GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Stream Condition Assessments and Reporting

FIRE SITES

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1. EXECUTIVE SUMMARY

Water Technology was commissioned by the Goulburn Broken Catchment Management Authority (Goulburn Broken CMA) to assess the condition of 20 riparian sites in the upper Goulburn and Broken catchments affected by the bushfires in the summer of 2006/2007. The sites were selected on the basis of providing good spatial representation on fire affected waterways and vegetation types and to enable comparison with condition scores for a number of sites previously assessed for Index of Stream Condition (ISC) programs in 2004 and 2005. The 2009 assessments mark the second year of post-fire assessments completed at these sites.

The objectives of this project are to:

- Reassess the condition of 20 sites affected by fire in the summer of 2006/2007
- Assess how these sites are recovering approximately 2 years post-fire
- Compare benchmark data and new assessment data to identify trends and changes in condition at individual sites. This will include presentation of pre-fire ISC condition assessment results for the 9 sites previously assessed in 2004 and 2005 (note that metric and sub-index scores were only available for 8 sites) and post-fire assessment results for 2008 and 2009.

METHODS

The 2008 fire site assessments adopted a program consisting of the following assessment methods:

- 2004 (2nd edition, released in 2006) Index of Stream Condition (ISC), revised in 2007 (DSE 2006)
- Vegetation Quality Assessment (as used by Riparian Australia 2000)
- Rapid Habitat Assessment (DSE 2004)
- Other 'Riparian and Instream Health' parameters (Earth Tech 2005)
- Establishment of permanent photograph points.

These assessment methods are consistent with methods adopted for other riparian condition assessments completed in the Broken and Goulburn catchments over the past 5 years.

Observations during our field assessments indicated that the intensity of the fire was a key factor in the resulting condition of the riparian areas post-fire. A simple rating system for burn intensity was required and consequently the Fire Severity classification developed by DSE (2008) for fire salvage harvesting in similar forested areas was adopted. This classification was useful for categorising the intensity of the fire at individual sites to assist the understanding of the post-fire site condition.

RESULTS

The average condition scores for the 20 sites assessed using each of the methods indicate the relative change in condition at the group of sites over the past 12 months (Table 1). Despite the observations of continued improvements in relative covers of regenerating woody, grassy and herbaceous native vegetation, this is not reflected by the ISC Streamside Zone scores.

The results of the 2009 ISC assessments indicate that the Physical Form and Streamside Zone sub-index scores have improved at 15 sites and nine sites respectively. While only two sites recorded a decline in Physical Form condition, a decrease in Streamside Zone condition was recorded at 11 of the 20 sites assessed. Conversely, the habitat quality of the recovering fire affected sites based on the Rapid Habitat Assessment (RHA) method, have mostly either improved (14 sites) or remained static (5 sites), with only one site declining in condition over the previous 12 months.

The average quality score based on the Vegetation Quality Assessment (VQA) method has improved slightly between 2008 and 2009, with a number of sites improving their quality class to Excellent. A

number of the variables were assessed at their maximum score in 2008 (e.g. above bank width of vegetation, tree regeneration and species richness), with no room for further improvement in subsequent assessments.

Table 1 Summary of average condition scores for 20 fire affected sites.

Assessment Method	Average Condition Scores for 20 sites		
	2008	2009	Change
ISC Physical Form	5.0	5.6	+0.6 / 10
ISC Streamside Zone	7.5	7.5	0 / 10
Rapid Habitat Assessment (RHA)	16.7	17.6	+0.9 / 20
Vegetation Quality Assessment (VQA)	29.2	30.7	+1.5 / 35
Riparian & Instream Health metrics	11.7	12.0	+0.3 / 16

LIMITATIONS

Each of the four methods provides a measurement of current condition of the fire affected sites and enables relative comparisons in condition between sites in similar catchment areas. These methods were not designed for the purpose of detecting short term changes in site condition, however the annual assessment of the Riparian Trend project sites (Water Technology 2009) is being used to determine the ability of these four methods to detect change over shorter timescales.

The ISC method has been revised several times since 2004. The key revisions occurred prior to the 2006 autumn assessment period when the 2004 2nd edition was released and prior to the 2007 autumn assessment period when additional requirements for the annual sentinel site assessments were implemented. This may result in minor changes to indicator metric and sub-index scores that are not related to the fire event between 2004/2005 and 2008 assessments for the 9 sites that were assessed in both of these periods.

CONCLUSION

Average condition scores for the twenty sites using the four methods suggests that overall, the condition of the sites has improved over the previous 12 months. More detailed assessments of the changes in individual indicator scores has also been provided for each method.

Review of the pre-fire (2004/2005) and post-fire (2008, 2009) ISC assessment results indicates that approximately two years following fire, relatively undisturbed, upland areas have not consistently regained the pre-fire channel form and vegetation condition adjacent to the waterway. A strong determination in the post-fire condition is the severity of the fire at individual locations. The ISC Physical Form and Streamside Zone sub-indices show that the measurable condition of the sites may be up to 30% less, two years after fire disturbance. Conversely, one site recorded an improvement in Physical Form and Streamside Zone condition by up to 20% and 30% respectively. However, given that there have been some minor changes to the ISC method between these assessment periods, the changes in scores may not be solely attributable to the damage caused by the fire event. As the RHA, VQA and Riparian and Instream methods had not been applied previously at any sites, no conclusions can be drawn regarding the recovery to pre-fire condition using these methods.

It is recommended that additional analysis be undertaken to assess the correlation between the fire intensity (through use of the Fire Severity Classification) and the individual metric, sub-index and total scores for each of the methods. This may be of further use in predicting the likely vegetation response periods and potential issues for areas recently burnt in other similarly vegetated catchments across the Goulburn Broken region in February 2009.

2. INTRODUCTION

Water Technology was commissioned by the Goulburn Broken Catchment Management Authority (Goulburn Broken CMA) to assess the condition of 20 riparian sites in the upper Goulburn and Broken catchments affected by the bushfires in the summer of 2006/2007. The location of the 20 fire affected sites assessed under this program is shown on Figure 1.

The sites were initially selected and monitored in 2008 on the basis of providing good spatial representation on fire affected waterways and vegetation types and to enable comparison with condition scores for a number of sites previously assessed for Index of Stream Condition (ISC) programs in 2004 and 2005.

The objectives of this project are to:

- Reassess the condition of 20 sites affected by fire in the summer of 2006/2007
- Assess how these sites are recovering approximately 2 years post-fire
- Compare baseline data and new assessment data to identify trends and changes in condition at individual sites. This will include presentation of pre-fire ISC condition assessment results for the 9 sites previously assessed in 2004 and 2005 (note that metric and sub-index scores were only available for 8 sites) and post-fire assessment results for 2008 and 2009.

This report details the assessment methods, the likely pre-fire vegetation type for each of the sites, results of the 2009 condition assessments and presents pre-fire (where available for 2004 or 2005) and post-fire site ISC condition assessment results from the 2008 assessments. Reference is also made to the observed burn intensity at each of the sites, through adoption of the Fire Severity Classification developed by the Department of Sustainability and Environment (2008) for fire salvage harvesting in these areas.

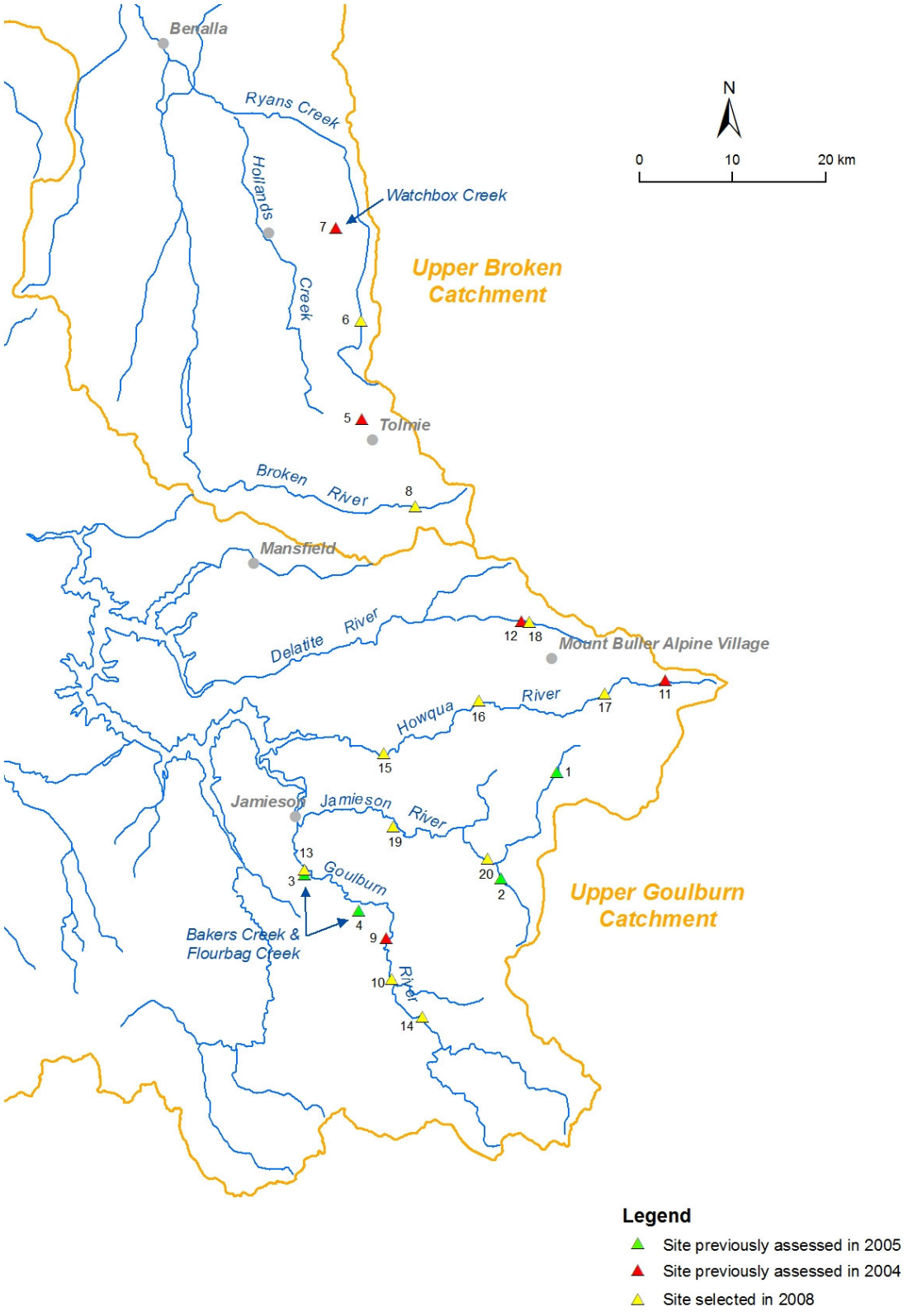

Figure 1 **Fire affected sites assessed in the upper Broken and Goulburn catchments.**

3. ASSESSMENT METHODS

The 2009 fire site assessments adopted a program consisting of the following assessment methods:

- 2004 (2nd edition, released in 2006) Index of Stream Condition, revised in 2007 (DSE 2006)
- Vegetation Quality Assessment (as used by Riparian Australia 2000)
- Rapid Habitat Assessment (DSE 2004)
- Other 'Riparian and Instream Health' parameters (Earth Tech 2005)
- Establishment of permanent photograph points.

These assessment methods are consistent with methods adopted for other riparian condition assessments completed in the Broken and Goulburn catchments over the past 5 years, including the Riparian Trend project (Water Technology 2009) and several riparian Crown land assessments (Earth Tech 2007b). The methods were initially adopted by the Goulburn Broken CMA as they were accepted as recognised and repeatable methods (Earth Tech 2005). A brief summary of each of the four assessment methods is provided in the following section.

3.1 2004 (2nd edition) Index of Stream Condition

The ISC method of data collection measures the environmental condition of rivers from an ecological perspective and enables comparisons in waterway/catchment health to be made across the state. The Department of Sustainability and Environment (DSE) are the custodians of the ISC method and are responsible for the assessment and reporting of catchment condition across the state every five years. When the method was applied statewide in 1999, it was the first consistent and comprehensive study of environmental condition carried out anywhere in Australia (DSE 2005). The second benchmarking undertaken during 2004, continued to develop the picture of river health across the state and also assisted in measuring progress towards targets specified by Catchment Management Authorities and the State government. An annual Sentinel Site program also commenced across the state in 2005. Sentinel sites are assessed annually to detect natural climatic and temporal changes in condition on a variety of stream types across catchments within Victoria. These annual assessments allow verification of any natural changes that may alter results between the five yearly state-wide audits.

Five key components of river health are assessed in the ISC, these components, or sub-indices, measure changes in hydrology, water quality, streamside zone (vegetation), physical form (bed and bank condition and instream habitat) and aquatic life. Each sub-index is scored out of a maximum of 10. The overall score for the ISC is between 0 – 50. Once an overall score has been calculated, the condition can be classified into one of five classifications, Very Poor (0-19), Poor (20-25), Moderate (26-34), Good (35-41) and Very Good (42-50).

The ISC can assist Catchment Management Authorities to set management objectives and measure the effectiveness of long term programs for the rivers in their catchment. The use of the ISC to measure the effectiveness of riparian protection and enhancement works at individual sites is currently being tested by the Goulburn Broken CMA and Melbourne Water through a number of riparian condition assessment projects.

Data for the Streamside Zone and Physical Form sub-indices of the ISC was assessed for this program of 20 fire affected sites. Further information about the ISC method can be found at www.vicwaterdata.net.

3.2 Vegetation Quality Assessment

The Vegetation Quality Assessment (VQA) is a method that was used to assess Crown land parcels by Riparian Australia (2000). It is a quick assessment method that provides a general indication of habitat condition (vegetation and soil disturbance) in the riparian zone. This method derives a condition score based on seven key attributes:

- Above bank vegetation width
- Soil disturbance
- Tree health
- Tree regeneration
- Weed presence
- Species richness
- Vegetation structure

Each attribute is scored out of five. The final VQA score obtained is between 7 and 35. Once a final score has been calculated, the condition can be classified into one of five classifications, Very Poor (7-12), Poor (13-18), Moderate (19-24), Good (25-30) and Excellent (31-35).

For the purposes of this assessment and consistent with the Riparian Trend project (Earth Tech 2007a), the following species richness qualifiers were adopted: ≤3 species = score 1, 4-5 species = score 2, 6-7 species = score 3, 8-9 species = score 4, ≥10 species = score 5.

Further information about the VQA method and the 'Ground Validation Assessment Rules' (Riparian Australia 2000) is provided in Appendix A.

3.3 Rapid Habitat Assessment

The Department of Sustainability and Environment (DSE) has developed a method to assess vegetation quality (habitat condition) uniformly across Victoria. This method, known as 'Habitat Hectares' (DSE 2004) is a site-based measure of quality and quantity of native vegetation assessed in the context of the relevant vegetation type. Through the development of the Native Biodiversity Resource Kit (DSE 2004), a land manager self-assessment method has been developed based on the Habitat Hectares approach. The single page assessment, also referred to as the Assessment of Habitat Quality, assesses native vegetation against the following seven habitat components:

- Presence of large old trees
- Tree canopy cover
- Understorey (determined by percentage cover and number of perennial lifeforms)
- Recruitment of woody species (or small herbs in grasslands)
- Cover of weeds
- Cover of organic litter
- Logs (for forests and woodlands).

Habitat quality also assesses the site according to its size and location in the surrounding landscape. Landscape context is a measure of the following three components:

- Size (defined by the area being assessed and any adjoining native vegetation)
- Links to an amount of neighbouring vegetation (defined by the percentage area covered within 1km radius of the site)

- Core area (defined by the distance from a block of native vegetation greater than 50ha).

In the RHA, sites are assigned to an 'EVC Group' according to their mapped Ecological Vegetation Class (EVC). 'EVC Groups' define a much broader vegetation classification than EVC's. Current vegetation condition on site is then compared with the characteristics specified for each EVC Group. The characteristics specified for each EVC Group represent vegetation and habitat condition in an undisturbed (pre-settlement) environment.

The RHA has been field assessed against the complete habitat hectares assessment and results indicate that the scores from the RHA are within 5% of the full habitat hectares assessment results (Andrew Straker, *pers. comm*.).

Once a final score has been calculated, the condition can be classified into one of three ratings, Low (0-6.5), Medium (7-11.5) and High (12-20).

Further information about the RHA method can be found in the Native Biodiversity Resource Kit available on the DSE website www.dse.vic.gov.au .

3.4 Riparian and Instream Health

Earth Tech (2005) considered it was important to collect additional information relevant to frontage condition within the 100m long quadrat in which the RHA was applied. Several parameters adopted from the 2004 ISC method and an assessment of macrophytes was deemed necessary. These parameters were compiled in a fourth group of assessment parameters called 'Riparian and Instream Health'. The parameters are:

- Width of Streamside Zone (based on 2004 ISC methodology)
- Longitudinal Continuity (consistent with 2004 and 2004 2nd edition ISC methods)
- Instream Habitat (LWD) (based on the 2004 ISC methodology)
- Macrophytes (rushes & reeds)

3.5 Permanent Photopoints

As with other similar studies conducted for the Goulburn Broken CMA, permanent photopoints were established at one end of each transect within the measuring site (i.e. three permanent photopoints per site). Permanent photopoints provide a visual representation of the changes occurring at particular locations at each site over time (Water Technology 2008). This will compliment the stream and habitat condition data collected at each site.

A photo renaming convention, consistent with that adopted for other similar studies conducted for the Goulburn Broken CMA, has also been used for this project. The photograph naming convention is further described in the 'Field Procedure' section of this report.

4. FIELD PROCEDURE

The field procedure adopted for the 2007 Riparian Trend project was also adopted for the initial assessments completed at fire affected sites in 2008 (Water Technology 2008). An example of the field assessment sheet is provided in Appendix B.

In general, a 430m length of streamside zone was assessed at each site. This distance is the standard length of stream over which an ISC assessment is completed. The length of the site was also lengthened or shortened to ensure that representative fire affected areas were included in the assessment. Each transect always remained 30m in length, however the position of the transects was relatively adjusted to reflect a change in site length where required. The locations of each ISC transect and areas or quadrats where VQA, RHA and Riparian and Instream Health assessments were performed for a typical 430m long site are illustrated in Figure 2.

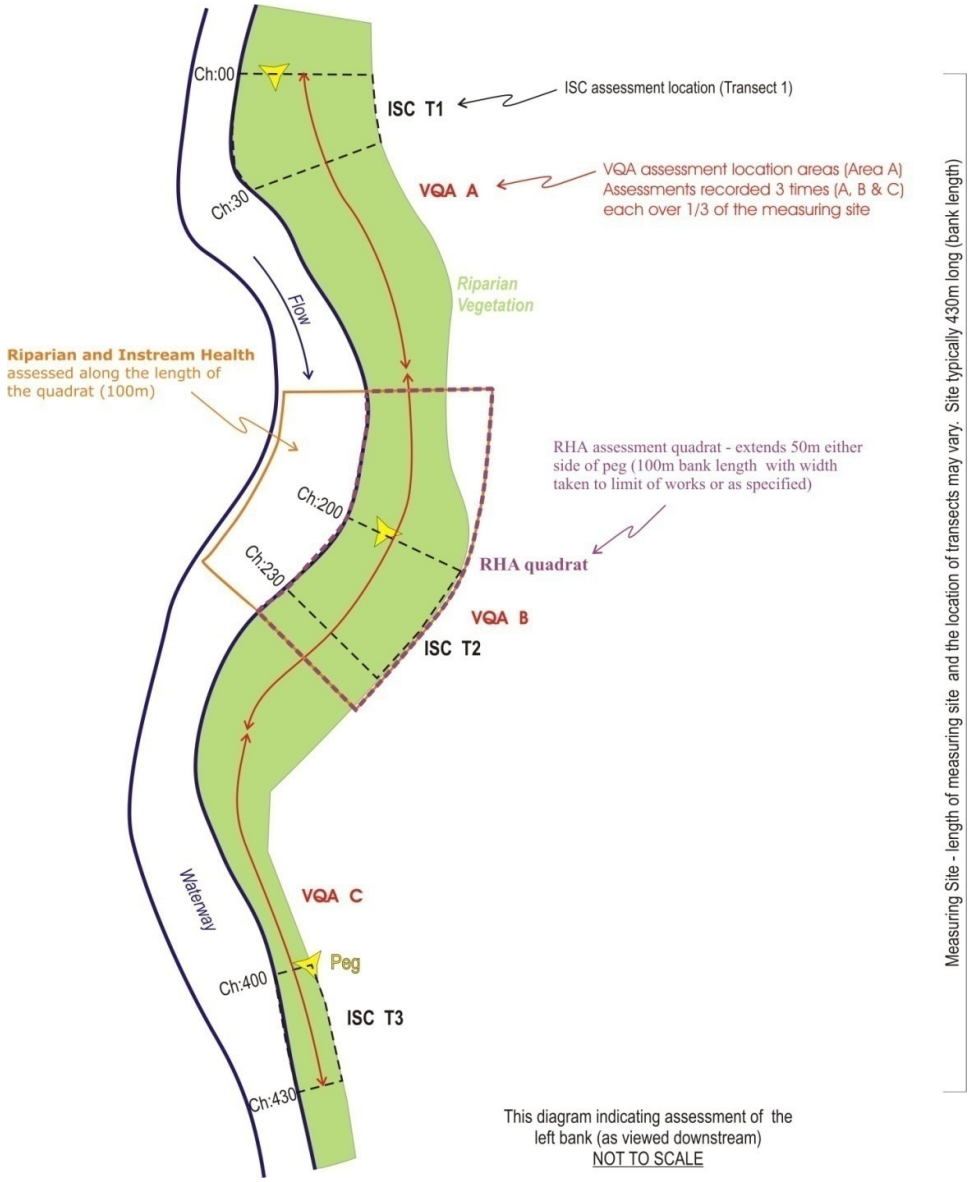

Figure 2 Application of the four assessment methods at a typical site.

The upstream end of each of the three transects in the measuring site were marked using a green tag or white survey peg marked with the site number, transect number and chainage in metres. The tags were attached to nearby fence posts, strainers and tree branches, or pegs were placed in the ground. Consideration was given to placing the permanent markers in locations where chances of damage by stock or other access was minimal.

The VQA was completed in zones A, B and C as illustrated in Figure 2. This method was completed while traversing from one transect to the next, providing a general indication of habitat condition (vegetation and soil disturbance) in the riparian zone.

The RHA and Riparian and Instream Health assessments were completed in a quadrat which was 100m long and extending offstream to the limit of the riparian vegetation. The upstream extent of the quadrat was located at Ch:150m and the downstream extent of the quadrat located at Ch:250m for a typical 430m long site.

Transect markers also indicate the location of permanent photopoints. The use of markers ensures that subsequent photographs are taken from the same location each year to give an accurate visual representation of changes occurring at particular locations at each site over time.

A photograph convention was adopted whereby three photographs were taken at each transect. The subject and direction are listed below:

1. Riparian zone facing downstream
2. Stream facing downstream
3. Peg facing the stream

The photograph convention is illustrated below in Figure 3.

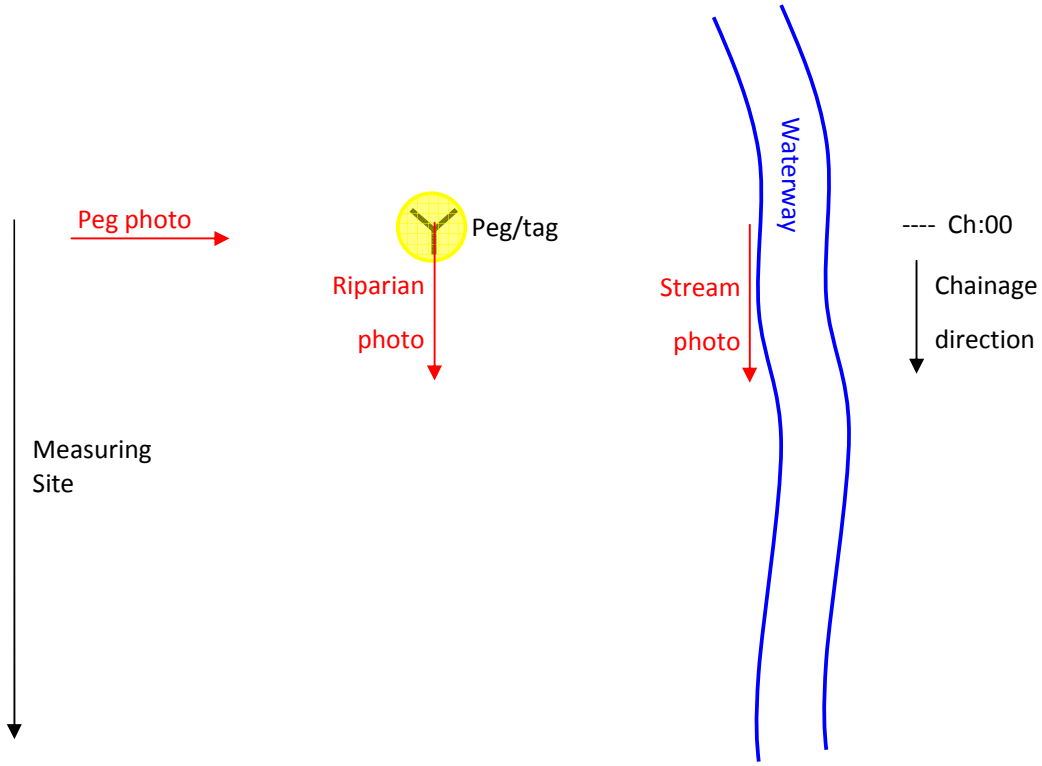

Figure 3 Photograph convention

5. DATA ENTRY

5.1 ISC Online Database

ISC data analysis is performed using a web based data entry tool developed in 2007 by DSE. The ISC online database can be accessed through the following web address; http://isc.dse.vic.gov.au/. This website enables accredited users to input, calculate and view ISC field data for Streamside Zone and Physical Form sub-indices. The tool was designed to limit errors in data transcripts, reduce time spent entering data, reduce costs of data gathering and analysis and to provide a transparent application of the ISC which can be accessed and utilised quickly, efficiently and with very high confidence in data accuracy and calculations. While anyone can view the general information on the ISC website, only accredited and authorised ISC field assessors may upload and view ISC field data.

The ISC data input tool was released in 2007 for use by the public after undergoing testing and revision. However it is a relatively new tool which still contains several fields that are incompatible with the data sheets or errors that need to be rectified by DSE in future version updates of the input tool. These fields and errors included:

Width of Vegetation (Adjacent vegetation Width) - the symbols < or > cannot be entered to describe a width. Where possible adjacent vegetation widths have been estimated and recorded, however when the width extends off stream in greater than 200m, it has simply been recorded as 200m. Refer to original data sheets for further information.

Width of Vegetation (Highly Modified) – This information couldn't be included in the database as it wasn't collected in the field because it is not incorporated on the 2008 field data collection sheet. Therefore in every case the 'no' category was selected in order to move through the data entry process.

Width of Vegetation (Riparian Width Key Identifiers) – key identifiers have been established to help ensure that all critical features are considered before the riparian width is defined. The three key identifiers are Indicative Species, Geomorphic and Cleared. While a combination of key identifiers is often relevant to determine riparian width, the most dominant indicator has been selected and recorded. Please refer to the data sheets for further information for individual sites.

Recruitment – The recruitment metric is required to be assessed at every site, however recruitment was not observed at all sites. Due to the sequential nature of the database you are required to select a recruitment type category (either natural or planted) before being able to select 'zero lifeforms recruiting'. Thus, when a site had no observed recruitment, its recruitment type was selected as 'natural' and 'zero lifeforms recruiting'. Please refer to data sheets for further information on individual sites.

EVC – The tool only allows riparian EVC's to be used. In cases where a non-riparian EVC was used, this was entered as a riparian EVC for the purposes of score calculation on the online data entry tool.

Data was entered between April and June 2008 and submitted to DSE for analysis on Tuesday 1st July 2008.

Data was submitted to DSE for score calculation on 20th May 2009. Comprehensive quality checking of the ISC indicator and sub-index scores was completed by Water Technology to ensure that the results received from the data reporting module of the tool were correct. A sample of 5 sites was randomly selected to confirm the calculation of each indicator score and all sub-index scores were also confirmed. No further issues were identified and all scoring was considered accurate as at the 4th June 2009.

5.2 VQA, RHA and Riparian and Instream Health Methods

The entry of remaining assessment methods was keyed into Microsoft Excel spreadsheets for calculation of scores and ratings and inclusion in this report. Please refer to Appendix C for tabulated site assessment results for the assessments of the 20 fire affected sites.

5.3 Site Photographs

Site photographs for assessments have been included on a CD contained in Appendix E. The convention developed by Earth Tech (2007a) for the Riparian Trend project has been adopted for this assessment of fire affected sites. Transect photographs were renamed using the convention:

Year_Site_WaterwayName_Transect_View & Photo no._Direction.JPG

Where:

- **Year** – 2009
- **Site** – number 1 to 20
- **Waterway Name** – no spaces, i.e. JamiesonRiver
- **Transect** – 1, 2, 3 or chainage of specific photo or issue (ie.ch230)
- **View** – R (riparian), S (stream), P (peg or tag)
- **Photo no.** – where multiples of same views at each transect, use 1, 2, 3, etc. i.e. R1, R2 for riparian photo 1 and riparian photo 2 at each transect
- **Direction** – us (upstream), ds (downstream), o (other), s (facing stream)

6. RESULTS

This project reassessed the condition of 20 sites affected by the summer 2006/2007 fires in the upper Broken and Goulburn catchments using the methods and field procedure detailed in Sections 3 and 4 respectively.

Pre-fire ISC assessments had previously been completed at 9 of these sites in 2004 or 2005 and sub-index scores from these assessments have also been calculated to allow a comparison of pre-fire and post-fire condition to be made for this selection of sites. Post-fire assessments were initially completed in autumn 2008 at each of the 20 sites and results of these assessments have also been included in this reporting for comparison.

The results of this study have been presented as follows:

- A summary of the site details for the 2009 assessment program, including date and location of assessment and assessor names are presented in Section 6.1.
- A summary of the adopted pre-fire vegetation type based on mapped Ecological Vegetation Class (EVCs) and field observations at each site are presented in Section 6.2. The type of vegetation at a site is a function of a number of spatial attributes, including geology and soil type, position and aspect, and climatic factors such as rainfall and temperature. Vegetation in different climatic and spatial zones is not subjected to the same burning regimes and will also respond differently to fire.
- A summary of the observed burn intensity at each of the sites is presented in Section 6.3, as our field assessments indicated that the intensity of the fire event was a key factor in the resulting condition/structure of the riparian areas post-fire. A simple rating system for burn intensity was required to enable categorisation of the fire intensity at each site. The Fire Severity Classification developed by DSE (2008) for fire salvage harvesting in similar catchment areas was adopted and applied at each site.
- Tabulated results of the ISC, RHA, VQA and Riparian and Instream Health assessments are presented in Appendix C.
- Individual site summary sheets are provided in Appendix D. These sheets include results for each metric of the assessment methods (2004/2005, 2008 and 2009), representative site photographs, site location details, site access details, vegetation type and estimated fire severity rating.
- Digital format of all data is provided in Appendix E, including Microsoft Excel spreadsheets (2007 version), site photographs (JPEG) and mapping files (ESRI shapefiles) of site locations.

6.1 Assessment Program

The 20 fire affected sites were assessed between 25th March and 19th May 2008 by paired crews of Water Technology staff Jamie Kaye, Sally Day, Julian Martin and Monica Hersburgh, from the bases of Wangaratta, Jamieson, Mansfield and Woods Point. At least one assessor in each paired crew had assessed each site in 2008 to ensure consistency in data collection and ease of site access. The locations of the assessments are shown in Figure 1 and details of the assessed sites are tabulated in Table 2.

Table 2 **Assessment program for fire affected sites, March-May 2009. Site locations are provided as MGA zone 55 co-ordinates (GDA94 datum).**

Basin	Reach	Site	Waterway	Previous Site ID	Easting	Northing	Site Length	Date	Assessors
5	77	1	Jamieson River – North Branch	5.77.2	451422	5876497	460m	14/05/2009	Jamie Kaye & Sally Day
5	78	2	Jamieson River – South Branch	5.78.3	445409	5865041	380m	31/03/2009	Sally Day & Monica Hersburgh
5	79	3	Bakers Creek	5.79.4	424256	5865429	430m	2/04/2009	Sally Day & Monica Hersburgh
5	80	4	Flourbag Creek	5.80.5	430072	5861585	430m	2/04/2009	Sally Day & Monica Hersburgh
4	15	5	Holland Creek	4.15.319	430458	5914490	430m	19/05/2009	Sally Day & Monica Hersburgh
4	17	6	Ryans Creek	-	430326	5925039	430m	17/04/2009	Julian Martin & Sally Day
4	19	7	Watchbox Creek	4.19.408	427680	5935064	400m	17/04/2009	Julian Martin & Sally Day
4	6	8	Broken River	-	436230	5905100	430m	8/05/2009	Jamie Kaye & Julian Martin
5	15	9	Goulburn River	5.15.457	433061	5858577	430m	2/04/2009	Sally Day & Monica Hersburgh
5	15	10	Goulburn River	-	433644	5854188	330m	6/05/2009	Jamie Kaye & Julian Martin
5	70	11	Howqua River	5.70.1939	463092	5886361	400m	14/05/2009	Jamie Kaye & Sally Day
5	72	12	Delatite River	5.72.1989	447657	5892699	400m	25/03/2009	Sally Day & Monica Hersburgh
5	15	13	Goulburn River	-	424276	5865982	230m	6/05/2009	Jamie Kaye & Julian Martin
5	16	14	Goulburn River	-	436962	5850164	380m	7/05/2009	Jamie Kaye & Julian Martin
5	70	15	Howqua River	-	432769	5875492	430m	3/04/2009	Sally Day & Monica Hersburgh
5	70	16	Howqua River	-	443037	5884156	360m	13/05/2009	Jamie Kaye & Sally Day
5	70	17	Howqua River	-	456580	5884925	430m	13/05/2009	Jamie Kaye & Sally Day
5	72	18	Delatite River	-	448484	5892646	230m	25/03/2009	Sally Day & Monica Hersburgh
5	76	19	Jamieson River	-	433857	5870649	430m	1/04/2009	Sally Day & Monica Hersburgh
5	76	20	Jamieson River	-	444006	5867122	430m	15/05/2009	Jamie Kaye & Sally Day

6.2 Vegetation Type

Native vegetation communities vary significantly across Victoria reflecting the differences in geology, soil, climate, rainfall, elevation, drainage and aspect where these communities are growing. Groups of plants suited to similar conditions are commonly associated with each other, and these associations are referred to as Ecological Vegetation Classes (EVCs). EVCs are derived from large-scale forest type and plant community mapping and are based on the following types of information:

- plant communities and forest types (including species and structural information)
- ecological information relevant to the species that comprise the communities (including life-form and reproductive strategies)
- information that describes variation in the physical environment (including aspect, elevation, geology and soils, landform, rainfall, salinity and climatic zones).

The Biodiversity Interactive Map (www.dse.vic.gov.au) can be used to determine the bioregion, Pre 1750 EVC (i.e. pre-European), Extant EVC (i.e. current) and appropriate EVC Group for each site. This mapping has been used to guide the field determination of vegetation characteristics for the 20 fire affected sites as shown in Table 3. The mapping of this information has often been undertaken at scales of 1:100 000 and therefore requires field validation prior to adoption of these reference vegetation types for the assessments. This occasionally leads to a difference in the mapped and adopted EVC for a site as highlighted for several sites in Table 3. The EVCs adopted for 2009 assessments are consistent with those adopted in 2008.

The fire affected sites of the upper Broken and Goulburn catchments are located within the Highlands-Northern Fall (HNF) and Central Victorian Uplands (CVU) bioregions. The EVCs for these sites have been mapped as one of the following types:

- EVC 18 – Riparian Forest
- EVC 21 – Shrubby Dry Forest
- EVC 23 – Herb-rich Foothill Forest
- EVC 29 – Damp Forest
- EVC 41 – Montane Riparian Thicket
- EVC 84 – Riparian Forest/Swampy Riparian Woodland/Riparian Shrubland/Riverine Escarpment Scrub Mosaic

These EVCs can be more coarsely classified a general group of vegetation types above the level of EVCs, these are referred to as EVC groups:

- EVC Group 3 – Dry Forests (e.g. EVC 21, EVC 23)
- EVC Group 14 – Riparian Scrubs or Swampy Scrubs and Woodlands (e.g. EVC 41)
- EVC Group 15 – Riparian Forests or Woodlands (e.g. EVC 18, EVC 84)
- EVC Group 20 – Wet or Damp Forests (e.g. EVC 29)

Table 3 **Bioregions, mapped and adopted EVCs and EVC groups for fire affected sites assessed in the upper Broken and Goulburn catchments.**

Site	Waterway	Bioregion	Mapped EVC		Adopted Extant EVC		EVC Group
			Pre1750	Extant	2004/ 2005	2008	
1	Jamieson River	HNF	18	18	18	18	15
2	Jamieson River	HNF	29	29	29	29	20
3	Bakers Creek	HNF	18	18	29	29	20
4	Flourbag Creek	HNF	18	18	23	23	3
5	Holland Creek	HNF	41	41	T1/T2 18 T3 29	18	15
6	Ryans Creek	HNF	29/18	29/18	-	18	15
7	Watchbox Creek	CVU	18	18	18	18	15
8	Broken River	HNF	21	21	-	21	3
9	Goulburn River	HNF	18	18	18	18	15
10	Goulburn River	HNF	18	18	-	18	15
11	Howqua River	HNF	84	58	18	18	15
12	Delatite River	HNF	18	18	18	18	15
13	Goulburn River	HNF	18	18	-	18	15
14	Goulburn River	HNF	18	18	-	18	15
15	Howqua River	HNF	18	18	-	18	15
16	Howqua River	HNF	84	58	-	18	15
17	Howqua River	HNF	18	18	-	18	15
18	Delatite River	HNF	18	18	-	18	15
19	Jamieson River	HNF	18	18	-	18	15
20	Jamieson River	HNF	18	18	-	18	15

6.3 Fire Severity Classification

Observations during our field assessments indicated that the intensity of the fire event was a key factor in the resulting condition of the riparian areas post-fire. Examples of important features that were modified following fire at a site includes loss of large trees, large changes to canopy density, loss of particular lifeforms (e.g. large shrubs or small shrubs), changes in species composition of understorey, loss of terrestrial habitat logs and weed invasion. We required a simple rating system for burn intensity that would enable categorisation of the fire intensity at our fire affected sites with the intention that this would help to explain the differences in observed vegetation quality at the assessed sites. In discussion with fire management staff from DSE (Jacinta Ludeman, *pers. comm.*) and Vic Forests (Owen Bassett, *pers. comm.*), we adopted the Fire Severity classification developed by DSE (2008) for fire salvage harvesting in similar forested areas (refer to Table 4). As this method was developed with the intention of it being applied immediately post-fire, and mainly to canopy trees, some interpretation was made by Water Technology to apply this to our assessments (refer to Table 5).

Table 4 Fire Severity classification adopted from DSE (2008).

Severity Class	Severity Type	Description
1	Crown burn	90 - 100% of eucalypt and non-eucalypt crowns are burnt *an intense burn with widespread crown removal*
2	Crown scorch	60 - 100% of eucalypt and non-eucalypt crowns are scorched, some crowns are burnt *an intense understorey fire with complete crown scorch of most eucalypt and non-eucalypts*
3	Moderate crown scorch	30 - 65% of eucalypt and non-eucalypt crowns are scorched *a variable intensity of fire ranging from a warm ground burn with no crown scorch to an intense understorey fire with complete crown scorch of most eucalypt and non-eucalypts*
4	Light crown scorch	1 - 35% of eucalypt and non-eucalypt crowns are scorched *a light ground burn with isolated patches of intense understorey fire and some crown scorch*
5	No crown scorch	< 1% of eucalypt and non-eucalypt crowns are scorched *understorey may be burnt or unburnt*

Table 5 **Interpretation of the Fire Severity Classification (DSE 2008) by Water Technology for this project.**

Severity Class	Water Technology Interpretation Comments	Representative Photo
1	**Crown burn** - Many trees dead, extensive epicormic growth on Eucalypts - Total destruction of mature woody understorey *Site 15 – Howqua River*	
2	**Crown scorch** - Occasional tree dead, extensive epicormic growth - Total destruction of mature woody understorey *Site 5 – Holland Creek*	
3	**Moderate crown scorch** - No dead trees, much epicormic growth - Most woody understorey burnt, channel fringing vegetation often unburnt *Site 13 – Goulburn River*	

Severity Class	Water Technology Interpretation Comments	Representative Photo
4	**Light crown scorch** - Patchy burn or - Some crown scorch and associated epicormic growth - Moderate understorey damage *Site 3 – Bakers Creek*	
5	**No crown scorch** - Canopy intact - Cool understorey burn with most woody understorey surviving *Site 18 – Delatite River*	

This classification has been applied to the fire sites post field assessment, when it was realised that categorisation of the fire intensity at our sites may assist with interpretation of the condition assessment results. The fire severity ratings for each of the 20 fire affected sites based on the classifications in Table 4 and Table 5 are shown in Table 6.

Table 6 **Fire severity class and type for fire affected sites in the upper Broken and Goulburn catchments.**

Site	Waterway	Fire Severity Class (1=hottest, 5=coldest)	Fire Severity Type
1	Jamieson River	3	Moderate crown scorch
2	Jamieson River	5	No crown scorch
3	Bakers Creek	4	Light crown scorch
4	Flourbag Creek	4	Light crown scorch
5	Holland Creek	2	Crown scorch
6	Ryans Creek	2	Crown scorch
7	Watchbox Creek	1	Crown burn
8	Broken River	4	Light crown scorch
9	Goulburn River	5	No crown scorch
10	Goulburn River	3	Moderate crown scorch
11	Howqua River	5	No crown scorch
12	Delatite River	4	Light crown scorch
13	Goulburn River	3	Moderate crown scorch
14	Goulburn River	1	Crown burn
15	Howqua River	1	Crown burn
16	Howqua River	4	Light crown scorch
17	Howqua River	1	Crown burn
18	Delatite River	5	No crown scorch
19	Jamieson River	2	Crown scorch
20	Jamieson River	2	Crown scorch

The intensity of fire at the 20 assessed sites ranged from No Crown Scorch through to a Crown Burn based on the Fire Severity Classification (DSE 2008). This post assessment classification of fire severity indicates that sites with a range of different fire intensities were assessed. The assessors observed that as expected fire intensity appears to have had a direct influence on condition of the sites post-fire.

6.4 Condition Assessment Results

The following section presents a summary of results for the current and previous assessments completed at the fire affected sites in the upper Broken and Goulburn catchments as per the method and field procedure outlined in Sections 3 and 4.

Condition assessment scores and ratings for each of these methods are presented in the following Sections (Table 7 to Table 10) and also in Appendix C. Individual Site Summary Sheets contained in Appendix D provide greater detail at an individual site level.

6.4.1 Index of Stream Condition

The results of the 2009 ISC assessments (Table 7) indicate that the average Physical Form sub-index score has increased (5.6/10 cf. 5/10) and the average Streamside Zone sub-index score has remained constant (7.5/10) over the past 12 months.

Table 7 ISC results for sites field assessed in 2008 and 2009 (based on the 2004 2nd edition method) and where available, their scores for 2004/2005 (based on the 2004 method).

Site	Waterway	ISC Physical Form sub-index			ISC Streamside Zone sub-index		
		2004/2005	2008	2009	2004/2005	2008	2009
1	Jamieson River	6	6.3	6.3	9	7.2	8.6
2	Jamieson River	8	5.0	6.9	9	7.9	7.3
3	Bakers Creek	7	5.6	6.3	8	8.4	8.2
4	Flourbag Creek	6	4.4	5.0	8	8.3	8.2
5	Holland Creek	n/a*	4.4	3.8	n/a*	7.3	6.7
6	Ryans Creek		4.4	6.3		7.5	7.6
7	Watchbox Creek	6	4.4	4.4	6	5.9	4.9
8	Broken River		4.4	5.0		6.5	6.5
9	Goulburn River	5	5.0	6.3	7	8.5	8.5
10	Goulburn River		5.0	6.3		7.9	7.6
11	Howqua River	7	6.9	6.9	9	8.2	8.3
12	Delatite River	6	6.3	5.6	8	8.5	6.4
13	Goulburn River		3.8	5.0		7.7	6.9
14	Goulburn River		4.4	4.4		7.3	7.7
15	Howqua River		5.0	5.0		6.9	6.9
16	Howqua River		4.4	4.4		5.8	7.0
17	Howqua River		4.4	6.9		6.8	7.2
18	Delatite River		7.5	7.5		8.5	8.9
19	Jamieson River		4.4	5.0		7.6	7.5
20	Jamieson River		4.4	4.4		7.6	8.2
Average		**-**	**5.0**	**5.6**	**-**	**7.5**	**7.5**

* site assessed in 2004, however incomplete data entry prevented the calculation of sub-index scores

The majority (15 sites) of the 20 sites assessed showed an increase in the Physical Form sub-index score, while scores at three sites remain unchanged and only two sites decreased in value. The changes in the Physical Form scores have occurred as a result of adjustments in the Large Wood and Bank Stability scores at individual sites. Individual Physical Form scores have improved by up to 2.5/10 at Site 17, where improvements in both Large Wood and Bank Stability were recorded. At sites where a decrease in the Physical Form score was observed, this is due solely to a reduction in the Large Wood score.

The abundance of instream large wood may be variable at individual sites over time, as a result of fire affected trees gradually falling into the waterway and timber moving through the system or deposited out of the channel in larger flow events following the fire. Bank stability has improved at approximately 30% of sites by one condition class, with the bank condition at the remaining sites consistent with 2008 assessments. Improvements in bank stability are expected with time, as woody vegetation regeneration continues to establish and ground species recover.

Despite the average Streamside Zone sub-index score remaining constant between 2008 and 2009 (7.5/10), individual site scores decreased at just over half (11 sites) of the 20 sites assessed and increased at the remaining nine sites. The maximum increase at individual sites between years was 1.4 points out of a maximum of 10, while the maximum decrease was 2 points.

Further decline in the streamside zone condition between 2008 and 2009 (i.e. approximately 26 months post-fire) was not expected. Further inspection of individual metric scores for the Streamside Zone sub-index have been described below in an attempt to qualify this finding:

- As expected, no change to the Streamside Zone Width was recorded at any sites.
- Large Tree scores have altered at seven sites. Scores increased at four sites where the health of the large tree canopy had improved. A decrease in scores was noted at three sites, where either a reduction in tree health or a reduction in the total number of standing trees was recorded.
- Understorey Lifeform scores have altered at eight sites. The changes in scores have occurred as a result of changes in the total number of lifeforms present at each site. The lifeforms most affected in the last 12 months and recording a decrease in cover have been bryophytes, moss and lichen, ground ferns and small herbs. These lifeforms are all ground species that are sensitive to changes in environmental conditions including light and soil moisture. This is consistent with the assessors' observations that sites generally appeared drier this year. There also seemed to be a greater abundance of herbs in 2008, whereas 2009 has generally seen a proliferation of grasses and woody regeneration. Increases in the cover of medium shrubs and sub canopy trees were also noted at two sites, consistent with the ongoing establishment and growth of post-fire regeneration.
- Recruitment scores have altered at eight sites, with scores improving at six sites and decreasing at two sites. The changes in recruitment are complex to summarise, as they are linked closely to the assessment of whether particular woody understorey lifeforms are present at the site. Changes in scores at the majority of sites are linked to the recently recorded presence and/or maturation of medium shrubs. The regeneration of this lifeform is often highly dependent on fire, and the elapsed period since the fire event (approx. 26 months) is obviously sufficient time for these shrubs to grow and mature, as indicated by flowering and fruiting. The most common medium shrub observed in its adult form (i.e. flowering) is Common Cassinia (*Cassinia aculeata*), which is a known disturbance species.
- Longitudinal Continuity scores have altered at six sites, with scores increasing at three sites and decreasing at three sites. Improvements in continuity have occurred as a result of continuing improvements in the tree health, and subsequently canopy cover, and also an increase in the cover of blackberry at individual sites (Note: Blackberry is considered woody vegetation and counted as continuous if of sufficient cover). Conversely, decreases in the continuity score have

occurred as a result of blackberry spraying and the more recent death of fire affected canopy trees.

- Tree Canopy scores have altered at just over half of the sites (11 sites) with canopy scores improving at nine sites and further decreasing at two sites. The measurable increase in canopy health, up to 1.3 points out of 5, is mostly due to the extensive growth of epicormic shoots and continued recovery of the canopy over the post-fire period. Very occasionally, tree epicormic canopy cover is lost where the tree later dies.
- Organic Litter scores have altered at 12 sites, with scores improving at eight sites and decreasing at four sites. Variations in the organic litter score can arise from deviations in benchmark cover levels and the proportion of exotic/native litter. In all instances, organic litter was predominantly native (i.e. >50% cover native) and mostly comprised Eucalypt leaves. The score increases at six sites were due to a reduction in litter cover towards benchmark levels and the score increases at the remaining two sites were due to the cover of litter increasing towards benchmark levels. The reduction in organic litter scores at four sites has occurred due to litter covers increasing above benchmark levels (i.e. too much litter at a site is scored down appropriately). The abundance of organic litter is affected by the health of the tree canopy. Assessors often observed a local increase in organic litter adjacent to trees that have died within the past 12 months.
- The Logs scores have increased at six sites and decreased at three sites. The variations in log scores can arise from either changes in the size or the quantity of logs. Four sites demonstrated a change in logs score as a result of a change in the proportion of large sized logs at the site. A change in the quantity of logs impacted upon logs scores at the five remaining sites. Assessors observed recently fallen dead limbs and tops of trees at some sites, while existing timber also became more difficult to assess, as it became covered with dense vegetation including blackberry.
- Weed Cover scores have altered at half of the assessed sites, with scores improving at four sites and decreasing at six sites. Variations in weed cover scores between 2008 and 2009 are mostly due to changes in the cover of either shrub or ground weeds. Only one site was affected by a change (increase) in tree layer weeds. Sites that demonstrated an increase in the weed score (i.e. a drop in total weed cover) have occurred due to a decrease in ground weeds (3 sites) and a drop in shrub weeds (1 site). Assessors observed a drop in ground weed covers over the past 12 months at several sites, particularly spear thistle and fleabane, which was surprising given the prevalence of seeding specimens at sites in 2008. While this is not directly reflected in Understorey scores at this stage, the decrease in ground weeds is probably reflective of increased competition from native regeneration, affecting the availability of light and moisture for these herbaceous weeds. Despite weed control having been undertaken at two sites (Sites 9 & 13) for blackberry and cape broom, weed scores have not improved at either of these sites.

Review of the 2004/2005, 2008 and 2009 ISC scores was also completed to determine the post-fire response of the site relative to the original pre-fire condition. There have been some minor changes to the ISC method between these periods, as indicated in Section 7.1. In addition, unlike the MS access database employed for the calculation of scores in 2004/2005, the 2007 data entry tool allows calculation of the sub-index scores to several decimal points. The discussion provided below assumes sub-index scores rounded to whole numbers, as per the intention for the quotation of ISC sub-index scores in DSE (2005):

- Physical Form sub-index scores have remained constant at three sites (Sites 1, 11 & 12), indicating that fire has had little impact on the physical channel condition at these sites. These sites correspond with areas that experienced a fire severity class of 3 to 5, indicating that some mid storey probably remained unburnt, particularly channel fringing vegetation, assisting in retaining similar bank condition scores.

- Both the Physical Form score and Streamside Zone score improved at Site 9 over the period between 2004/2005 and 2009, despite the impacts of fire. The fire severity class of this site was a 5, indicating that the fire was a cool understorey burn with most woody understorey surviving. The bank condition has improved at this site, possibly through the establishment of post-fire regeneration. The cover of weeds has also reduced through significant blackberry spraying at the site, which may have also contributed to the improvement in understorey lifeforms following the fire. Improvements to the large tree indicator score cannot be explained by the fire, but are more likely to be a function of assessor variability (e.g. CMA versus Water Technology staff), or trees reaching the large tree threshold in the previous 4-5 years.
- Physical form scores have decreased at the remaining four sites, with three sites decreasing by 1 point (Sites 2, 3 & 4) and one site decreasing by 2 points (Site 7). These sites had a fire severity classification of 4 or 5, and 1 respectively. This finding suggests that sites that have been impacted by fire of the highest severity are yet to regain their previous physical form condition as a result of a decrease in bank stability and the presence of instream wood.
- Streamside Zone sub-index scores have remained constant at three sites (Sites 1, 3 & 4) between 2004/2005 and 2009. These sites experienced fire with a severity rated as 3 or 4, ranging from a moderate to light crown scorch, with variable fire damage to the understorey. Two of these sites remained in very similar condition both pre and post-fire, while one site demonstrated an initial drop in condition immediately post-fire followed by an improvement in condition over the past 12 months.
- Streamside Zone condition has not returned to the pre-fire condition at four sites, with two sites 2 points down (Sites 1 & 12) and 2 sites 1 point down (Sites 7 & 11) approximately 26 months following the fire. The fire severity at these sites ranged between a 1, 4 and 5. The condition of three of these sites has further deteriorated over the past 12 months, with one site remaining in roughly the same post-fire condition in 2008 and 2009.

As expected, these finding suggest that approximately two years following fire, relatively undisturbed, upland areas may still not have consistently regained the pre-fire channel form and vegetation condition adjacent to the waterway. A strong determination in the post-fire condition is the severity of the fire at individual locations. Fire severity is greatly influenced by the local topography, aspect, and vegetation type, as well as the direction of the fire front and other antecedent weather conditions. The Physical Form and Streamside Zone sub-indices of the ISC suggest that the measurable condition of the sites may be up to 30% less, two years after fire. Conversely, one site recorded an improvement in Physical Form and Streamside Zone by up to 20% and 30% respectively.

6.4.2 Rapid Habitat Assessment

The results (Table 8) indicate that the habitat quality of the recovering fire affected sites have mostly either improved (14 sites) or remained static (5 sites), with only one site declining in condition over the previous 12 months. Habitat quality ratings remained unchanged at all sites and remain as High with the exception of the site on the upper Broken River. The average habitat score has improved from 16.7/20 to 17.6/20 in the period between the 2008 and 2009 assessments.

Table 8 Summary of post-fire assessment results using the Rapid Habitat Assessment method for 2008 and 2009 assessments.

Site	Waterway	2008		2009	
		Score (/20)	Rating	Score (/20)	Rating
1	Jamieson River	19.5	High	20	High
2	Jamieson River	20.5	High	20.5	High
3	Bakers Creek	19	High	18	High
4	Flourbag Creek	18	High	18	High
5	Holland Creek	14	High	17	High
6	Ryans Creek	15	High	18	High
7	Watchbox Creek	13	High	14	High
8	Broken River	9	Medium	11	Medium
9	Goulburn River	18	High	19	High
10	Goulburn River	16	High	17	High
11	Howqua River	17	High	20	High
12	Delatite River	18	High	18	High
13	Goulburn River	17.5	High	17.5	High
14	Goulburn River	16	High	16.5	High
15	Howqua River	15	High	16	High
16	Howqua River	15.5	High	16	High
17	Howqua River	17	High	18	High
18	Delatite River	19	High	19	High
19	Jamieson River	17.5	High	19.5	High
20	Jamieson River	19	High	19.5	High
Average		**16.7**	**High**	**17.6**	**High**

Improvements in the total habitat quality scores over the previous 12 months ranged from 0.5 (e.g. Sites 1, 14 & 16) to 3 (e.g. Sites 5, 6 & 11). The improvement in the total habitat quality scores has resulted from increases in Canopy Cover (4 sites), Understorey Lifeforms (3 sites), Organic Litter (2 sites), Weeds (4 sites) and Recruitment (5 sites). Such changes are not unexpected and improvements to these individual metrics are further discussed below:

- The continuing improvement in canopy cover is expected as epicormic growth becomes established and the foliage carrying capacity of the tree increases. Over time this will lead to improvements in both the projective foliage cover and the health of the canopy.

- New recruits of a number of shrub species have also continued to emerge in the previous 12 months, increasing the diversity of native shrub regeneration at most sites. At some sites, greater than 20 individual native woody species were observed to be recruiting.
- While changes in the total cover of understorey were only observed at a few sites, an adjustment of individual understorey components was observed at the majority of sites. For example, the high cover of small herbs observed in 2008 approximately 15 months post-fire (up to 80% at some sites), has significantly decreased in 2009. This cover of herbs, and in some cases mosses and lichens, has been balanced by an increase in grass and sedge cover and further growth of recruiting native shrubs and trees. This high cover of small herbs has played an important role by acting as a living mulch, assisting in the protecting the soil surface and encouraging appropriate conditions for the germination and establishment of understorey species.
- Commensurate with the increase in canopy cover, the continued establishment of post-fire regeneration of native shrubs and trees and the death of additional sub-canopy and canopy trees that initially produced epicormic shoots, there have often been notable increases in organic litter at sites. As the threshold for the maximum organic litter score is quite low using this method (e.g. 20% for Riparian Forest), many sites had received the maximum score in 2008 and further improvements in organic litter cover did not register any improvement in this score. The increase in organic litter has also likely impacted upon the role and cover of small herbs at sites.
- Several sites demonstrated a measurable decrease in weed cover over the past 12 months. This decrease is mainly attributed to the drop in ground weeds at many sites. Species such as fleabane and thistle were initially quite abundant post-fire. Despite evidence of these species flowering and seeding last year, germination may have been suppressed by the increasing cover of organic litter and small herbs, and light competition from establishing native shrubs and trees. At sites where the weed cover mostly comprised blackberry in 2008, the size of infestations have either remained static or have continued to increase in both density and patch size. Assessments in 2009 also revealed that blackberry that emerged post-fire is now flowering and fruiting.

6.4.3 Vegetation Quality Assessment

The average quality score based on the Vegetation Quality Assessment method has improved slightly between 2008 and 2009 (29.2/35 cf. 30.7/35), with a number of sites improving their quality class to Excellent (Table 9). As this method is primarily designed for application to grazed lowland frontages and the sites assessed during this project are located in fully forested upper catchments recently subjected to fire, a number of the variables were assessed at their maximum score in 2008 (e.g. above bank width of vegetation, tree regeneration and species richness), with no room for further improvement in subsequent assessments. Other metrics, such as soil disturbance, tree health, weed presence and vegetation structure, may be much more sensitive to changes in structure and composition of the vegetation following fire.

Table 9 Summary of post-fire assessment results using the Vegetation Quality Assessment method for 2008 and 2009 assessments.

Site	Waterway	2008		2009	
		Score (/35)	Class	Score (/35)	Class
1	Jamieson River	33	Excellent	34	Excellent
2	Jamieson River	29	Good	33	Excellent
3	Bakers Creek	28	Good	30	Good
4	Flourbag Creek	31	Excellent	32	Excellent
5	Holland Creek	29	Good	29	Good
6	Ryans Creek	30	Good	31	Excellent
7	Watchbox Creek	29	Good	29	Good
8	Broken River	29	Good	31	Excellent
9	Goulburn River	30	Good	31	Excellent
10	Goulburn River	30	Good	32	Excellent
11	Howqua River	29	Good	30	Good
12	Delatite River	29	Good	31	Excellent
13	Goulburn River	28	Good	31	Excellent
14	Goulburn River	28	Good	29	Good
15	Howqua River	27	Good	27	Good
16	Howqua River	29	Good	29	Good
17	Howqua River	28	Good	30	Good
18	Delatite River	29	Good	31.5	Excellent
19	Jamieson River	29	Good	32	Excellent
20	Jamieson River	30	Good	31	Excellent
Average		**29.2**	**Good**	**30.7**	**Excellent**

Closer inspection of the individual metric scores for each site (Appendix C) revealed the following general trends:

- As expected, there was no change to the width of above bank vegetation at any of the sites.
- Soil disturbance has either remained unaffected by fire or in similar condition to 2008 at 10 sites, with 8 sites improving in condition and two have deteriorated.
- There was a measurable improvement in tree health at 6 sites over the past 12 months, with the remaining assessed sites displaying similar canopy health to 2008.
- Tree regeneration, including trees and large woody shrubs, has improved either one or two classes at 7 sites and remained constant at the remaining sites.
- Weed cover in the context of this method, includes broad leaved and woody weeds (i.e. excludes all exotic grasses). Over the past 12 months, the total weed cover has dropped at 5 sites and increased/worsened at 3 sites. At sites where weed covers have continued to increase, the species of greatest threat are cape broom (Site 14), blackberry (Sites 14, 16, 20), mint (Site 16) and fleabane and thistle (Sites 16, 20).
- As expected, species richness has remained high at all sites and there is no change in the previous 12 months.
- Vegetation structure has either remained constant or improved, with 6 sites exhibiting an improvement in structure by one class.
- The density of fallen timber has altered at 12 sites, with 4 of these sites suggesting a decline in the abundance of fallen timber. As this metric is qualitatively assessed and largely depends on the path walked through the site, the results of the scoring can be variable.
- Similarly, the percentage of the crown cover at the site provided by large, hollow bearing trees has altered at 7 sites in the previous 12 months. An improvement in the cover provided by large trees has been noted at 5 sites, which is attributable to the post-fire growth and recovery of foliage for large trees. Two sites have an observed decrease in the cover provided by large trees, and this has occurred due to the further death of several large trees approximately 2 years after the fire.

6.4.4 Riparian and Instream Health metrics

The average total score for the Riparian and Instream Health metrics has slightly improved over the previous 12 month period (11.7/16 cf. 12/16) (Table 10).

Table 10 Summary of post-fire assessment results using the Riparian and Instream Health metrics for 2008 and 2009 assessments.

Site	Waterway	2008	2009
		Score (/16)	Score (/16)
1	Jamieson River	11	13
2	Jamieson River	13	10
3	Bakers Creek	12	13
4	Flourbag Creek	12	12
5	Holland Creek	13	10
6	Ryans Creek	11	11
7	Watchbox Creek	7	6
8	Broken River	8	9
9	Goulburn River	9	9
10	Goulburn River	14	14
11	Howqua River	13	13
12	Delatite River	14	13
13	Goulburn River	14	14
14	Goulburn River	13	13
15	Howqua River	11	11
16	Howqua River	13	13
17	Howqua River	9	13
18	Delatite River	14	14
19	Jamieson River	11	15
20	Jamieson River	11	13
Average		**11.7**	**12.0**

Review of the individual metric scores (Appendix C, Appendix D) has identified the following general trends:

- There has been no change to the width of the streamside zone at individual sites.
- Longitudinal continuity has largely remained unchanged at the majority of sites (16 sites). Of the remaining sites, the continuity of vegetation has improved at two sites to become fully continuous and decreased to mostly continuous at two sites. This may have occurred through the further death of fire affected sub-canopy and canopy trees and evidence of blackberry spraying at Site 5 (Holland Creek).
- Instream large wood has varied at seven sites, with close to an equal number of these sites recording an increase and decrease in abundance since 2008. In these upland streams, large

wood is often transient, moving through a reach or being deposited out of the channel in higher flow events. Additional instream wood has also been recorded at several sites as a result of the recent fire-damaged trees or limbs collapsing into the waterway.

- The abundance of macrophytes, recorded as the proportion vegetated along the length of quadrat (e.g. none, <50%, >50%) has improved at two sites, decreased at one site and remained constant at all other sites. Increases have occurred due to the continual growth and recruitment of native sedge populations (e.g. *Carex* sp.) since the initial fire disturbance.

6.4.5 Summary of average site condition

The average site condition scores presented in the preceding sections are summarised for each of the methods in Table 11. The change between 2008 and 2009 average scores suggests an improvement in instream condition of 6% (ISC Physical Form) and an improvement in riparian vegetation condition up to approximately 4% (RHA, VQA).

Table 11 Summary of average condition scores for 20 fire affected sites.

Assessment Method	Average Condition Scores for 20 sites		
	2008	2009	Change
ISC Physical Form	5.0	5.6	+0.6/10
ISC Streamside Zone	7.5	7.5	0/10
Rapid Habitat Assessment (RHA)	16.7	17.6	+0.9/20
Vegetation Quality Assessment (VQA)	29.2	30.7	+1.5/35
Riparian & Instream Health metrics	11.7	12.0	+0.3/16

7. LIMITATIONS

Each of the four methods provides a current benchmark condition of the fire affected sites and enables relative comparisons in condition to be determined between sites in similar catchment areas. These methods were not designed with the intention of detecting short term changes in condition, however the Riparian Trend Project (Water Technology 2009) has been assessing the ability of the methods to detect change over smaller timescales. The limitations of each of the methods will be discussed in turn in the following section.

7.1 Index of Stream Condition

The ISC method has been revised several times since 2004. The key revisions occurred prior to the 2006 autumn assessment period when the 2004 2nd edition was released and prior to the 2007 autumn assessment period when additional requirements for the annual sentinel site assessments were implemented. This may result in small changes to indicator metric and sub-index scores that are not related to the fire event between 2004/2005 and 2008 assessments for the 8 sites that were assessed in both of these periods.

The key revisions to the method between these assessment periods are summarised below:

- *Bank stability* - The descriptions of the 2004 (2nd edition) typical bank stability ratings incorporates comments about the proportion of exposed woody roots, the level of livestock damage and access and the shape of the bank profile.
- *Width of Vegetation* - The method applied in 2005 to determine the width indicator score is based on percentage cover of woody vegetation (i.e. vegetation was considered continuous if there is at least 20% woody vegetation cover over the transect). However, the 2004 (2nd edition) ISC method determined the width indicator score based on the extent of riparian vegetation that is dependent on the stream for survival. Indicators used to assist with this assessment include land clearance, indicator species and geomorphic controls.
- Other metrics including large trees, cover of weeds, tree canopy cover, organic litter, logs, understorey lifeforms and recruitment are applied over the determined width of vegetation. Therefore changes to the width of vegetation between the 2004 and 2008 assessments as a result of the change in ISC method noted above may also alter scores for these various other indicators. Note: assessed widths were noted in 2008 so that future repeat assessments will be consistent.
- *Recruitment* - The percentage of adequate recruitment is assigned to one of three categories, and these categories have changed between the two sets of assessments at these sites. The categories for the classification of adequate recruitment were:
    - <30%, 30-70% and >=70% in 2004 and 2005
    - ≤ 35%, >35-80% and >80% for 2008.

  These changes have mostly affected sites where either 1 out of 3 (or 33%) or 3 out of 4 (or 75%) lifeforms are adequately recruiting, by reassigning them to the lowest and the middle categories respectively in 2008.
- *Large Trees* - The way in which the health value is assigned has changed between the 2004/2005 and 2008 assessments. In 2004 and 2005 the health value was scored based on the average canopy health of the sample of large trees assessed. In 2008, assessors were required to count the number of healthy large trees (a healthy tree is one that is not dead, and has more than 50% healthy foliage i.e. not affected by insect attack, decline or mistletoe infestation), and divide this by the total number of large trees within the site. The resulting proportion of healthy large trees is then assigned to the <30%, 30-70% and >70% value as appropriate. These redefinitions are likely to have changed the health value and categorisation for some sites.

7.2 Vegetation Quality Assessment

As this method has been adopted from the Riparian Trend Project, the following comments are taken verbatim from Earth Tech (2007a).

The VQA method has broad scoring categories, where each of the seven attributes are rated from 1 to 5, where 1 is Very Poor and 5 is Excellent. The 'Ground Validation Assessment Rules' (Riparian Australia 2000) for the VQA are provided in Appendix A. These 'Ground Validation Assessment Rules' supply diagrams and definitions to ensure a representative score is selected for each attribute and assessor subjectivity is reduced. It is the assessor's opinion that the aids do not provide a sufficient level of detail and that the omission of defined references for the soil disturbance and vegetation structure metrics leads to subjectivity in the application of the method. The 'Ground Validation Assessment Rules' state that the scoring for the vegetation structure attribute 'will involve a high degree of subjectivity, and will probably be the most difficult for the assessors to have a high degree of confidence in the evaluation'. The lack of comprehensive reference material provided for assessors is a limitation of this method and results may be variable due to the broad interpretation of the ratings.

7.3 Rapid Habitat Assessment

As this method has been adopted from the Riparian Trend Project, the following comments are taken verbatim from Earth Tech (2007a).

The Rapid Habitat Assessment was a methodology originally developed to assess patches of remnant terrestrial vegetation (DSE 2004). Anecdotal evidence suggests that this method has also been applied to the assessment of narrow linear corridors of terrestrial vegetation, such as those usually present on roadsides (Andrew Straker, *pers. comm.*). To the assessor's knowledge, the method has not previously been applied to narrow strips of riparian vegetation. This does not impact on the robustness of the method to assess the quality of native vegetation at a site. However it is the application of the method, in terms of how it can be adapted to be applied to the narrow linear riparian corridors that lends itself to interpretation.

Water Technology have applied the RHA method for this project by adopting a width of an assessment site equal to width of the riparian zone (defined by the presence of riparian vegetation) up to a maximum width of 50m.

7.4 Riparian and Instream Health

The Riparian and Instream Health assessment adopts three of the 2004 edition ISC indicators (width of streamside zone, longitudinal continuity and instream habitat) and includes a generalised macrophyte distribution assessment. The 2004 ISC method definition involving the percentage of vegetation cover (20% rule) will continue to be applied for this metric. This will provide some indication in the relative change in width of streamside zone using one consistently applied definition of the width of vegetation between the two assessment periods.

8. CONCLUSION

Post-fire riparian condition has been re-assessed at twenty sites located in the upper Broken and Goulburn catchments affected by fires in the summer of 2006/2007. The 2009 assessments mark the second year of post-fire assessments completed at these sites. Average condition scores for the twenty sites using the four methods suggests that overall, the condition of the sites has improved over the previous 12 months. More detailed assessments of the changes in individual indicator scores has also been provided. Some general comments regarding the recovery of the native vegetation over the past 12 months are:

- The health and projective cover of the tree canopy are continuing to improve, through the continued establishment of epicormic growth. Further deaths of some individual sub-canopy and canopy trees, particularly *Eucalyptus* sp. and Blackwood (*Acacia melanoxlyon*) have been observed. The loss of additional large trees is also not uncommon.
- The understorey has continued to regenerate at the majority of sites. Many sites were characterised by a high cover of small herbs in 2008. The natural succession of these sites has seen the establishment of native grasses, sedges, ferns and further native tree and shrub recruitment over the past 12 months. Seedlings that initially regenerated post-fire are now well established and may extend more than 2m high, with some native shrub species including Cassinia and Lomatia now flowering and recruiting.
- The cover of small herbs and the organic litter mostly generated from Eucalypt epicormic shoots and tree and shrub recruitment, provides a mostly effective surface coverage, reducing moisture loss and weed invasion.
- Woody weed covers at most sites have remained either static or worsened, this is particularly the case for blackberry (*Rubus fruticosis*), cape broom (*Genista monspessulana*) and English broom (*Cytisus scoparius*). The cover of ground weeds, mostly spear thistle (*Circium vulgare*) and fleabane (*Conyza* sp.), has decreased at many sites, except where infestations were of a very high density in 2008.

Review of the pre-fire (2004/2005) and post-fire (2008, 2009) ISC assessment results indicates that approximately two years following fire, relatively undisturbed, upland areas have not consistently regained the pre-fire channel form and vegetation condition adjacent to the waterway. A strong determination in the post-fire condition is the severity of the fire at individual locations. The severity is greatly influenced by the local topography, aspect, and vegetation type, as well as the direction of the fire front and other antecedent weather conditions on the day. The ISC Physical Form and Streamside Zone sub-indices show that the measurable condition of sites may be up to 30% less, two years after fire disturbance. Conversely, one site recorded an improvement in Physical Form and Streamside Zone condition by up to 20% and 30% respectively. However, given that there have been some minor changes to the ISC method between these assessment periods, the changes in scores may not be solely attributable to the damage caused by the fire event. As the RHA, VQA and Riparian and Instream methods had not been applied pre-fire, no conclusions can be drawn regarding the recovery to pre-fire condition using these methods.

It is recommended that additional analysis be undertaken to assess the correlation between the fire intensity (through use of the Fire Severity Classification) and the individual metric, sub-index and total scores for each of the methods. This may be of further use in predicting the likely vegetation response periods and potential issues for areas recently burnt in other similarly vegetated catchments across the Goulburn Broken region in February 2009.

9. REFERENCES

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APPENDIX A VEGETATION QUALITY ASSESSMENT & RAPID HABITAT ASSESSMENT MANUALS

APPENDIX B SAMPLE FIELD ASSESSMENT SHEET

APPENDIX C TABULATED SITE ASSESSMENT RESULTS

APPENDIX D SITE SUMMARY SHEETS

APPENDIX E DIGITAL DATA

Site photographs – 2004/2005, 2008 & 2009
Mapping files (ESRI shapefiles)
Tabulated site details and scores
Scanned field sheets