



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

Tasmania

**Index of River Condition  
for the  
Ringarooma River Catchment**

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Report Series WRA 99/04  
March, 1999.

## ***Index of River Condition***

### **Executive Summary**

This study was developed as an adjunct to the requirements of the Water Resource Assessment Branch, DPIWE, to develop State of Rivers reports for specific catchments within Tasmania. The study consisted of a ground survey method that utilised a one off snapshot approach for selected sites within a given catchment. The information collected was through a rapid habitat assessment approach known as the Index of River Condition (IRC) for representative reaches of surveyed rivers. The methodology is designed to provide a broad picture of stream condition.

The whole concept was developed with a view to supplying a simple descriptive format that could provide a rapid qualitative assessment of river condition of specific sites and representative reaches. The basic presumption is that the report provides suitable data to illustrate the overall health of a number of representative reaches throughout each catchment. The data has been collected to provide a benchmark study, based on what is regarded as an unimpacted example, that can be re-run, or expanded, at a later date to observe changes over time.

The IRC uses a number of sub-indices based upon physical form of the river channel, streamside vegetation, water quality, aquatic life and hydrology as shown in Table 1.

**Table 1. The sub-index parameters and their associated indicator categories.**

<b>Sub-index</b>	<b>Indicator</b>
Physical form	Overall disturbance
Streamside zone	Width of streamside zone Density of native species Tree height Vegetation type
Water quality	Turbidity Conductivity
Aquatic life	SIGNAL
Hydrology	Upstream CWR's

The sub-indices are then weighted and combined to form the overall Index of River Condition. This represents a categorisation of each sampling site against conditions which would be expected at the site if it were unimpacted or "natural". The higher the rating, the closer the site is to a "natural" state and therefore the lower the impact of streamside and/or catchment activities. Table 2 highlights the categories and associated ratings which were adopted.

**Table 2. IRC category ratings.**

<b>Category</b>	<b>Numerical value (Rating)</b>
Essentially natural	4
Near natural	3
Some modification	2
Major modification	1
Highly modified	0

## 2. RESULTS

Field data collection for IRC parameters occurred at 40 sites within the catchment. 15 were on the main-stream Ringarooma River and 25 on tributary streams. Overall the ratings indicate that the catchment condition is one of 'near natural' indicating a respectively healthy environment.

This project was developed to provide a quality rating for sections of the catchment streams. The initial objectives of the study are as follows:

- to create an index of condition for all observed parameters (i.e. quality rating).
- to develop a system to determine overall site condition and incorporate this into a factor of river condition.
- to base site condition on physical parameters which detect departure from a condition of an estimated 'norm' or 'natural' condition.
- to produce a standardised, easily replicated format that is transferable to other systems.

### *Mainstream Ringarooma River*

The available information indicates that the sites on the main-stream Ringarooma River are slightly impacted but in good condition with the majority of sites falling within a state of near natural condition (IRC score 30 - 40). The data further indicates that there are few instream faunal problems, water quality is reasonable and physical form is largely unimpacted. The hydrological deviation was greatest for the main-stream. The streamside zone sub-index indicated that this zone was where most of the critical problems occurred. It is likely that any impacts have occurred due to intensive land practices such as farming, forestry and mining.

### *Tributaries of the Ringarooma River*

As with the main-stream of the Ringarooma River, the tributary sites are apparently impacted by land practices such as farming, forestry and, in certain areas, mining. These smaller streams are heavily influenced by riparian practices. The available data indicates that most of the critical problems for tributary streams occurs in the stream side zone. There are few instream faunal problems, water quality is reasonable and hydrology is largely unimpacted. The Physical form sub-index varies considerably indicating that there are physical problems associated with many of the catchment tributary streams. Upper catchment sites were generally less impacted than lower where most agricultural activities occur.

**Table 3. Environmental rating for all streams and combination of streams in the entire catchment (corresponds to an average value).**

Category	Numerical value (Rating)		
	Main-stream Ringarooma R. Sites	Ringarooma R. Tributaries	Average for all catchment sites
Hydrology	3.7	8.2	6.5
Physical form	8.4	7.7	8
Streamside zone	6.3	5.2	5.6
Water quality	7	6.4	6.6
Aquatic life	7.5	7.6	7.6
<b>Overall IRC</b>	<b>32.9 (3)</b>	<b>35.1 (3)</b>	<b>34.3 (3)</b>

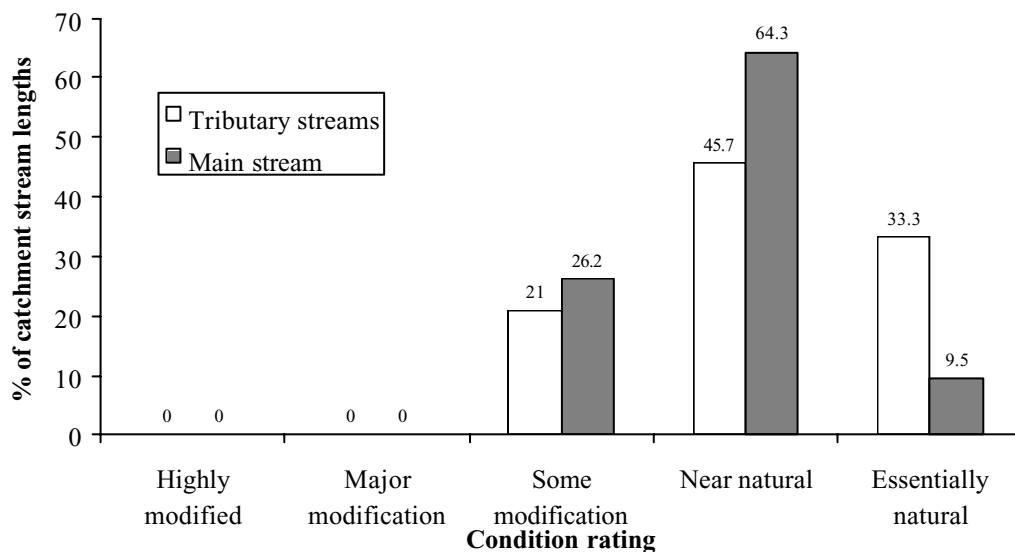
NB: bracketed 3 = good (near natural).

The data in Table 3 illustrates the average value score for each independent sub-index and overall IRC value for the combined sites within the catchment. The available data illustrates that, on average, the overall catchment condition is one of 'near natural' (score greater than 30) indicating a respectively healthy environment. Of all the category values aquatic fauna and physical form rate well, followed closely by water quality and hydrology. With the remaining ratings it is clear that the tributary streams are slightly more impacted than the main-stream. It should be noted that these values are only averages.

### 4.3 Rating of stream length

An examination of the overall condition ratings for both tributary and main-stream lengths reveals no section with a high or major modification to condition. Figure 1 details the rating structure of the proportion of stream lengths within the catchment. As illustrated in the chart over 50% of the catchment is in near or essentially natural condition, while approximately 20% of catchment streams indicate some modification from natural condition. The information available shows that overall condition of the catchment is respectably healthy.

**Figure 1. Proportional quantity of overall catchment river condition.**



## 6. CONCLUSION

The Index of River Condition assessment protocol has effectively illustrated the condition of specific sites and representative reaches within the Ringarooma River catchment. A broad range of sites were chosen to provide a suitable overall picture and to cover the range of variation in conditions that are present.

In general, it has been shown that there are a range of factors that strongly influence site condition, including land use and riparian management practices, water quality and water quantity (flow). It is clear from the information available that sites within the catchment vary away from a natural state but to no more than a moderate degree. Some of the main-stream

tributary streams are highly degraded but most of the catchment rates as near to natural in condition.

Final assessment of data sets for the Index of River Condition has clearly illustrated that it is a useful tool in assessing river condition at selected sites within a catchment that are representative of a given reach. It is a practical means of illustrating the deviation of a site away from its predicted natural state and has shown the overall condition of the catchment and its associated waterways.

The technique also highlights potential problems that may exist within a catchment which are, or have the potential to reduce riverine quality. Using the data available from this study it becomes possible for managers to target potential problem areas such as riparian weed control, revegetation of riparian zones and controlled stock access to river banks. Most major problems are related to the riparian zone. Physical form (bank and bed conditions, overall site disturbance) indicates reasonable condition of these parameters. Aquatic fauna (freshwater invertebrates) are healthy, and water quality is good overall.

With a management infrastructure in place for the catchment, it would be possible to re-run this program in 5 years using the same sites to determine if the overall condition of the catchment has improved or declined.

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## 1. INTRODUCTION

This study was developed as an adjunct to the requirements of the Water Resource Assessment Branch, DPIWE, to develop State of Rivers reports for specific catchments within Tasmania. The study consisted of a ground survey method that utilised a one off snapshot approach for selected sites within a given catchment. The information collected was intended to provide a rapid Index of River Condition (IRC) for representative reaches of surveyed rivers. The methodology is designed to provide a broad picture of stream condition.

The whole concept was developed with a view to supplying a simple descriptive format that could provide a rapid qualitative assessment of river condition of specific sites and representative reaches. The report is far from comprehensive but the basic presumption is that it provides suitable data to illustrate the overall health of a number of representative reaches throughout each catchment. The data has been collected to provide a benchmark study that can be re-run, or expanded, at a later date to observe changes over time.

For the purposes of this report 'stream condition' is defined as the physical condition of the river as directly related to a 'natural condition'. The basis of the whole process is to analyse data against a benchmark of what is regarded as an unimpacted example. Each parameter is also viewed in terms of its importance for maintaining adequate conditions to support a healthy population of instream fauna.

This report is a continuation of a program being developed by Water Resource Assessment Branch staff that is designed to provide rapid analysis of environmental conditions of Tasmanian streams. The basic methodology is a modification of methods that have been successfully trialed and are now operational in several mainland states.

## 2. STUDY AREA

The study catchment was that containing the main Ringarooma River system. The catchment is situated in the north-east corner of the state. It is a class 6 river at its mouth. The river is 107 km long and originates at an altitude of 1000 m off Mt. Maurice (Figure 1). The main-stream is unregulated but there are some major storage's on several tributary streams. The river originates in a granodiorite massive and passes through largely granite in its middle reaches and into alluvium in its lower reaches.

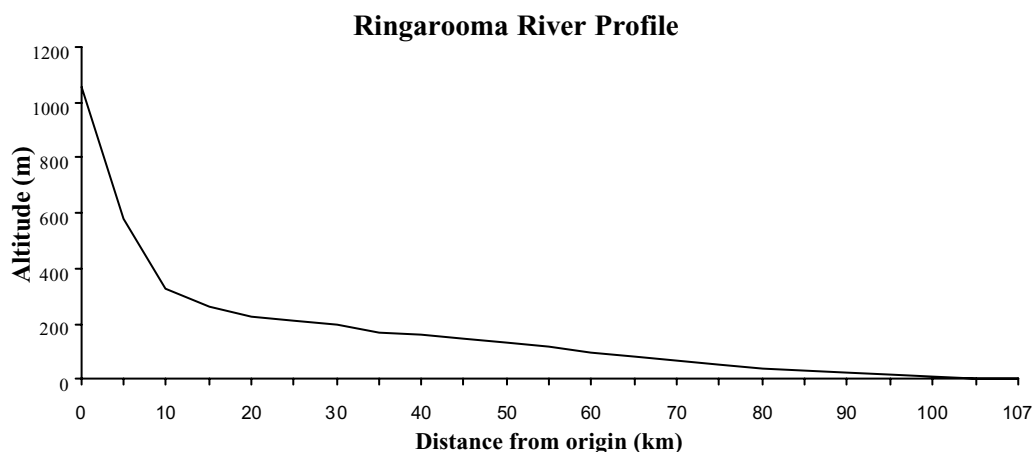




Figure 1. Ringarooma R. altitudinal profile.

The river is heavily influenced by dairy farming, particularly in its upper reaches. Forestry activities also occur in the upper reaches. The river and its surrounds also have an extensive history of alluvial tin mining. At one stage dredging for tin occurred within the river itself and heavy modification of the river bed in the lower reaches has led to massive input of alluvial sands which totally dominate the substrate. Mining began in 1875 and had ceased by 1982 (Knighton, 1989). The upper reaches are typified by a cobble-gravel substrate grading to boulder-cobble in the higher reaches. The majority of cleared agricultural land occurs in the upper catchment.

The annual median flow is 5.9 cumecs and summer median flow is 2.375 cumecs (calculated from Moorina gauging station). The average annual rainfall for the catchment is greater than 900 mm. There is an average (last 10 years) for the catchment summer (December to March) water extraction quantity of approximately 2363 megaliters.

Field data collection for IRC parameters occurred at 40 sites within the catchment. 15 were on the main-stream Ringarooma River and 25 on tributary streams (Figure 2).

### **3. METHODOLOGY DESCRIPTION**

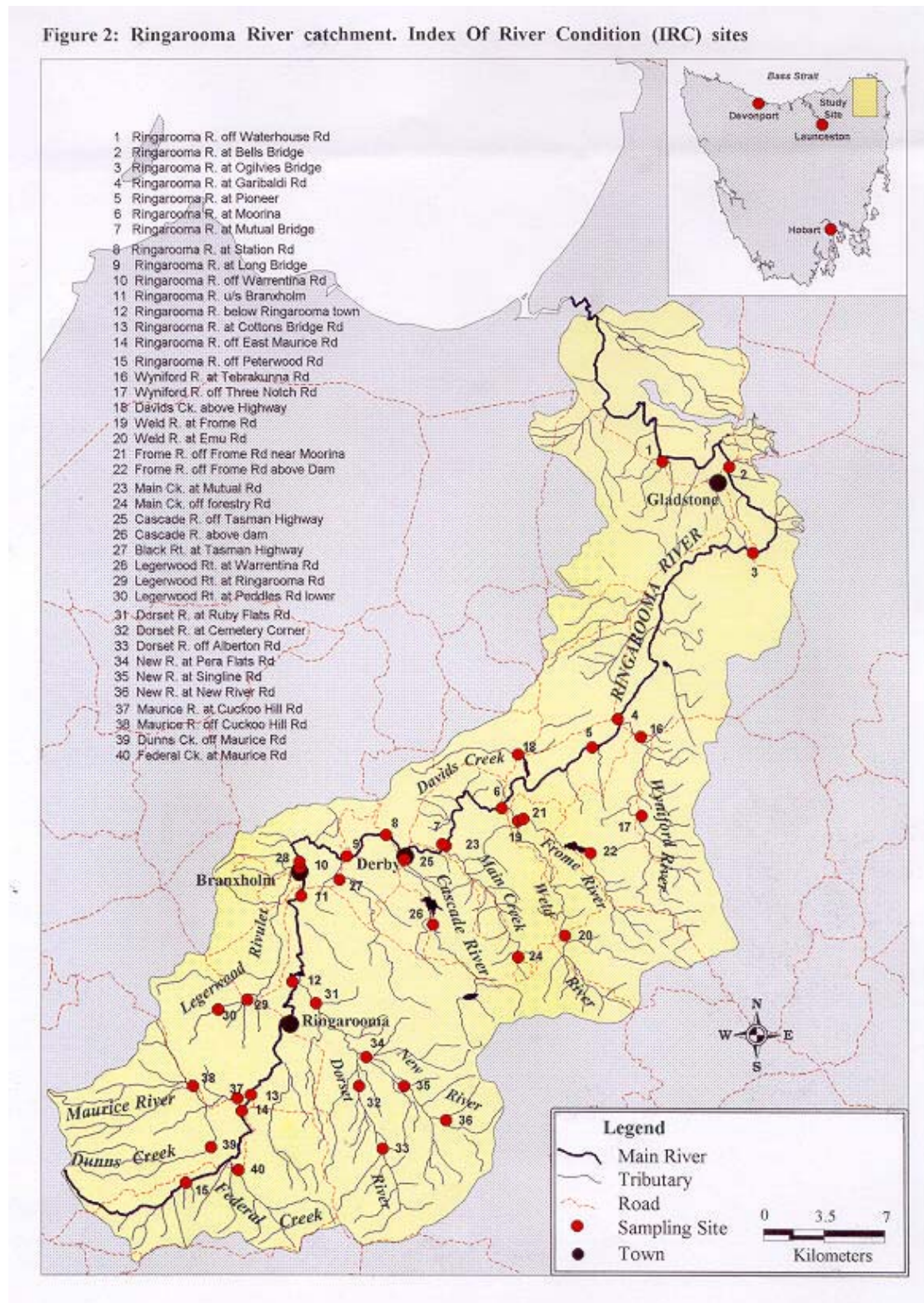
This technique is a modification of the methods adopted by the Queensland Department of Primary Industries 'State of the Rivers' studies and the 'Index of Stream Condition' developed by the Victorian Department of Conservation and Natural Resources. It involves the use of a 'snap-shot' approach, that is, a one off survey of river condition at a number of representative sites along the length of target streams within the catchment. Most of the recorded parameters have been adopted from the Victorian method. For a precise understanding of the parameters recorded in accordance with the Victorian model, readers are referred to CEAH (1997) Index of Stream Condition User's, Reference and Trial Application manuals.

The aim is to achieve an understanding of current physical conditions within a system which can be used as a bench-mark for future comparative work. This is achieved through gathering information on physical and ecological conditions of the stream system that will detect impacted reaches within the catchment and provide a baseline against which future assessments of river condition can be compared. The overall format, therefore, is designed not only to provide rapid assessment of river condition, but also as a long term tool for monitoring change within the catchment.

This procedure requires the assessment of data gathered from field and office sources. These assessments are based on a range of inputs that are placed into rating categories. A number of indicators may be recorded and these values will be combined under one group category to provide a sub-index value. Sub-index values are weighted on a scale of between 0 and 10. These scores are then combined to supply an overall environmental condition rating for each site. The final assessment of site and catchment condition is subjective in nature and findings must be viewed with this in mind.

Field sampling was conducted by teams of two. One team member sampled and picked the macroinvertebrate fauna, the other member assessed habitat variables. To standardise the sampling techniques each individual retained their role for the entire sampling period. If several teams were used they worked areas together and the close proximity of most sites enabled six to eight samples to be completed a day. This approach also ensured good

Figure 2: Ringarooma River catchment. Index Of River Condition (IRC) sites



communication between the teams, helping to standardise techniques and minimise potential problems.

The methodology is based on the following sub-indices:

- 1) Physical form;
- 2) Streamside zone;
- 3) Water quality;
- 4) Aquatic life;
- 5) Hydrology.

Each sub-index represents a composite of one or more parameter measurements, and the sub-indices are combined to provide a single rating of site condition.

#### *Objectives*

- a) to create an index of condition for all observed parameters (i.e. quality rating).
- b) to develop a system to determine overall site condition and incorporate this into a factor of river condition.
- c) to base site condition on physical parameters which detect departure from a condition of an estimated 'norm' or 'natural' condition.
- d) to produce a standardised, easily replicated format that is transferable to other systems.

Full descriptions of all physical aspects of each site are necessary to observe changes (improvements/degradation) in sites if subsequent studies are undertaken at a later date, and as optional input into the analysis of stream condition. Therefore, more information than is directly used in final analysis is normally collected as back-up information to observe potential anomalies or discrepancies in the data sets and as full descriptors of sites if follow-up studies are to be undertaken.

#### *Parameter ratings*

Parameter scoring is based on a 5 point rating scale wherever possible (Table 1). Ratings are based on the difference between the current value of the indicator and what it would be under unimpacted conditions. Victorian authorities justify the use of a 5 point scale by stating that higher ratings would be unrealistic given the current state of knowledge. With less than 5 points there are problems as the category size becomes too large.

Table 1. Example of a 5 point scale for indicator measurements.

<b>Category</b>	<b>Numerical value (Rating)</b>
Essentially natural	4
Near natural	3
Some modification	2
Major modification	1
Highly modified	0

#### *Training*

All team members participating in field sampling were required to undergo field training. Initial training is essential to maintain consistency in faunal sampling techniques and habitat assessment protocols. Training also highlights deficiencies in descriptive formats that can lead to confusion during field operations.

### 3.1 Sub-index headings

Through field measurements a number of indicators may be recorded (Table 2) and these values will be combined under 1 group category to provide a sub-index value. Sub-index values are weighted in a scale of between 0 and 10. Descriptions of sub-index parameters are detailed below.

Table 2. The sub-index parameters and their associated indicator categories.

Sub-index	Indicator
Physical form	Overall disturbance
Streamside zone	Width of streamside zone Density of native species Tree height Vegetation type
Water quality	Turbidity Conductivity
Aquatic life	SIGNAL
Hydrology	Upstream CWR's

#### 3.1.1 Physical form

##### *Bank condition*

Bank condition or stability is an assessment of the amount of erosion occurring at set points within the study site. Potential indicators of current bank instabilities include:

- a lack of vegetative cover or exposed soil.
- irregularities and sharp bends in the stream course.
- undermining of the toe of the banks and exposed roots.
- water discoloration along the toe of the bank, and
- evidence of recent soil slips.

##### *Bed condition*

Bed condition is a measure of overall aggradation and degradation of the stream bed at each transect location. Potential indicators of current bank instabilities include:

- erosion heads.
- there are bank instabilities on both sides of the bank (this indicates bed degradation).
- the type of soil present in the area (i.e. generally sand, mostly clays, etc.) is different to the soil in the bed;
- any accumulations of sediment around obstructions (typically coarse woody debris), and
- the general width to depth ratio is low for degradation and high for aggradation.

##### *Density and origin of coarse woody debris (snags)*

Instream woody debris can represent a very important habitat for aquatic animals. It provides a refuge for many animals, food source for many macroinvertebrates, and is important for spawning for some fish species (e.g. Blackfish). The rating scale is based on the proportion of available (maximum to minimum) snags. The rating assumes that the greater the proportion of snags available, the more habitat there is for instream fauna.

### *Influence of artificial barriers*

The presence of artificial barriers indicates a clear change from natural conditions. Barriers include weirs, dams, culverts, etc. Barriers largely affect fish movement but may heavily impact available downstream water quantity which can have an effect on all ecosystem functions. The rating for artificial barriers is based on a function of fish migration.

### *Overall site disturbance*

This parameter was singularly categorised as an overall rating for a total site reach. Six disturbance categories were available (extreme, very high, high, moderate, low and very low) one of which was selected for each site. All categories were present in this assessment. The categories are largely based on physical aspects of streamside vegetation.

## **3.1.2 Streamside zone**

Riparian vegetation plays an important role in the maintenance of stream condition. For example, streamside vegetation exhibits the following attributes (taken from AGS and Pen, 1995)

- increased bank roughness reducing erosion potential,
- roots bind and reinforce soil (bank stabilisation),
- roots also loosen soil allowing greater infiltration of rainwater,
- sediment and nutrient filters,
- promotes sediment deposition,
- ecological corridors,
- habitat availability for animals and plants.

Factors such as these aid in maintaining the quality and integrity of a waterway.

### *Width of streamside zone*

This was regarded as the average distance from water's edge at base flow to any cleared or developed land. The streamside zone is the interface between the aquatic and terrestrial environment. This parameter is largely designed to determine how much vegetation is present from the river bank to when some form of disturbance, such as clearing, occurs. Of course the streamside zone may be extensive therefore anything over 40 m should be recorded as such. The size of the streamside zone is important to determine how much of a buffering effect it is having from adjacent developed land and to indicate the continuous presence of vegetation which is important as faunal corridors and habitat.

### *Structural intactness*

Structural intactness is an indicator of disturbance relating to the original size distribution of streamside vegetation.

The following definitions for the three structural layers are based on the Victorian model.

- overstorey: woody plants greater than 5 m tall.
- understorey: woody plants less than 5 m tall.
- ground cover: other plants without woody stems.

The ratings for structural intactness are based on a scale of continuous, patchy and sparse. This rating is applied for each structural layer.

#### *Proportion of cover which is indigenous*

This category is reasonably self explanatory. It refers to the proportion of non-exotic or introduced species that are present. The amount of native species present provides a rating of how near to natural the site may be. The presence of exotic species may also be undesirable depending on the quantity and/or the particular species. Ratings are according to the percentage cover that is available and also applies to each structural layer.

#### ***Presence of regeneration of indigenous species***

Regeneration of indigenous species is an important descriptor of current condition. But, due to the difficulty in assessing the regeneration of ground cover species, it has been applied to overstorey and understorey species only.

#### *Condition of wetlands and ponds*

This factor has been directly adopted from the Victorian model but is of limited application for the Tasmanian environment. Nevertheless, there are examples of significant wetlands that exist so the category has been retained.

In general, this category has been developed to assess whether more than 50% of a wetland in a reach is in reasonable condition. This indicator only applies to floodplain reaches.

#### *Longitudinal continuity*

This parameter proved to be the most difficult for field staff to adopt yet it is one of the more effective measures. In essence, longitudinal continuity is simply a measure of how continuous streamside vegetation is. Any gap that exists in vegetation corridors has the potential to act as a barrier to faunal movement. The parameter specifications adopted here are the result of expert panel discussions. The two factors applied are:

- proportion of bank length with vegetation greater than 5 m wide, and
- the number of significant discontinuities per unit length.

A significant discontinuity is a gap in the streamside vegetation 10 m long or greater that is less than 5 m wide.

#### ***Overstorey streamside vegetation regeneration***

This parameter is regarded as a rough indicator of disturbance. Taller trees indicate long term stability potentially from fire, logging or general clearing.

#### *Vegetative regrowth categories*

This rating is based on the assumption that natural succession in vegetation occurs whereby the final position is that of pure rainforest (highest rating).

#### *Streamside cover*

The indicators for this section are categorised as follows:

- canopy cover
- vegetation overhang
- root overhang

- bank overhang
- man-made overhang

The data collected for this section provides an assessment of available habitat in the form of shelter and shading for aquatic life. Overhanging trees may also provide a direct food source in the form of leaf and insect fall into the stream.

### 3.1.3 Water quality

Water quality parameters were collected by two separate methods within this study. At each habitat analysis sampling date for each site a single set of water quality parameters were collected. In association with this a temporal pattern of catchment water quality is reviewed in a separate section of the State of Rivers report. This involved monthly spot samples of representative sites throughout the catchment over a 12 month period. This information, although collected separately to the IRC process, was made available so that a more rounded assessment of catchment water quality could be determined from a broader data set. All results are presented in accordance to the guidelines listed below.

#### *Turbidity Guidelines For Tasmanian Rivers*

Turbidity in water is caused by:

- suspended matter such as clay, silt, fine organic and inorganic matter.
- soluble coloured compounds.
- and microscopic organisms.

Turbidity is an expression of the optical property of the water that causes light to be scattered rather than transmitted in a straight line through the sample. It is a useful measure of the amount of sediment being transported in the river and high turbidity readings often indicate active erosion or stream disturbance.

Turbidity is often related to flow and can vary dramatically with time, so classification of a river using turbidity should be based on the average of many readings taken over a wide range of flows. This was achieved for selected sites throughout the catchment with spot samples for the remainder. Table 3 illustrates the rating scale for turbidity levels subject to reach location.

Table 3. Turbidity values for Tasmanian streams.

Mountain	Valley	Plain	Rating
< 5	< 10	< 15	4
< 7.5	< 12.5	< 17.5	3
< 10	< 15	< 20	2
< 12.5	< 22.5	< 30	1
> 12.5	> 22.5	> 30	0

\* Values are in Nephelometric Turbidity Units (NTU's).

#### *Conductivity Guidelines For Tasmanian Rivers*

The Electrical Conductivity measured in water provides an indication of the amount of dissolved salts and hence salinity. The following table (Table 4) is an approximate guide to what constitutes a high or low conductivity value with respect to dissolved salts. In Tasmania,



most of the lowland rivers will generally fall within the range of 100 -500  $\mu\text{S}$ . In upper catchments most readings will be between 20 - 100  $\mu\text{S}$ .

Table 4. Conductivity values for Tasmanian streams.

Mountain	Valley	Plain	Rating
< 20	<50	< 100	4
20 - 60	50 - 100	100 - 250	3
60 - 90	100 - 300	250 - 450	2
100 - 150	300 - 500	450 - 750	1
>150	>500	>750	0

\* All expressed in  $\mu\text{S cm}^{-1}$  (microSiemens per cm).

#### *pH Guidelines For Tasmanian Rivers*

Ratings for pH are presented in Table 5. Available pH data for Tasmanian rivers is limited at this stage, therefore, the rating scale adopted by Victorian authorities has been used for this survey.

Table 5. Criteria for assessing pH.

pH range	Rating
6.5 - 7.5	4
6.0 - 6.4 or 7.6 - 8.0	3
5.5 - 5.9 or 8.1 - 8.5	2
4.5 - 5.4 or 8.6 - 9.4	1
> 9.5 or < 4.5	0

A full evaluation for water quality for the whole catchment is detailed in the SOR water quality section of this report.

### 3.1.4 Aquatic Life

#### *Macroinvertebrate Sampling*

Invertebrates are animals without backbones, macroinvertebrates are those invertebrates that can be easily seen with the naked eye. As a group they have become widely used as biological indicators of stream and river health. They are one of the most easily studied biological components of streams. They can be simply collected in large quantities with inexpensive equipment and readily preserved and identified. They occupy a central role in the food chain and include herbivores which eat algae and other material, detritivores which eat dead animal and plant material and carnivores that eat other invertebrates. They themselves provide a valuable food source for freshwater vertebrates such as fish, platypus and birds.

A large number of species, or groups of species, are highly sensitive to even a mild stress. Impacts from agricultural and industrial activities, forestry operations and mining, and physical modification of streams such as damming and channelisation have all been known to effect the abundance and or composition of the macroinvertebrate community (Oldmeadow; In: Bobbi *et al.* 1996). Macroinvertebrates, therefore, are important indicators of instream quality and are a useful tool for monitoring purposes.



Macroinvertebrates were sampled from one riffle habitat. Edgewater habitats were sampled only if the level of flow was so low that riffle habitats were not available. Samples were taken using a standard 250µm mesh dip net (dimensions 25 x 35 x 70 cm, height x width x depth). The substrate from a ten metre section from each habitat was disturbed by kicking over and rubbing the surface of stones while the net was held downstream. This action dislodged organisms which were then swept into the net.

The contents of the dip net were emptied into a sorting tray and the sample picked for a total of 30 minutes using forceps. The picked material was identified to the taxonomic level of family and numbers were counted in the laboratory.

Aquatic invertebrates are good indicators of river health. Invertebrate data was collected for all 40 sites during the field sampling program. From the available invertebrate data a scoring system based on a sensitivity grade for Family level information can be determined to ascertain the health of a particular site. The conversion factors and comments for the appropriate grades are listed below (Table 6).

Table 6. SIGNAL values for faunal data based on Chessman (1995).

SIGNAL value	Rating	Comment
>7	4	Excellent
6-7	3	Clean water
5-6	2	Doubtful, mild pollution
4-5	1	Moderate pollution
<4	0	Severe pollution

The SIGNAL (Stream Invertebrate Grade Number Average Level) value is a simple biotic index based on a sensitivity grade for families of common invertebrate fauna to pollution in rivers. The index is calculated by summing the grades for all the families present at a site, the total is then divided by the number of families at the site which gives an average grade per family. Analysis of specific Tasmanian data has led to Tasmanian River Health Officers recommending the use of the original scale (Chessman, 1995) rather than the new national scale (Chessman, *et al.* 1997).

### 3.1.5 Hydrology

Tasmanian rivers suffer from a number of impacts that affect water quantity. Many rivers are subject to hydro-electric regulation, many others are impacted by agricultural, industrial and domestic extraction requirements. The DPIWE is the state regulator for Commission Water Rights (CWR's) which are licensed extraction quantities provided to consumers. The Ringarooma River catchment is largely influenced by irrigation extraction pressures particularly during the summer months. The catchment has only one hydro-electric impoundment which is situated on the Frome River.

The hydrology index encompasses the deviation between estimated unimpacted and current impacted flow regimes. The data used to calculate this index is the median monthly flow during the summer period (January to March) with the addition of the estimated CWR outake used to calculate what flow should be in the river. The deviation between the estimated natural flow and current flow is used to calculate a rating scale for this parameter. The median flow

over the past 10 years of record was chosen as the best representation of the normal amount of water in the river for each month.

## 4. RESULTS

The IRC results for the Ringarooma River system were assessed from a total of 40 catchment sites (Figure 2). Final analysis is reported in the following section. If no results were reported for a site then no data was available for evaluation. The results are presented for the main-stream Ringarooma River, and its tributaries. The final environmental rating for each site was determined by combining all the sub-index values from the sources indicated above. Table 7 illustrates the condition categories associated with the appropriate rating scores for the range of values that may be obtained for each individual site. This data can then be used to produce an overall environmental value for a site. This is a generalised category that supplies a descriptive condition for a site. A full list of site sub-index ratings are presented in Appendix 1.

Table 7. IRC rating categories for individual sites.

<b>Condition</b>	<b><u>Very poor</u> Highly modified</b>	<b><u>Poor</u> Major modification</b>	<b><u>Moderate</u> Some modification</b>	<b><u>Good</u> Near natural</b>	<b><u>Excellent</u> Essentially natural</b>
Total score	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50
Environmental rating	0	1	2	3	4

All field data was collected in February 1998.

Each site was selected as representative of a reach (length of river). Photographs of each site were also taken.

A graphical illustration of all the parameter ratings as estimated for each stream reach is presented in Appendix 3 to 7. The parameters are for the physical form, streamside zone, water quality, aquatic life and hydrology sub-index ratings.

#### 4.1 Summary results for main-stream Ringarooma River sites

The IRC results for the main-stream Ringarooma River are provided in Figure 3. Parameters that suggest major or extreme modification from a natural or ideal condition are highlighted in Table 8 along with data gaps. 15 sites (reaches 1-15) were sampled in the main-stream.

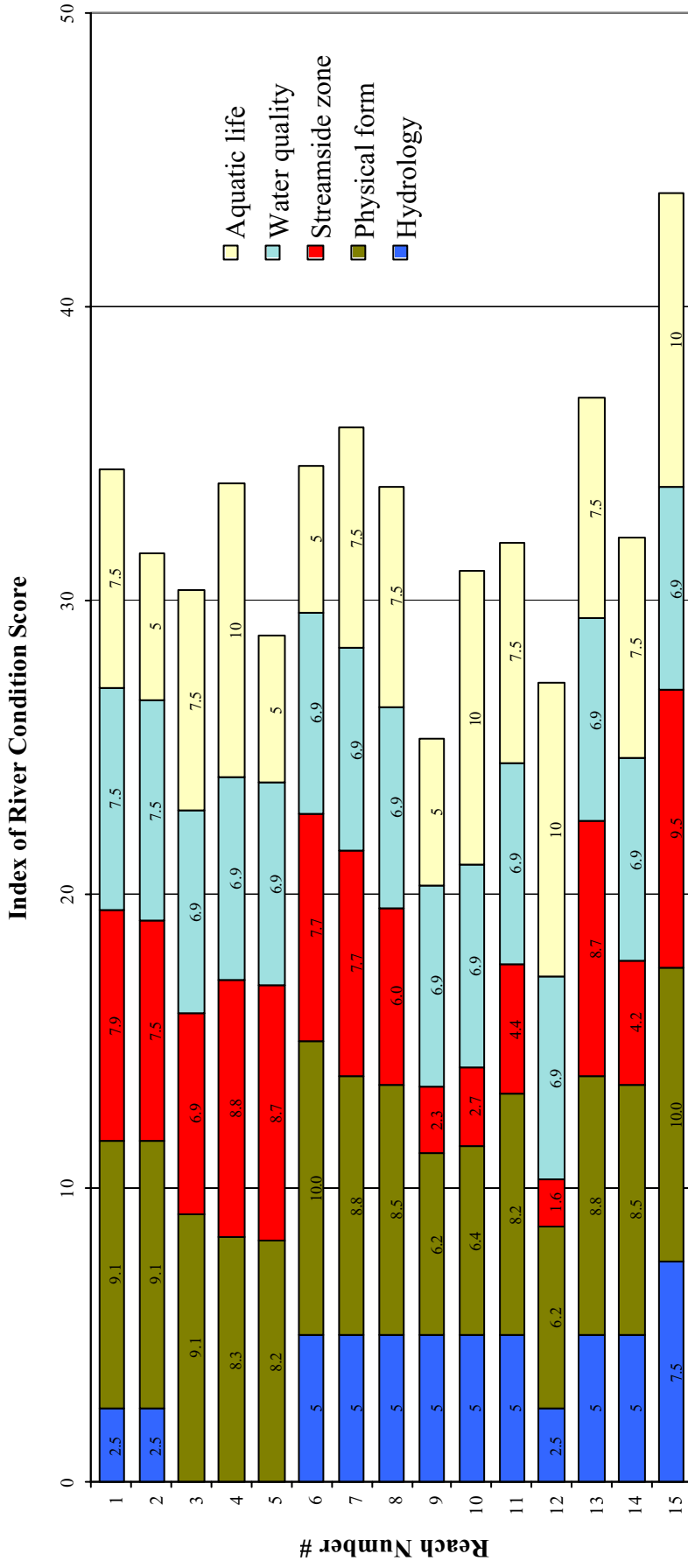
Comments on the results are highlighted as follows:

- The IRC scores indicate the majority of sites fall within a state of near natural condition (IRC score 30 - 40). The uppermost site on the river was above all land use activities and clearly rated as in essentially natural condition. Only 3 sites came out as slightly modified (20 - 30, sites 5, 9 & 12).
- The hydrology sub-index scores were low overall for most sites (including three 0 ratings) indicating extraction rates for the summer period are high and may be strongly influencing instream processes. Site 3, 4 and 5 (lower mainstream Ringarooma R.) all had 0 ratings indicating large Commissionial Water Rights within this section. Whether actual excessive outakes occur in this region is not known.
- Physical form sub-index rated well for all sites which is a strong indicator of good habitat conditions.
- The streamside zone sub-index scores were the lowest of all the sub-index values with 5 sites rating below 5 points. Streamside cover revealed at least a major difference from ideal condition for 10 of the 15 sites. Structural intactness also revealed at least a major difference from ideal condition for 7 sites. This largely indicates inadequate riparian zones.
- Water quality at all sites was consistently high.
- IRC results suggests that aquatic life within the main-stream is in healthy condition with only 4 sites exhibiting average conditions and 3 sites with a maximum score of 10.
- No data gaps were present for the main-stream sites.

Reach No.	Site	Easting (m)	Northing (m)	Altitude (m)	Area (Km <sup>2</sup> )
1	Ringarooma, Waterhouse Rd	582100	546630	15	825.1
2	Ringarooma, Bells Bridge	585500	5465800	25	798.3
3	Ringarooma, Ogilvies Bdge	586800	5461000	35	719.1
4	Ringarooma, Garibaldi Rd Bdge	579300	5451700	72	649.8
5	Ringarooma, Pioneer.	577900	5450100	78	599.8
6	Ringarooma, Moorina.	572900	5446700	110	503.1
7	Ringarooma, Mutual Bridge.	569600	5444700	130	442.4

8	Ringarooma, Station Rd.	566500	5445200	150	391.2
9	Ringarooma, Long Bridge.	564300	5444000	160	380.2
10	Ringarooma, Off Warrentina Rd	561700	5443700	170	339.1
11	Ringarooma, above Branhholm	561800	5441800	180	275.3
12	Ringarooma, Below Ringarooma town.	561300	5437000	200	146.2
13	Ringarooma, Cotton's Brdge Rd.	559100	5430700	250	116.1
14	Ringarooma, East Maurice Rd.	558500	5429800	310	50.5
15	Ringarooma, Off Petterwood Rd.	555600	5425800	355	16.3

Figure 3. IRC results for the Ringarooma River main-stream sites.



**Table 8. Indicators suggesting a major or extreme difference from natural or ideal conditions, and data gaps, for the Ringarooma R. main-stream sites.**

Reach	Hydrology (#)		Physical form (#)					Streamside zone (#)					Water quality (#)			Aquatic life (#)					
	M, V or F.	Dams or diversions	Hydro-electric	CWR extract.	Bank cond.	Bed cond	Barrier	CWD	OSD	Riparian width	Struct intact.	% indig.	Regen. Indig.	LC	Overst regen.		SC	Turb.	Cond	PH	
1	V	No	No	Red																	
2	V	No	No	Red																	
3	V	No	No	Red																	
4	F	No	No	Red						Red											
5	V	No	No	Red																	
6	V	Yes	No					Red													
7	V	No	No																		
8	V	No	No						Red												
9	V	Yes	No						Red												
10	F	No	No						Red												
11	V	No	No																		
12	F	No	No	Red					Red												
13	V	No	No																		
14	V	No	No							Red											
15	V	No	No																		

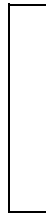
Key to table



Indicator suggests major or extreme difference from natural or ideal conditions.



Inadequate data to evaluate sub-index.



Adequate data to evaluate indicator and ratings suggest changes have not been extreme or major.

M = Mountain.

V = Valley.

F = Floodplain.

CWR = Commissioned water rights.

CWD = Coarse woody debris (snags).

OSD = Overall site disturbance.

LC = Longitudinal continuity.

# = refer to Section 3 (Methodology Description) for details of all parameters.

SC = Streamside cover.

#### 4.2.1 Summary results for tributary streams of the Ringarooma River.

The IRC results for the tributary streams of the Ringarooma River are provided in Figure 4 and 5. Results are split purely to reduce complication in analysis due to the large number of sites. Parameters that suggest major or extreme modification from a natural or ideal condition are highlighted in Table 9 and 10 along with data gaps. A total of 13 tributaries consisting of 25 sites (reaches 16-26) were sampled.

Comments on the results in Figure 4 and Table 9 are highlighted as follows:

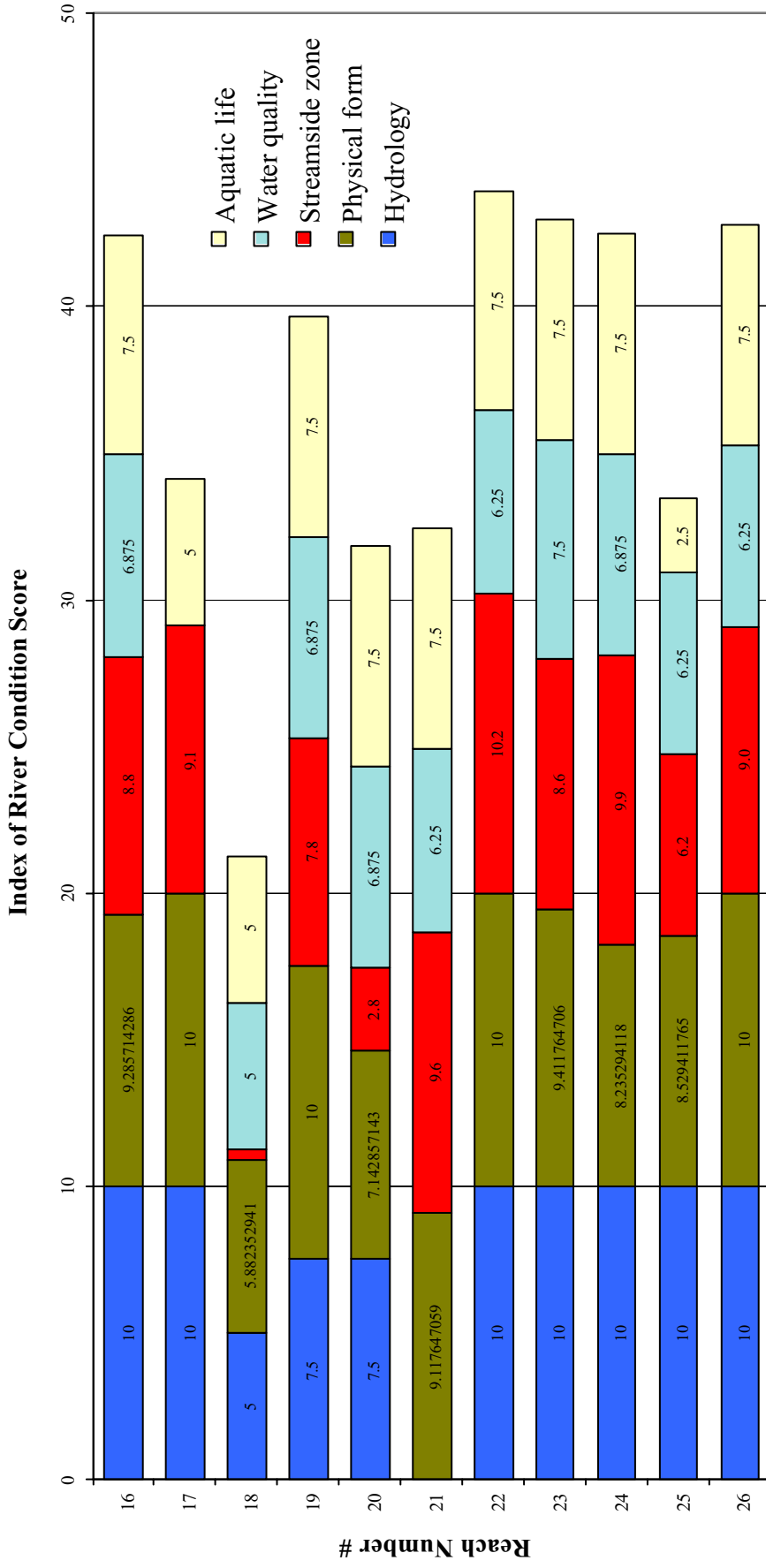
- A general observation is the clear increase in overall scores between upper and lower sites in each tributary (reach 16 & 17, Wyniford R., reach 21 & 22, Frome R., reach 25 & 26 Cascade R.) Upper catchment sites are frequently less impacted than lower. Main Ck (reach 23 & 24) is essentially unimpacted for both sites. Site 18 (Davids Ck) is clearly the most impacted with moderate modification from natural conditions. The remaining tributary sites are all in good condition or higher.
- The hydrology sub-index remains consistently high for all the tributaries except Davids Ck (reach 18, heavily modified agricultural system) and the lower Frome River (reach 21, has water diverted for Hydro-electricity).
- For all 11 reaches, the Physical form sub-index scored between 7.1 and 10, indicating an essentially natural condition except for Davids Ck (reach 18) which is highly modified from natural conditions.
- The Streamside zone sub-index scored consistently well except once again for Davids Ck (all parameters show extreme modification from natural) and the upper Weld R. site (reach 20) which exhibited extreme modification from natural for riparian width, structural intactness, proportion of indigenous species and longitudinal continuity.
- The Water quality sub-index showed no significant variation from a natural condition for all sites, except Davids Ck had a high turbidity reading indicating extreme modification. Data was missing for the upper Wyniford R. (reach 17) therefore limiting analysis of total IRC score for this site.
- The Aquatic life sub-index was extremely modified at the lower Cascade R. site (reach 25) possibly due to the effects of the upstream impoundment. Reach 17 and 18 (Wyniford R. and Davids Ck) showed some modification from natural condition.
- The only data gaps present were for water quality parameters on the upper Wyniford River (site 17).

Reach No.	Site	Easting (m)	Northing (m)	Altitude (m)	Area (Km <sup>2</sup> )
16	Wyniford R., Bottom.	580600	5450700	95	57.0
17	Wyniford R., Top.	580450	5446400	130	35.0
18	Davids Ck.	573800	5449700	105	8.1
19	Weld R., Bottom.	573800	5446000	220	50.2
20	Weld R., Top.	576400	5439600	350	26.0
21	Frome R., Bottom.	574100	5446100	220	17.8
22	Frome R, above dam.	577800	5444200	330	12.6
23	Main Ck., Bottom.	569800	5444600	140	20.6



24	Main Ck., Top.	573800	5438400	420	2.3
25	Cascade R., Tasman Highway	567500	5443800	160	38.0
26	Cascade R., Top.	569100	5440200	360	25.4

Figure 4. IRC results for the Ringarooma River tributaries.



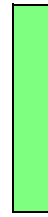
**Table 9. Indicators suggesting a major or extreme difference from natural or ideal conditions, and data gaps, for the Ringarooma R. tributary sites.**

Reach	M, V or F.	Hydrology (#)				Physical form (#)					Streamside zone (#)					Water quality (#)			Aquatic life (#)		
		Dams or diversions	Hydro- electric	CWR extract.	Bank cond.	Bed cond	Barrier	CWD	OSD	Riparian width	Struct intact.	% indig.	Regen. Indig.	LC	Overst regen.	SC	Turb.	Cond.		pH	
16	F	No	No																		
17	V	No	No																		
18	V	No	No																		
19	V	No	No																		
20	F	No	No																		
21	V	Yes	Yes																		
22	V	No	No																		
23	V	No	No																		
24	V	No	No																		
25	V	No	No																		
26	V	No	No																		

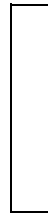
Key to table



Indicator suggests major or extreme difference from natural or ideal conditions.



Inadequate data to evaluate sub-index.



Adequate data to evaluate indicator and ratings suggest changes have not been extreme or major.

M = Mountain.

V = Valley.

F = Floodplain.

CWR = Commissioned water rights.

CWD = Coarse woody debris (snags).

OSD = Overall site disturbance.

LC = Longitudinal continuity.

SC = Streamside cover.

# = refer to Section 3 (Methodology Description) for details of all parameters.

#### **4.2.2 Summary results for tributary streams of the Ringarooma River.**

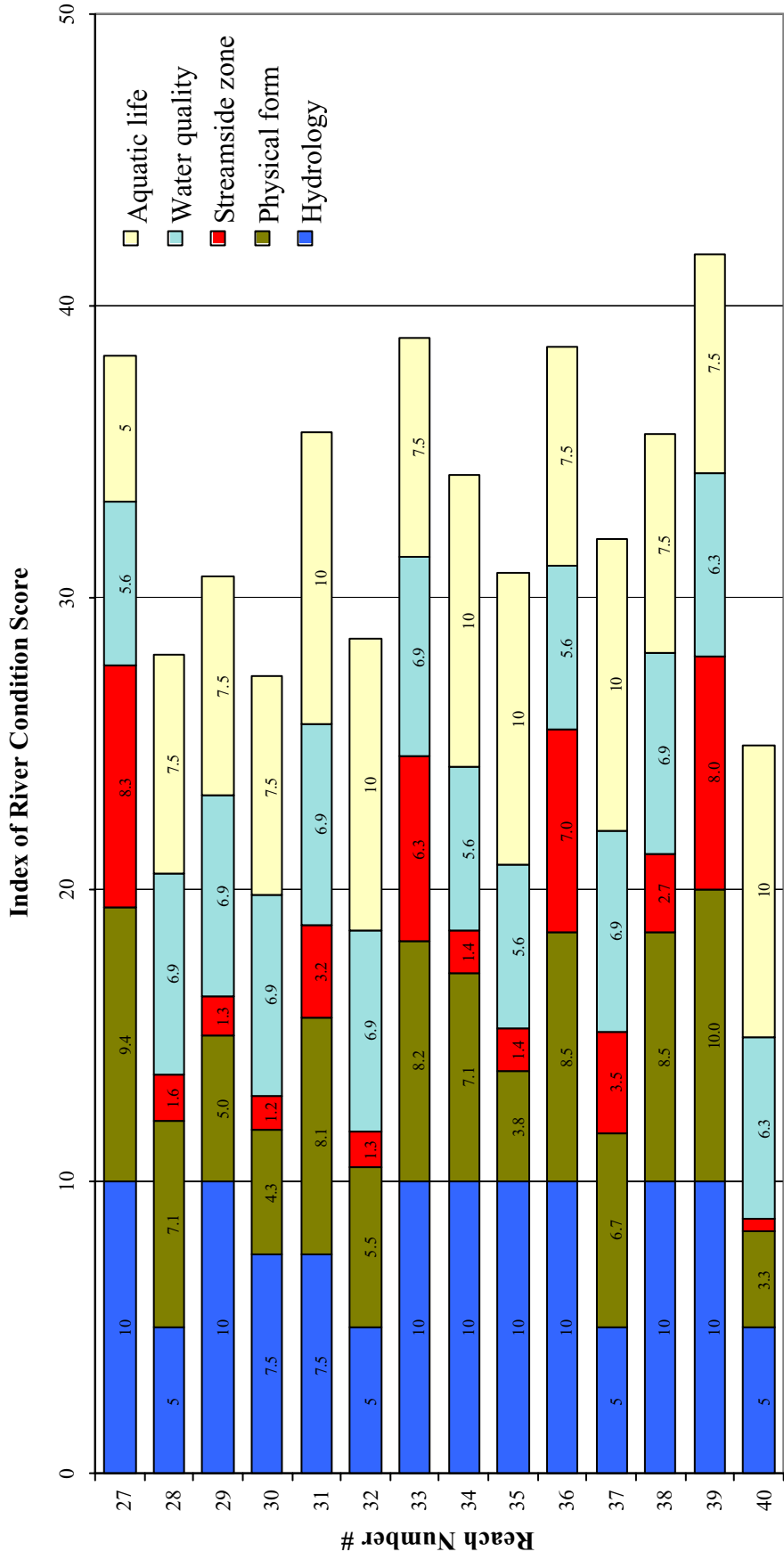
The second IRC results for the tributary streams of the Ringarooma River are provided in Figure 5 (reaches 27-40). Parameters that suggest major or extreme modification from a natural or ideal condition are highlighted in Table 10. No data gaps were encountered for this group of sites.

Comments on the results are highlighted as follows:

- Total IRC scores vary between moderate modification from a natural condition (4 reaches), near natural (9 reaches), to essentially natural (1 reach, upper Dunns Ck). Ledgerwood Ck is a highly modified agricultural catchment and there is little variation between the sites (reaches 28, 29 and 30). The Dorset R. (reaches 31, 32 and 33) and New R. (reaches 34, 35 and 36) also illustrate they are variable systems with the upper catchment sites (reach 33 and 36) scoring the highest. Dunns Ck (reach 39) is an unimpacted system and scores highly, whereas Federal Ck (reach 40) is a highly impacted reach and the low score illustrates this.
- The hydrology sub-index exhibits only minor modification from natural conditions for 6 reaches and the remaining 8 reaches rank as essentially natural.
- The Physical form sub-index varies considerably. Reach 35 (New R.) and 40 (Federal Ck) are highly modified with extreme modification in the parameters bank and bed stability, coarse woody debris and overall site disturbance. Reach 30 (upper Ledgerwood R.) exhibited extreme difference from natural or ideal conditions through the parameters bank stability, coarse woody debris and overall site disturbance. The parameter overall site disturbance exhibited extreme difference from natural or ideal conditions at 8 of 14 sites. This indicates that there are physical problems associated with many of the catchment tributary streams.
- Streamside zone sub-index showed extreme modification for 10 out of 14 reaches. Only reach 27 (Black Rivulet), 33 (upper Dorset R.), 36 (upper New R.) and 39 (Dunns Ck) exhibited minor modification. All the sub-index parameters were extremely modified in some form for all sites. Again this indicates that riparian condition of the catchment tributary streams is in poor condition, particularly for the upper catchment tributaries (Table 10).
- The Water quality sub-index parameters rated as moderate modification or near natural. pH exhibited extreme difference from natural or ideal conditions for reach 27 (Black Rt), 34, 35 and 36 (all New R. reaches).
- Aquatic life sub-index rated near to natural for all sites except reach 27 (Black Rt) which was moderately modified.

Reach No.	Site	Easting (m)	Northing (m)	Altitude (m)	Area (Km <sup>2</sup> )
27	Black Rt	563900	5442800	170	22.4
28	Legerwood R., at Warrentina Rd.	561700	5443400	180	60.7
29	Legerwood R., Peddles Rd.	557200	5435450	260	8.1
30	Legerwood R., Ringarooma Rd.	558800	5436000	240	13.8
31	Dorset R., Ruby Flats Rd	562600	5435800	210	115.8
32	Dorset R., Cemetery Corner	565000	5431200	260	29.9
33	Dorset R., Top.	566300	5427700	320	21.4
34	New R., Pera Flats Rd.	565400	5432800	240	52.1
35	New R., Singline Rd.	567500	5431200	270	29.3
36	New R., New R. Rd.	569800	5429300	325	10.6
37	Maurice R., Cuckoo Hill Rd.	558200	5430500	250	61.1
38	Maurice R., Top.	555700	5431300	280	30.4
39	Dunns Ck.	556800	5427800	290	16.7
40	Federal Ck.	558300	5426500	305	15.5

Figure 5. IRC results for the Ringarooma River tributaries.



**Table 10. Indicators suggesting a major or extreme difference from natural or ideal conditions, and data gaps, for the Ringarooma R. tributary sites.**

Reach	M, V or F.	Hydrology (#)				Physical form (#)					Streamside zone (#)						Water quality (#)			Aquatic life (#)
		Dams or diversions	Hydro-electric	CWR extract.	Bank	Bed	Barrier	CWD	OSD	Riparian width	Struct int.	% indig.	Regen	LC	Overst regen.	SC	Turb.	Cond.	pH	
27	V	No	No																	
28	V	No	No																	
29	F	No	No																	
30	F	No	No																	
31	F	No	No																	
32	F	No	No																	
33	V	No	No																	
34	F	No	No																	
35	F	No	No																	
36	V	No	No																	
37	F	No	No																	
38	V	No	No																	
39	V	No	No																	
40	F	No	No																	

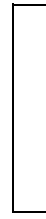
Key to table



Indicator suggests major or extreme difference from natural or ideal conditions.



Inadequate data to evaluate sub-index.



Adequate data to evaluate indicator and ratings suggest changes have not been extreme or major.

M = Mountain.

V = Valley.

F = Floodplain.

CWR = Commissioned water rights.

CWD = Coarse woody debris (snags).

OSD = Overall site disturbance.

LC = Longitudinal continuity.

# = refer to Section 3 (Methodology Description) for details of all parameters.

SC = Streamside cover.



### 4.3 Rating of stream length

An examination of the overall condition ratings for both tributary and main-stream lengths reveals no section with a high or major modification to condition. Figure 6 details the rating structure of the proportion of stream lengths within the catchment. As illustrated in the chart over 50% of the catchment is in near or essentially natural condition, while approximately 20% of catchment streams indicate some modification from natural condition.

The information is limited by the location of each study site and stream length condition is an extrapolation of site information that were chosen as reasonably representative of that particular reach. Only major tributaries and the main-stream river were targeted. The information available shows that overall condition of the catchment is respectably healthy.

**Figure 6. Proportional quantity of overall catchment river condition.**

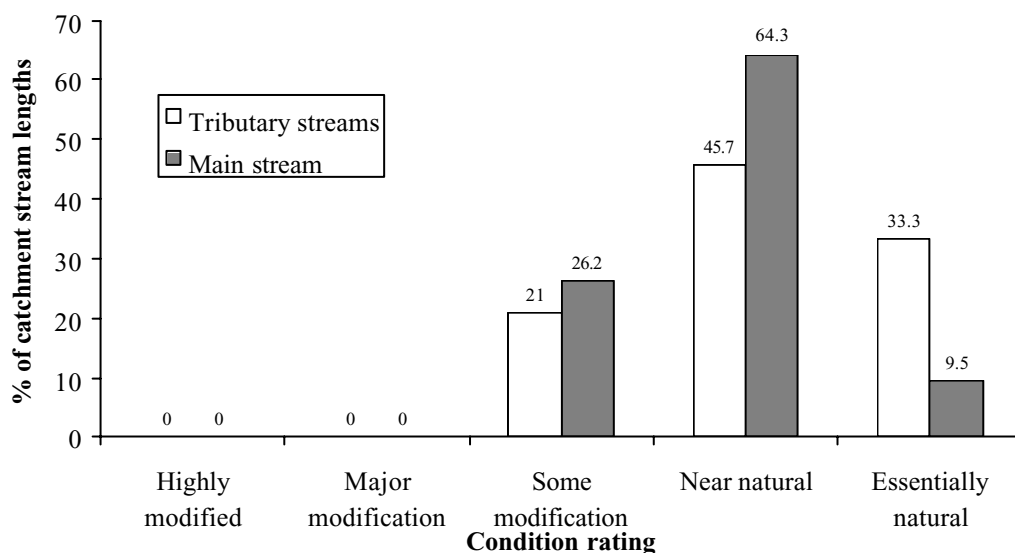
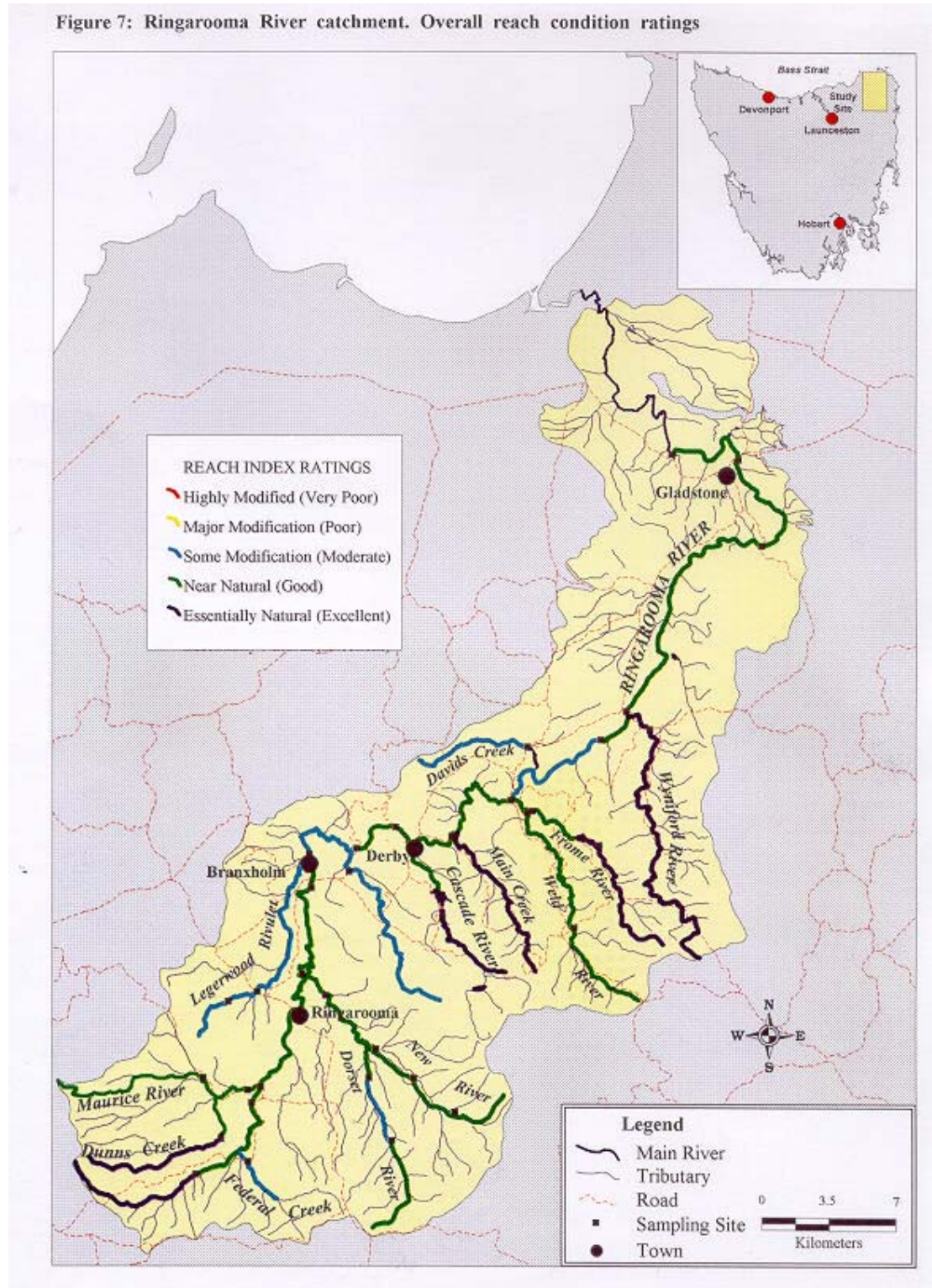


Figure 7 graphically illustrates the estimated distribution of overall condition ratings for stream length within the catchment on a site specific basis. The data indicates (Figure 6) that 33% of tributary streams and 9% of the mainstream are essentially natural or in excellent condition and 45% of tributaries and 64% of mainstream are near to natural or in good condition. Only 21% of stream length for tributaries and 26% of the mainstream were slightly modified. The information available indicates that overall condition of the catchment is respectably healthy with the lowest score of moderate change from natural or ideal conditions with no major or high modification from ideal conditions. As detailed above, sub-index parameters within each final rating structure may vary considerably from site to site.

Figure 7: Ringarooma River catchment. Overall reach condition ratings



The data in Table 11 illustrates the average value score for each independent sub-index and overall IRC value for the combined sites within the catchment. These values are highly dependant on site selection and the result may be skewed towards higher or lower values dependant on site information. The available data illustrates that, on average, the overall catchment condition is one of 'near natural' (score greater than 30) indicating a respectively healthy environment. Of all the category values aquatic fauna and physical form rate well, followed closely by water quality and hydrology. The greatest proportion of water extraction occurs on the main-stream Ringarooma River and this has dragged the hydrology index rating down accordingly. With the remaining ratings it is clear that the tributary streams are slightly more impacted than the main-stream. It should be noted that since these values are only averages they will differ when compared with the specific site information detailed above.

Table 11. Environmental rating for all streams and combination of streams in the entire catchment (corresponds to an average value). Ratings correspond to values illustrated in Table 7.

Category	Numerical value (Rating)		
	Main-stream Ringarooma R. Sites	Ringarooma R. Tributaries	Average for all catchment sites
Hydrology	3.7	8.2	6.5
Physical form	8.4	7.7	8
Streamside zone	6.3	5.2	5.6
Water quality	7	6.4	6.6
Aquatic life	7.5	7.6	7.6
<b>Overall IRC</b>	<b>32.9 (3)</b>	<b>35.1 (3)</b>	<b>34.3 (3)</b>

NB: bracketed 3 = good (near natural).

## 5. DISCUSSION

The Index of River Condition assessment protocol has effectively illustrated the condition of specific sites and representative reaches within the Ringarooma River catchment. A broad range of sites were chosen to provide a suitable overall picture and to cover the range of variation in conditions that are present. Resource limitations will always restrict the number of sites that can be assessed therefore only major tributaries and the main-stream river were covered.

In general, it has been shown that there are a range of factors that strongly influence site condition, including land use and riparian management practices, water quality and water quantity (flow). It is clear from the information available that sites within the catchment vary away from a natural state but to no more than a moderate degree. Some of the main-stream tributary streams are highly degraded but most of the catchment rates as near to natural in condition.

### *Main-stream Ringarooma River*

The available information indicates that the sites on the main-stream Ringarooma River are slightly impacted but in good condition. It is likely that any impacts have occurred due to intensive land practices such as farming, forestry and mining. Appendix 2B lists potential

management issues that could be addressed throughout the catchment. Obvious factors that came out as influencing site condition included the presence of non-native species in the stream-side zone, such as Crack willow, which was shown to be well established in certain sections of the Ringarooma River and some tributaries such as the Legerwood Rivulet. Blackberries also appear as a streamside weed at 22 of the 40 sites. The excessive growth of blackberries is inhibitory to the growth of native species and may encroach on pasture. The effects of willows, if they become too well established, include:

- runoff patterns are altered due to a lack of understorey;
- instream habitat is altered; and
- canopy cover inhibits primary production.

The streamside zone sub-index indicated that this zone was where most of the critical problems occurred. It was noted at many sites that stock has unrestricted access to stream banks. This frequently creates excessive bank erosion and may lead to increased sediment load into a watercourse. Lack of riparian vegetation at sites throughout the catchment was also noted. The streamside zone is the interface between the aquatic and terrestrial environment. This zone is an important buffer to any activities that may occur in the adjacent land zone. It provides protection from sediment runoff from forestry, farming or roading activities. It may act as a filter to chemical spray from intensive agriculture or forestry. It provides bankside stability and inhibits erosion. It forms an important relationship with aquatic systems by providing instream and bankside habitat for fauna. It is the source of nutrient inputs through snags and leaf fall. It reduces water temperature through shading effects, and continuous vegetation is also important as faunal corridors and habitat. The presence of pasture grass and other weeds does not provide the deep soil-root matrix required to support the river embankment, particularly from the effects of erosion.

The available data indicates that there are few instream faunal problems, water quality is reasonable and physical form is largely unimpacted. The hydrological deviation was greatest for the main-stream. This is not necessarily a problem since at this point data used to calculate the index is based on estimated outakes only.

The Ringarooma River has also been heavily influenced by mining activities in the past. Regeneration programs and natural regrowth over time have now improved streamside condition of most of the lower Ringarooma River reaches. Sediment input may still be significant but this factor was not assessed within the protocol of this survey.

In summary, the available data indicates that most of the critical problems for the main-stream occurs in the stream side zone. There are few instream faunal problems, water quality is reasonable and hydrology is largely unimpacted. Upper catchment sites were generally less impacted than lower.

### ***Tributaries of the Ringarooma River***

As with the main-stream of the Ringarooma River, the tributary sites are apparently impacted by land practices such as farming, forestry and, in certain areas, mining. There is no indication of impacts through modified flow regimes. However, these smaller streams are heavily influenced by riparian practices. Issues and impacts include the following:

- severe erosion due to destruction of streamside zones;
- uncontrolled stock access;

- choking of waterways from exotic species;
- pollution inputs, and
- forestry practices including extensive plantations with no natural streamside zones and limited understorey.

The available data indicates that most of the critical problems for tributary streams occurs in the stream side zone. There are few instream faunal problems, water quality is reasonable and hydrology is largely unimpacted. Davids Creek was the most heavily impacted system bordering on major modification from a natural state. Upper catchment sites were generally less impacted than lower where most agricultural activities occur. The most common problems encountered for the tributary streams were excessive quantities of exotic weed species and unrestricted stock access to streamside zones.

#### ***Wyniford R. (Sites 16 and 17)***

The Wyniford R. is a largely unimpacted system. Forestry activity does occur in the catchment and old mine workings heavily impacted the river but only in isolated locations. In general, riparian structure and quality is good, aquatic life is healthy and water quality is high. Other than the potential to rehabilitate mine sites there are few management issues in the catchment. The lower overall rating for the upper site is due to missing water quality data.

#### ***Davids Ck. (Site 18)***

This catchment was the most impacted within the entire system. It is a heavily modified agricultural system with little to no streamside zone and degraded aquatic fauna, water quality, physical form and hydrology. Due to limited streamside protection the banks are degraded, stock has unrestricted access to the stream and exotic weeds are prevalent.

#### ***Weld R. (Sites 19 and 20)***

This catchment reverses the usual trend of improved conditions higher in the system. The lower catchment is in excellent condition as recorded through all parameters. The upper catchment has been impacted by farming activities, as a result physical form rating is down and the streamside zone is heavily modified. A moderate degree of build up of bed material was noted along with a reduction in instream woody debris (important faunal habitat). The main management issues are a lack of riparian zone, unrestricted stock access to the stream banks (erosional problems) and evident weed species such as blackberries.

#### ***Frome R. (Sites 21 and 22)***

The Frome R. catchment has been heavily modified by the construction of the Frome dam. The upper catchment above the dam is a largely unimpacted and is an excellent example of an unimpacted stream. The lower Frome R. has been highly modified by the diversion of water from the dam into the power station race. This has left minimal flows in the lower reaches although water quality, aquatic life and streamside vegetation was still recorded as respectively healthy.

#### ***Main Ck. (Sites 23 and 24)***

Main Ck rated well for all parameters. There were no management issues recorded for the catchment although it was noted that blackberries are present at the lower site.

***Cascade R. (Sites 25 and 26)***

This is another catchment that has been altered through the impact of a large impoundment in the lower reaches. The cascade dam has inundated a large section of the river and has restricted flows below the dam. At the lower site most parameters rate highly except for aquatic life which rates poorly, arguably due to the effects of the dam. The upper site is an excellent example of an unimpacted reach.

***Black Rt (Site 27)***

This is a largely unimpacted system.

***Legerwood R. (Sites 28, 29 and 30)***

The Legerwood River is also a highly modified agricultural system that has been dammed and cleared. Three sites were selected along the length of the system and all sites rated similarly. The streamside zone is in very poor condition and rated extremely low for all sites. Physical form improved downstream which is unusual but may be a result of an increase in coarse woody debris downstream and site specific overall disturbance ratings being higher for the lower sites. Aquatic life rates reasonably well possibly due to reasonable water quality. Management problems noted were evident erosion, unrestricted stock access to streamside zones and the presence of weed species such as blackberries and willows.

***Dorset and New R. (Sites 31 to 36)***

This sub-catchment varies considerably in quality throughout its length. The middle reaches are the most heavily influenced by farming activities and seem to be the most impacted. For example, the 3 middle catchment sites (32, 34 & 35) all have a very low streamside zone rating. Each one also has modified physical form although water quality and aquatic life are in reasonable condition throughout the catchment. There was also evident erosion of banks at the three middle sites and unrestricted stock access to the banks. Blackberries were the major weeds recorded at all of the sites.

***Maurice R. (Sites 37 and 38)***

The Maurice R. system is typical of most of the tributaries in that the lower section is heavily impacted by agricultural activities and the upper catchment is relatively unimpacted. Issues include lack of streamside zone and excessive blackberry weeds.

***Dunns Ck. (Site 39)***

Dunns Ck runs off Mt Maurice and is an excellent example of a natural stream. Agricultural activities occur at the very bottom of the catchment but the majority of the stream runs through unimpacted forest. All parameters rate highly.

***Federal Ck. (Site 40)***

This system is heavily influenced by agricultural activities. The study site had no streamside vegetation other than grasses, the banks were significantly unstable and stock has unrestricted access to the river. Stabilisation of banks through establishment of a riparian zone would be an important management issue.

As with the main-stream of the Ringarooma River, the tributary sites are apparently impacted by land practices such as farming, forestry and, in certain areas, mining. There is no indication of impacts through modified flow regimes from water extraction. However, these smaller streams are heavily influenced by riparian practices. Issues and impacts include the following:

- severe erosion due to destruction of streamside zones;
- uncontrolled stock access to streambanks;
- choking of waterways from exotic species;
- pollution inputs;
- lack of streamside vegetation, and
- forestry practices including extensive plantations with no natural streamside zones and limited understorey.

The available data indicates that most of the critical problems for tributary streams occurs in the stream side zone. There are few instream faunal problems, water quality is reasonable and hydrology is largely unimpacted. Davids Creek was the most heavily impacted system bordering on major modification from a natural state. Upper catchment sites were generally less impacted than lower where most agricultural activities occur. The most common problems encountered for the tributary streams were excessive quantities of exotic weed species and unrestricted stock access to streamside zones.

## 6. CONCLUSION

Final assessment of data sets for the Index of River Condition has clearly illustrated that it is a useful tool in assessing river condition at selected sites within a catchment that are representative of a given reach. It has proven a practical means of illustrating the deviation of a site away from its predicted natural state and has illustrated the overall condition of the catchment and its associated waterways. This is evident through comparison with unimpacted and impacted reaches.

The technique also highlights potential problems that may exist within a catchment which are, or have the potential to reduce riverine quality. Using the data available from this study it becomes possible for managers to target potential problem areas. Nevertheless, it would be unreasonable to assume that sites should be returned to as near a natural state as possible for this does not necessarily mean the health of a site would be improved. Management options to improve the overall condition would be more appropriate. These may include:

- streamside zone management to allow the regeneration of an appropriate buffer strip of native species;
- weed reduction and control programs;
- stream bank protection by limiting stock access; and
- the assessment of pollution sources within the catchment.

From the available data it has become clear that the major management problems in the catchment revolve around riparian weed control, revegetation of riparian zones and controlled

stock access to river banks. Physical form (bank and bed conditions, overall site disturbance) indicates reasonable condition of these parameters. Aquatic fauna (freshwater invertebrates) are healthy, and water quality is good overall.

This project set out to illustrate the condition of specific sites as representatives of a given reach within the Ringarooma River catchment and to this end the results indicate that this has been suitably achieved. Data collection for this study provides a baseline of information that can be used for comparative purposes to observe changes within the catchment over time.

With a management infrastructure in place for the catchment, it would be possible to re-run this program in 5 years using the same sites to determine if the overall condition of the catchment has improved or declined.

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## **Acknowledgements**

The author would like to thank the following individuals from the DPIWE for their assistance in on-ground field data collection and in preparation of this report.

- Nick Probert
- Henry Maxwell
- Martin Read
- David Horner
- Adam Jagler

The author would also like to acknowledge the support received from landowners within the Ringarooma River catchment during the field program.

## APPENDICES

APPENDIX 1 Sub-index and overall ISC ratings and associated values for all catchment sites (refer to Fig. 2 for site locations).

Reach	Hydrology sub-index	Physical form sub-index	Streamside zone sub-index	Water quality sub-index	Aquatic life sub-index	Total IRC for site out of 50	Grid reference Easting - Northing
1	2.5	9.1	7.9	7.5	7.5	34.5	582100 546630
2	2.5	9.1	7.5	7.5	5	31.6	585500 5465800
3	0	9.1	6.9	6.9	7.5	30.4	586800 5461000
4	0	8.3	8.8	6.9	10	34	579300 5451700
5	0	8.2	8.7	6.9	5	28.8	577900 5450100
6	5	10	7.7	6.9	5	34.6	572900 5446700
7	5	8.8	7.7	6.9	7.5	35.89	569600 5444700
8	5	8.5	6	6.9	7.5	33.9	566500 5445200
9	5	6.2	2.3	6.9	5	25.33	564300 5444000
10	5	6.4	2.7	6.9	10	31	561700 5443700
11	5	8.2	4.4	6.9	7.5	32	561800 5441800
12	2.5	6.2	1.6	6.9	10	27.2	561300 5437000
13	5	8.8	8.7	6.9	7.5	36.92	559100 5403700
14	5	8.5	4.2	6.9	7.5	32.1	558500 5429800
15	7.5	10	9.5	6.9	10	43.9	555600 5425800
16	10	9.3	8.8	6.9	7.5	42.44	580600 5450700
17	10	10	9.1	##	5	##	580450 544640
18	5	5.9	0.4	5	5	21.27	573800 5449700
19	7.5	10	7.8	6.9	7.5	39.7	573800 5446000
20	7.5	7.1	2.8	6.9	7.5	31.8	576400 5439600
21	0	9.1	9.6	6.3	7.5	32.4	574100 5446100
22	10	10	10	6.3	7.5	43.9	577800 5444200
23	10	9.4	8.6	7.5	7.5	42.97	569800 5444600

**APPENDIX 1 (cont.)**

24	10	8.2	9.9	6.9	7.5	42.48	573800 5438400
25	10	8.5	6.2	6.3	2.5	33.47	567500 5443800
26	10	10	9	6.3	7.5	42.8	569100 5440200
27	10	9.4	8.3	5.6	5	38.31	563900 5442700
28	5	7.1	1.6	6.9	7.5	28.07	561700 5443400
29	10	5	1.3	6.9	7.5	30.72	557200 5435450
30	7.5	4.3	1.2	6.9	7.5	27.31	558800 5436000
31	7.5	8.1	3.2	6.9	10	35.7	562600 5435800
32	5	5.5	1.3	6.9	10	28.6	565000 5431200
33	10	8.2	6.3	6.9	7.5	38.9	566300 5427700
34	10	7.1	1.4	5.6	10	34.21	565400 5432800
35	10	3.8	1.4	5.6	10	30.88	567500 5431200
36	10	8.5	7	5.6	7.5	38.61	569800 5429300
37	5	6.7	3.5	6.9	10	32.04	558200 5430500
38	10	8.5	2.7	6.9	7.5	35.6	555700 5431300
39	10	10	8	6.3	7.5	41.8	556800 5427800
40	5	3.3	0.4	6.3	10	25	558300 5426500

Actual average	10	10	10	10	10	50	
Observ. average Condition	7.38	7.51	4.95	6.53	7.25	33.62	
	Good Near natural	Good Near natural	Poor Major modification	Moderate Some modification	Good Near natural	Good Near natural	

## = no data available.

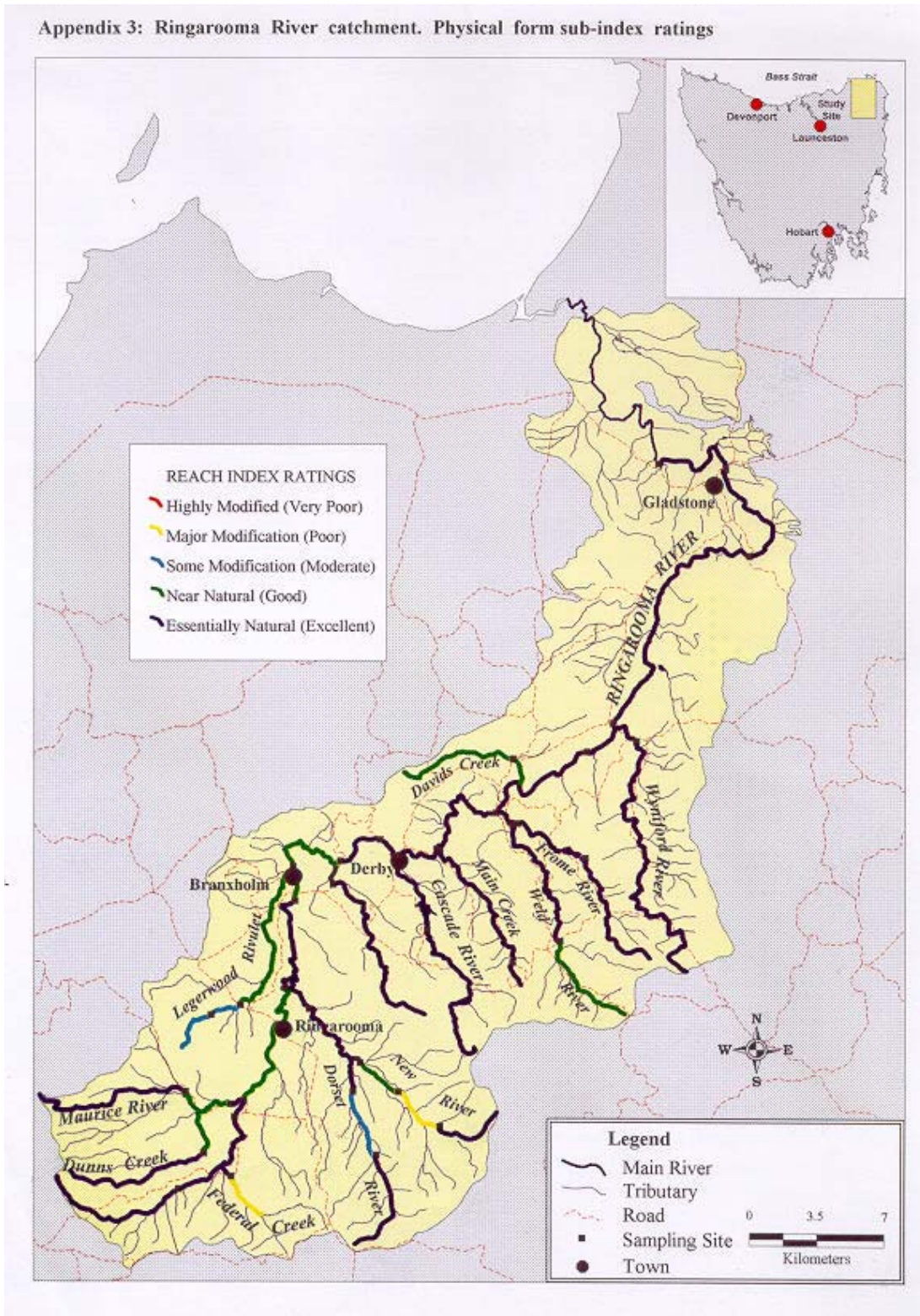
**APPENDIX 2A. Site list with grid references for each study location.**

<b>Reach No.</b>	<b>Site</b>	<b>Easting (m)</b>	<b>Northing (m)</b>	<b>Altitude (m)</b>	<b>Area (Km<sup>2</sup>)</b>
1	Ringarooma, Waterhouse Rd	582100	546630	15	825.1
2	Ringarooma, Bells Bridge	585500	5465800	25	798.3
3	Ringarooma, Ogilvies Bdge	586800	5461000	35	719.1
4	Ringarooma, Garibaldi Rd Bdge	579300	5451700	72	649.8
5	Ringarooma, Pioneer.	577900	5450100	78	599.8
6	Ringarooma, Moorina.	572900	5446700	110	503.1
7	Ringarooma, Mutual Bridge.	569600	5444700	130	442.4
8	Ringarooma, Station Rd.	566500	5445200	150	391.2
9	Ringarooma, Long Bridge.	564300	5444000	160	380.2
10	Ringarooma, Off Warrentina Rd	561700	5443700	170	339.1
11	Ringarooma, above Branhholm	561800	5441800	180	275.3
12	Ringarooma, Below Ringarooma town.	561300	5437000	200	146.2
13	Ringarooma, Cotton's Bdrge Rd.	559100	5430700	250	116.1
14	Ringarooma, East Maurice Rd.	558500	5429800	310	50.5
15	Ringarooma, Off Petterwood Rd.	555600	5425800	355	16.3
16	Wyniford R., Bottom.	580600	5450700	95	57.0
17	Wyniford R., Top.	580450	5446400	130	35.0
18	Davids Ck.	573800	5449700	105	8.1
19	Weld R., Bottom.	573800	5446000	220	50.2
20	Weld R., Top.	576400	5439600	350	26.0
21	Frome R., Bottom.	574100	5446100	220	17.8
22	Frome R, above dam.	577800	5444200	330	12.6
23	Main Ck., Bottom.	569800	5444600	140	20.6
24	Main Ck., Top.	573800	5438400	420	2.3
25	Cascade R., Tasman Highway	567500	5443800	160	38.0
26	Cascade R., Top.	569100	5440200	360	25.4
27	Black Rt	563900	5442800	170	22.4
28	Legerwood R., at Warrentina Rd.	561700	5443400	180	60.7
29	Legerwood R., Peddles Rd.	557200	5435450	260	8.1
30	Legerwood R., Ringarooma Rd.	558800	5436000	240	13.8
31	Dorset R., Ruby Flats Rd	562600	5435800	210	115.8
32	Dorset R., Cemetery Corner	565000	5431200	260	29.9
33	Dorset R., Top.	566300	5427700	320	21.4
34	New R., Pera Flats Rd.	565400	5432800	240	52.1
35	New R., Singline Rd.	567500	5431200	270	29.3
36	New R., New R. Rd.	569800	5429300	325	10.6
37	Maurice R., Cuckoo Hill Rd.	558200	5430500	250	61.1
38	Maurice R., Top.	555700	5431300	280	30.4
39	Dunns Ck.	556800	5427800	290	16.7
40	Federal Ck.	558300	5426500	305	15.5

**APPENDIX 2B. Management issues identified for the main-stream Ringarooma River sites.**

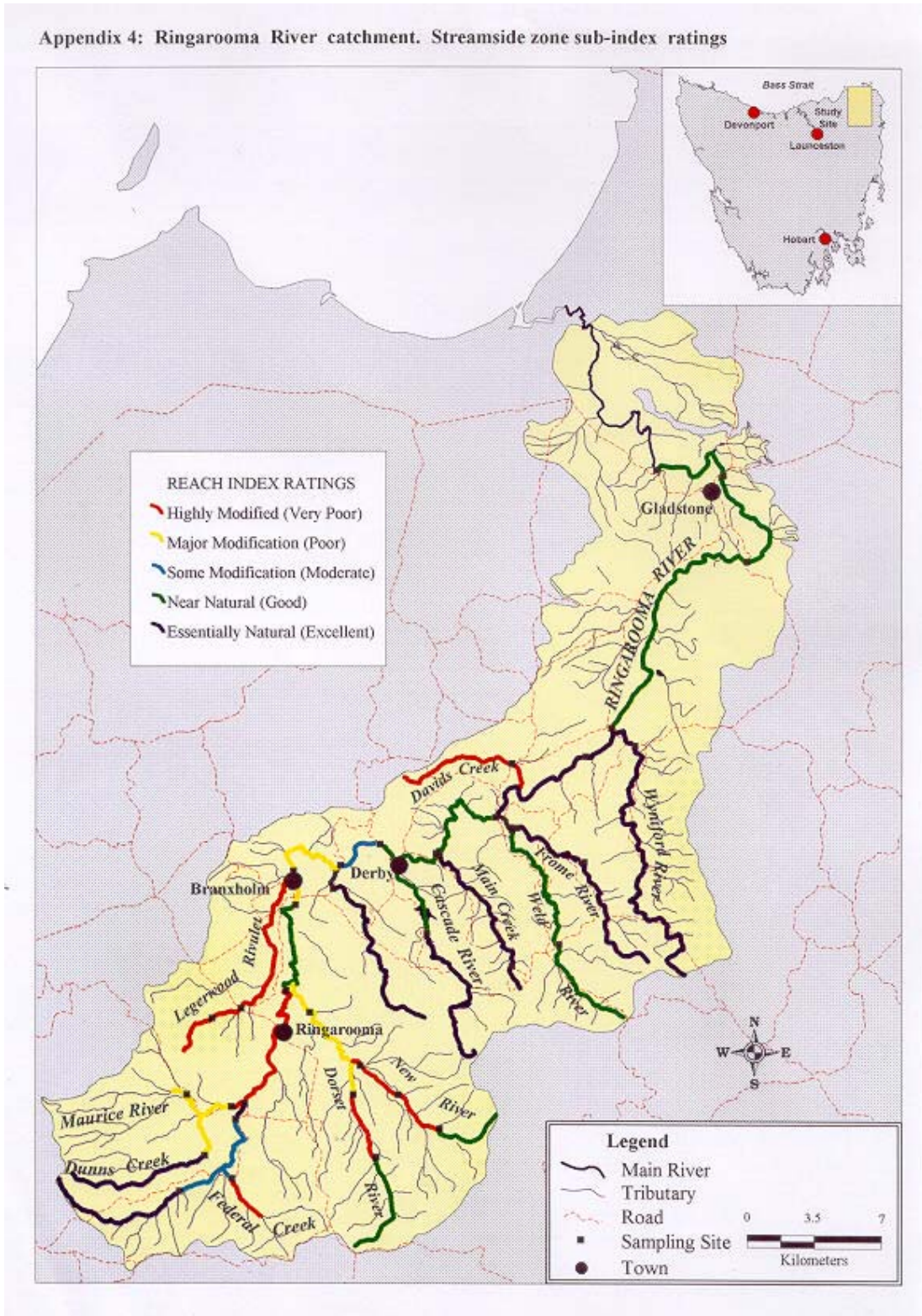
<b>Reach</b>	<b>Management issues</b>
1	None
2	Weeds: Willows.
3	None
4	Weeds: Willows, Blackberries.
5	None
6	Weeds: Willows, Blackberries.
7	Weeds: Willows, Blackberries.
8	Weeds: Willows, Blackberries, Broom.
9	Weeds: Willows, Blackberries. Limited riparian zone, unstable banks, unrestricted stock access to river.
10	Weeds: Willows, Blackberries. Limited riparian zone.
11	Weeds: Blackberries. Limited riparian zone.
12	Weeds: Willows, Blackberries. Limited riparian zone.
13	Weeds: Gorse, Blackberries.
14	Limited riparian zone, bank instability, unrestricted stock access to river.
15	None
16	None.
17	None.
18	Weeds: Blackberries. Limited riparian zone, unstable banks, unrestricted stock access to river.
19	None.
20	Weeds: Blackberries. Limited riparian zone, unrestricted stock access to river.
21	None.
22	None.
23	Weeds: Blackberries.
24	None.
25	Weeds: Blackberries, Broom.
26	None.
27	None.
28	Weeds: Blackberries. Limited riparian zone, unrestricted stock access to river.
29	Weeds: Blackberries, Willows. Limited riparian zone, unstable banks, unrestricted stock access to river.
30	Weeds: Willows, Hawthorn. Limited riparian zone, unstable banks and bed, unrestricted stock access to river.
31	Weeds: Blackberries. Limited riparian zone.
32	Weeds: Blackberries. Limited riparian zone, unstable banks and bed, unrestricted stock access to river.
33	Weeds: Blackberries.
34	Weeds: Blackberries, Hawthorn, Thistles. Limited riparian zone, unrestricted stock access to river.
35	Weeds: Blackberries. Limited riparian zone, unstable banks and bed.
36	Weeds: Blackberries. Unrestricted stock access to river.
37	Weeds: Blackberries. Limited riparian zone.
38	Weeds: Blackberries. Limited riparian zone, unrestricted stock access to river.
39	None.
40	Limited riparian zone, unstable banks and bed, unrestricted stock access to river.

Appendix 3: Ringarooma River catchment. Physical form sub-index ratings



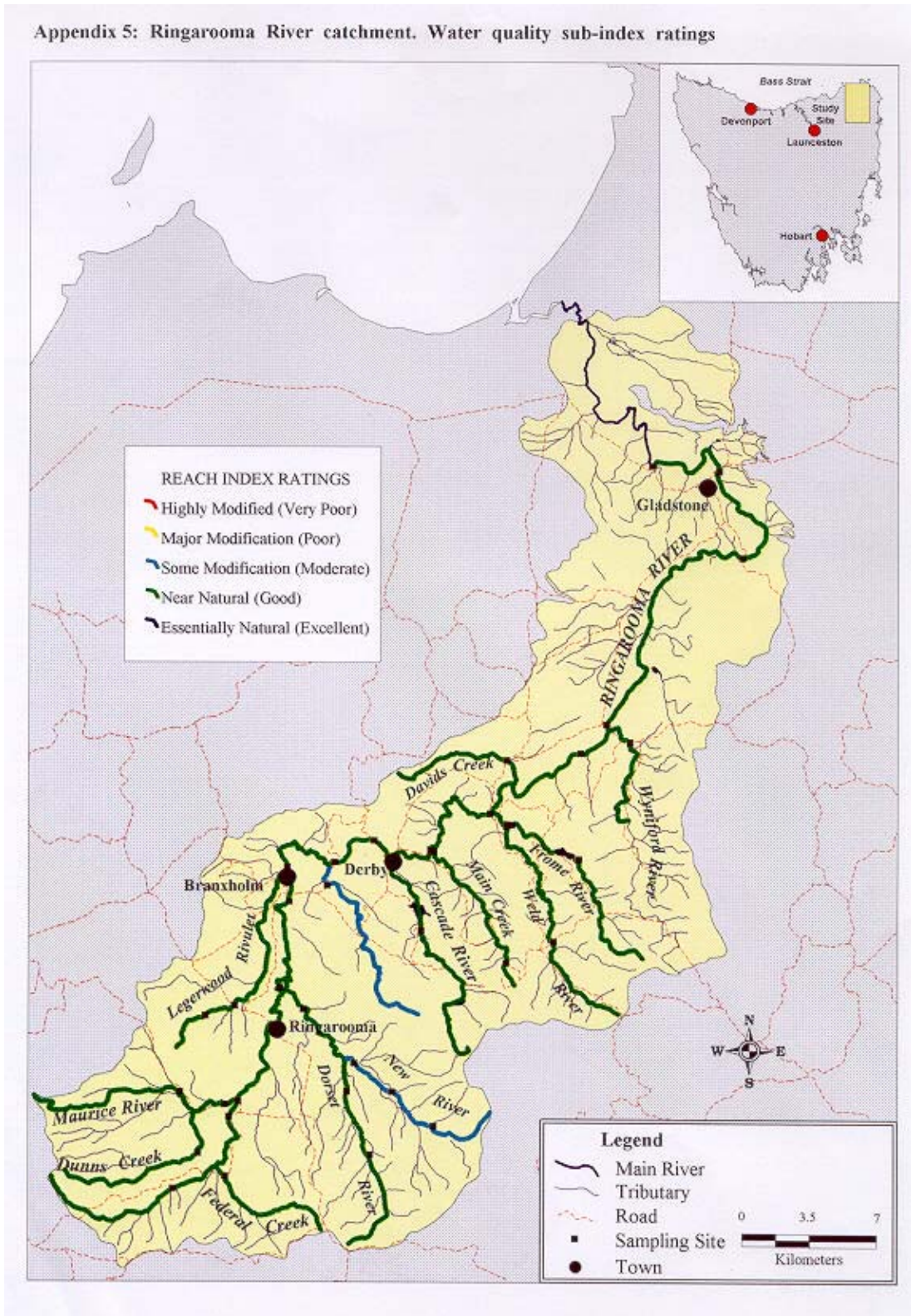


Appendix 4: Ringarooma River catchment. Streamside zone sub-index ratings





Appendix 5: Ringarooma River catchment. Water quality sub-index ratings





Appendix 6: Ringarooma River catchment. Aquatic life sub-index ratings

