
METALS													
Total Al	mg/L	O.2		<0.1	<0.1	<0.1	0.1	0.16	0.253	0.125	0.197	0.49	0.068
Inorganic As	mg/L	0.05	<0.005	<0.005	<0.01	<0.005	<0.005	<0.001	<0.001	0.005	0.008	0.006	0.001
Total Cd	mg/L	0.005						<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004
Total Cr	mg/L	0.05	<0.01	0.03	0.01	0.05		0.014	<0.005	<0.005	<0.005	<0.005	<0.005
Total Cu	mg/L	1	<0.01	<0.003	0.01	<0.01	<0.01	<0.005	<0.005	<0.005		<0.005	
Cynanide	mg/L	0.1							<0.05	<0.51		<0.05	<0.05
Total Fe	mg/L	0.3	1.1	0.95	0.85	0.6	0.5	0.899	0.738	0.958	0.776	1.08	0.881
Total Pb	mg/L	0.05	<0.01	<0.02	<0.01	<0.03	<0.03	<0.001	0.001	<0.001	0.006	<0.001	0.001
Total Mn	mg/L	0.10	0.02	0.02	0.067	0.041	0.039	0.068	0.025	0.094	0.039	0.034	<0.005
Total Hg	mg/L	0.001						0.0002	0.0002	<0.0001	0.0001	<0.0001	<0.0001
Total Zn	mg/L	5	<0.01	<0.01	<0.01	0.04	0.05	<0.005	<0.005	<0.005		<0.005	