Australian Government

MURRAY–DARLING BASIN AUTHORITY

Sustainable Rivers Audit 2

The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010)

Volume 2

The second **Sustainable Rivers Audit** (SRA) is the most comprehensive assessment of river health undertaken for the Murray–Darling Basin.
The report is prepared by ISRAG, an independent panel of ecology experts.:

Peter Davies | Michael Stewardson | Terry Hillman | Jane Roberts | Martin Thoms

www.mdba.gov.au

Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Murray–Darling Basin Authority acknowledges and pays its respect to the Traditional Owners and their Nations of the Murray–Darling Basin. The contributions of earlier generations, including the Elders, who have fought for their rights in natural resource management are also valued and respected.

The Authority recognises and acknowledges that the Traditional Owners and their Nations in the Murray–Darling Basin have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters. The Authority understands the need for recognition of Traditional Owner knowledge and cultural values in natural resource management associated with the Basin. Further research is required to assist in understanding and providing for cultural flows. The Authority supports the belief of the Northern Murray–Darling Basin Aboriginal Nations and the Murray Lower Darling Rivers Indigenous Nations that cultural flows will provide beneficial outcomes for Traditional Owners.

The approach of Traditional Owners to caring for the natural landscape, including water, can be expressed in the words of Ngarrindjeri elder Tom Trevorrow: 'our traditional management plan was don't be greedy, don't take any more than you need and respect everything around you. That's the management plan—it's such a simple management plan, but so hard for people to carry out.[1]

This traditional philosophy is widely held by Traditional Owners and respected and supported by the Murray–Darling Basin Authority.

1. Tom Trevorrow (2010) Murrundi Ruwe Pangari Ringbalin 'River Country Spirit Ceremony: Aboriginal Perspectives on River Country'.

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Australian Government

MURRAY–DARLING BASIN AUTHORITY

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About SRA report 2 (volume 2)

The Sustainable Rivers Audit (SRA) is a systematic assessment of the health of river ecosystems in the Murray–Darling Basin. It is overseen by a panel of independent ecologists, the Independent Sustainable Rivers Audit Group (ISRAG), who are the authors of this report. It is based on data collected and analyses by a multi-jurisdictional team from state and federal governments.

The second full SRA assessment report provides assessments of ecosystem health for each of 23 major river valleys of the Basin, using data gathered in 2008–2010, on the condition of five key ecological components: fish, benthic macroinvertebrates, riverine vegetation, physical form and hydrology.

This document is volume 2 of ISRAG's Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010) submitted to the Murray–Darling Basin Ministerial Council in 2012. It presents the assessment findings for Murray–Darling Basin valleys listed alphabetically from the Avoca to the Loddon.

Volume 1 describes the framework of the SRA, its design and operation, new developments in Themes, analyses and metrics, and recommendations for future implementation and use. It also includes a first assessment of trends in condition of fish, macroinvertebrates and hydrology, based on an initial set of observations through time.

Please refer to Volume 1, Sections 1.6 and 3.2, for important caveats and context information for the assessments reported here. Important caveats include that: these assessments were made prior to the 2010–11 breaking of the drought; the Themes vary in their stage of development; Hydrology is assessed from an ecosystem point of view, as opposed to a purely quantity-based assessment; river ecosystem health ratings are based on the condition of riverine vegetation, fish and macroinvertebrates.

Volume 3 contains the assessment findings for Murray–Darling Basin valleys listed alphabetically from the Macquarie to the Wimmera.

All three volumes as well as an MDBA summary report are available through the Murray–Darling Basin Authority's website: www.mdba.gov.au.

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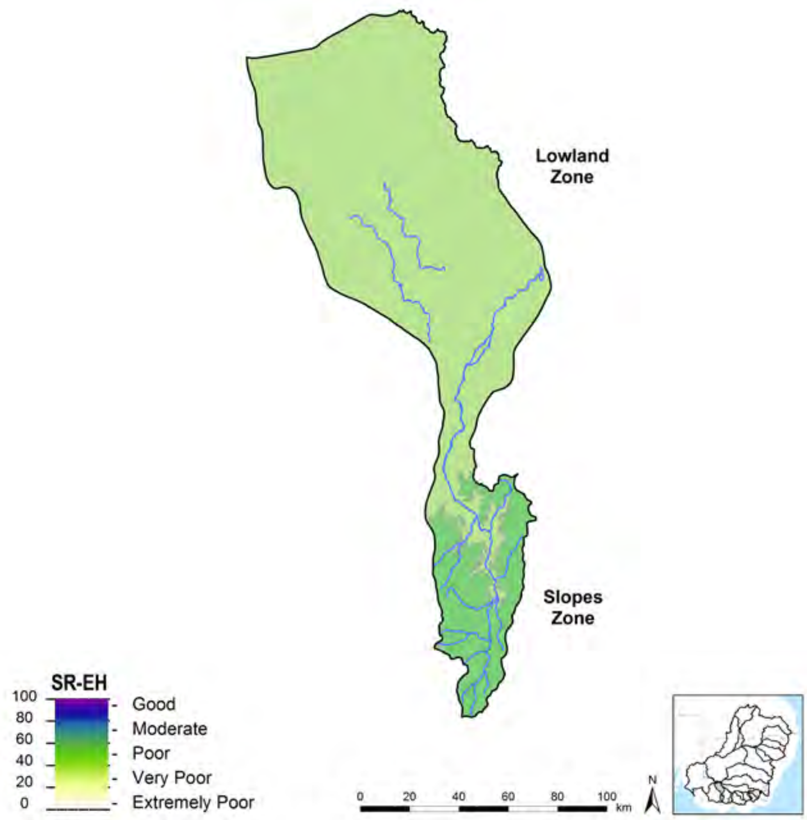

Figure AVC 1: Avoca Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure AVC 1 shows the Ecosystem Health ratings for the Avoca Valley and Tables AVC 1 and AVC 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Avoca Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Very Poor, Moderate and Poor condition respectively, while Physical Form and Hydrology were in Moderate and Good condition respectively.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecological Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Avoca Valley river system. River Ecosystem Health was rated as Poor (Lowland zone: Very Poor; Slopes zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Avoca Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Slopes Poor, Lowland Very Poor. The Fish community was in Very Poor condition. There were reduced numbers of expected native species, a very small biomass of native fish, and a high relative biomass of alien fish. The Macroinvertebrate community was in Moderate condition, with substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Poor condition overall, with reduced abundance and nativeness in the Near Riparian and Lowland Floodplain domains; and a moderate increase in fragmentation in the Lowland Floodplain domain. The Physical Form of the river system was in Moderate condition overall with channel form and bank dynamics in Good condition and bed dynamics in Poor condition. There were moderate levels of floodplain sediment deposition. The river system's Hydrology was in Good condition, with little change from Reference Condition in headwater stream flow variability, flow seasonality, low and zero flow events, high flow events and gross flow volume.

Ecosystem Health

With the exception of Hydrological Condition (and noting that this could be assessed only for headwater streams), the Avoca Valley ranked in the lower 50% of valleys for all Theme indices of Condition. The Avoca was ranked 2nd lowest among 15 valleys rated as having Poor Ecosystem Health (see Table 5.2).

The biotic components of the ecosystem, particularly macroinvertebrates and fish in this case, may be expected to reflect (among other things) the extended dry conditions that have prevailed in the Avoca Valley during the SRA. Macroinvertebrate and fish sampling for the current cycle were completed in late 2008, and samples taken after the onset of wetter conditions (from the second half of 2010) might be expected to reflect some improvement in condition. However, factors that are expected to operate on a longer time-scale—notably aspects of vegetation abundance and diversity and physical form, particularly bed dynamics—also score poorly and suggest a broad basis for the Poor Ecological Health rating of the Avoca Valley. Under these circumstances the capacity of the more reactive components of the ecosystem (such as fish, macroinvertebrates, and some aspects of vegetation quality) to respond to improved climatic conditions may be limited.

Fish Theme

The Fish Condition Index SR–FI = 23, indicating Very Poor condition (Lowland zone: Extremely Poor; Slopes zone: Moderate). The Expectedness indicator = 46, indicating Very Poor condition and a very large difference from Reference Condition. The Nativeness indicator = 22, indicating Very Poor condition, and a very large difference from Reference Condition. The Recruitment indicator = 31, indicating Very Poor condition, and a very large difference from Reference Condition. Numbers of native fish caught in the Lowland and Slopes zones were very low.

Overall, the fish community of the Avoca had reduced numbers of expected native species and a very small biomass of native fish. The alien species, common carp, dominated the fish biomass in both zones.

The Avoca Valley ranked thirteenth among the 23 SRA valleys in terms of Fish condition and was similar to the Loddon, Campaspe, and Central Murray valleys.

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Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 67, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate). The simOE metric = 46, indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Moderate condition was high across both zones, and four sites (13%) were in Good condition.

Family richness was generally reduced compared to Reference Condition. The valley contained 46% of all families found across the Basin, with the Lowland zone having the lowest representation of Basin-wide fauna. Most (> 80%) of the fauna of the valley was found in each of the two zones.

In terms of Macroinvertebrate condition the Avoca Valley ranked sixteenth among the 23 SRA valleys, equal with the Lachlan Valley.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 40, indicating Poor condition (Lowland zone: Poor; Slopes zone: Extremely Poor). The Vegetation Abundance and Diversity indicator = 54, indicating Poor condition and a large difference from Reference Condition for the abundance and stability of vegetation groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 45, indicating Poor condition and a large difference from Reference Condition for the structure, nativeness and fragmentation of vegetation communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains. The Lowland Floodplain domain is moderately affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area was moderately different from Reference Condition.

The Riverine Vegetation condition of the Avoca Valley ranked eighteenth among the 23 SRA valleys, equal with that of the Kiewa and Wimmera valleys.

Physical Form Theme

The Physical Form Condition Index SR–PI = 71, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate). The Channel Form indicator = 84, indicating Good condition and showing near Reference Condition. The Bed Dynamics indicator = 41, indicating Poor condition and showing a moderate difference from Reference Condition. The Bank Dynamics indicator = 94, indicating Good condition and showing near Reference Condition. The Floodplain Form indicator = 61, indicating Moderate condition and showing a minor difference from Reference Condition.

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation both on the floodplain and within the channel[1]. There was also evidence of channel enlargement in the Lowland zone. Together with the Condamine and Gwydir, the Avoca Valley ranked equal nineteenth among the 23 SRA valleys in terms of Physical Form condition.

1 Vlok et al.. (2007) reported high levels of erosion in the Avoca catchment expected to lead to significant in-channel sedimentation.

Hydrology Theme

The Hydrology Condition Index SR–HI = 99, indicating Good condition (Lowland zone: unrated; Slopes zone: Good). The Avoca Valley river system was characterised by headwater streams in Good condition. The headwater streams were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume. There is no mainstem river represented in the hydrological models for the Avoca Valley, and the assessment was limited to headwater stream reaches. Noting this limitation, hydrological condition of the Avoca Valley ranked equal fourth, with the Kiewa, among the 23 SRA valleys.

Table AVC 1: Avoca Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	SLOPES	LOWLAND
		Poor	Poor	Very Poor

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Fish	SCORE RATING	23 (15–28) Very Poor	63 (43–76) Moderate	8 (1–14) Extremely Poor
Macro-invertebrates	SCORE RATING	67 (62–72) Moderate	66 (54–74) Moderate	68 (63–72) Moderate
Vegetation	SCORE RATING	40 Poor	15 Extremely Poor	55 Poor

Table AVC 2: Avoca Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Physical Form	SCORE RATING	71 (60–80) Moderate	62 (48–76) Moderate	76 (60–88) Moderate
Hydrology	SCORE RATING	99 Good	99 Good	

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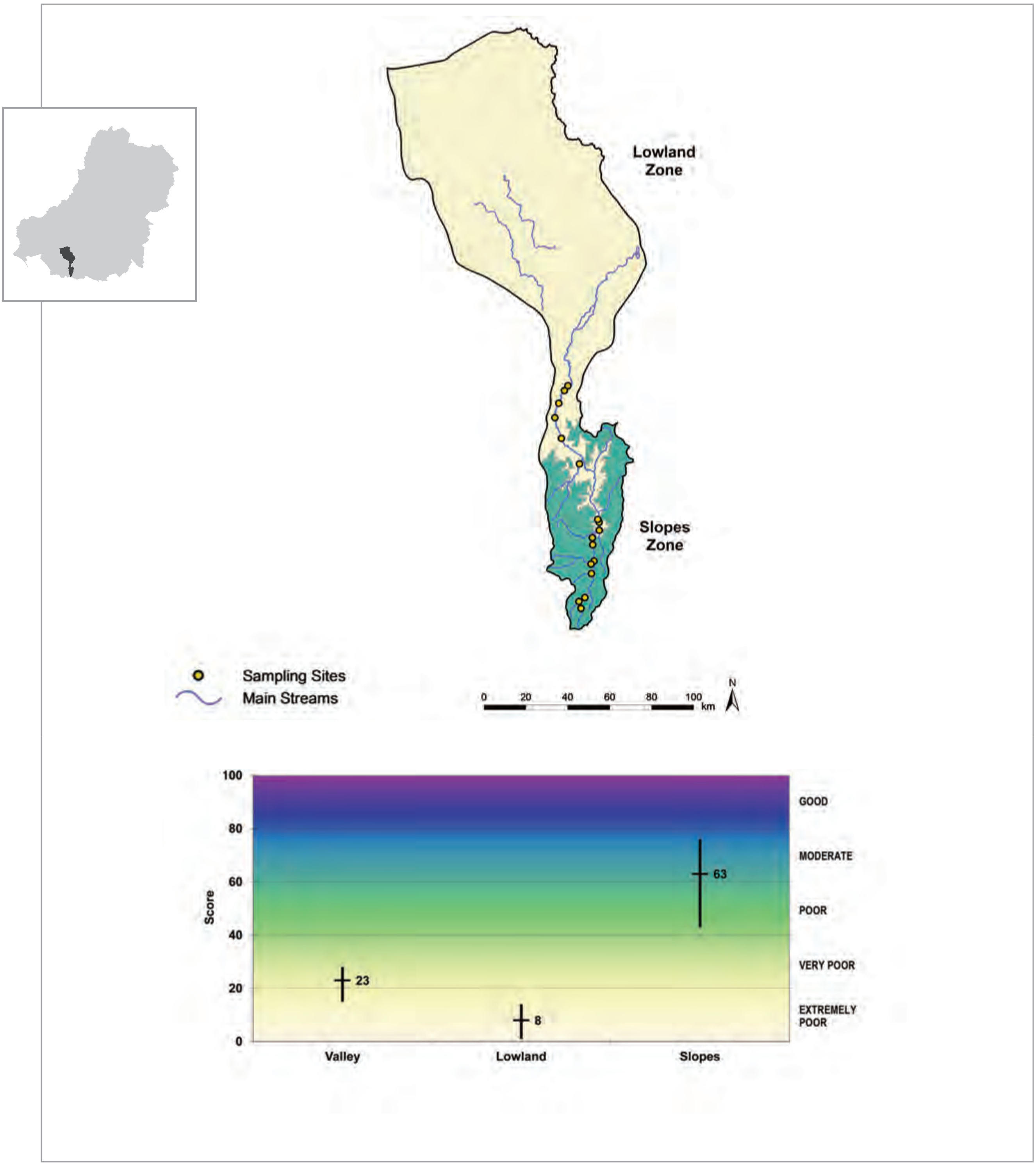

Figure AVC 2: Avoca Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the of the Avoca Valley river system was in Very Poor condition, with an aggregate Fish Index score (SR–FI) of 23. The condition of the fish community in the zones was as follows: Lowland Extremely Poor; Slopes Moderate. The fish community was characterised by a Poor score for expected native fish species, a Very Poor score for nativeness and a Very Poor score for native fish recruitment. The Lowland zone in particular had few fish and lacked almost 70% of the predicted native species. The valley had lost much of its native species richness and alien species contributed over 96% of the biomass in samples. Native fish recruitment was Very Poor and Poor in the Lowland and Slopes zones, respectively.

Seventeen sites were surveyed across the Avoca Valley in November–December 2008, yielding 1,111 fish. Analyses showed a very large difference from Reference Condition for the Avoca Valley, with:

- SRA Fish Index (SR–FI) = 23 (CL 15–28), indicating Very Poor condition of the fish community.
- The Expectedness indicator = 46 (CL 38–55), indicating Poor condition, and a large difference from Reference Condition. Only 44% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 22 (CL 15–29), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 31 (CL 12–38), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for 8 of the 17 native species observed in the valley.

Figure AVC 2 shows sampling sites, zones and corresponding SR–FI values, and Table AVC 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Avoca Valley was thirteenth highest amongst the 23 valleys, and close to that for neighbouring valleys, Loddon, Murray Central, and Campaspe. The Lowland zone community was in much poorer condition (SR–FI = 8) than that in the Slopes zone (SR–FI = 63).

Expectedness differed significantly between the two zones. Only five of 16 predicted (RC–F) native fish were recorded in the Lowland zone, with five alien species. In the Slopes zone, all six RC–F species were recorded, with four alien species.

Nativeness in the Slopes zone was rated as Poor but scored considerably higher than the Lowland zone, rated as Extremely Poor. The Slopes zone had all six expected species present, had four alien species, and the numbers of native and alien individuals were approximately equal. In the Lowland zone only five of the 16 expected species were sighted, there were five alien species caught and alien fish outnumbered natives by more than two to one.

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The Avoca Valley had the second lowest biomass of native fish per site of all 23 valleys (286 g/site) and this represented only 3.9% of the total fish biomass. In contrast the total catch of common carp was 106 kg (6.3 kg/site), 86% of the total fish biomass sampled from the Avoca Valley.

Very few large-bodied native species were caught in either zone (Table AVC 4) and alien species dominated the fish biomass throughout the valley – particularly in the Lowland zone where native species contributed only 2.4% of the total fish biomass and the weight of common carp alone was more than 34 times the combined biomass of native fish caught in that zone.

Of the five native species recorded from the Lowland zone, two showed some evidence of recruitment in at least some sites. In the Slopes zone four out of the six native species showed evidence of recruitment. The alien species gambusia, common carp, and redfin perch all showed evidence of extensive recruitment, with over 70% of the redfin perch population being recruits throughout the valley.

In general, the fish community of the Avoca Valley had reduced numbers of expected native species and a very small biomass of native fish. The alien species, common carp, dominated the fish biomass in both zones.

Table AVC 3: Avoca Valley SRA Fish Condition Index, indicators, metrics and derived variables.

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	**Fish Condition (SR-FI)**	**23 (15–28)**	**63 (43–76)**	**8 (1–14)**
Indicator	Expectedness	46 (38–55)	100 (98–100)	26 (15–38)
Metric	O/E	0.57 (0.43–0.71)	0.96 (0.74–1.00)	0.42 (0.26–0.58)
Metric	O/P (zone level)	0.50 (0.50–0.50)	1.00 (1.00–1.00)	0.31 (0.31–0.31)
Indicator	Nativeness	22 (15–29)	56 (36–74)	9 (3–17)
Metric	Proportion biomass native	0.13 (0.06–0.21)	0.41 (0.15–0.69)	0.02 (0.01–0.04)
Metric	Proportion abundance native	0.32 (0.21–0.43)	0.54 (0.26–0.80)	0.24 (0.12–0.35)

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Metric	Proportion species native	0.37 (0.28–0.46)	0.59 (0.43–0.77)	0.29 (0.18–0.38)
Indicator	**Recruitment**	**31 (12–38)**	**46 (20–62)**	**26 (3–35)**
Metric	Proportion of sites with native recruits	0.41 (0.19–0.45)	0.54 (0.31–0.64)	0.36 (0.10–0.40)
Metric	Proportion of native taxa with recruits	0.47 (0.35–0.69)	0.67 (0.50–0.80)	0.40 (0.25–0.67)
Metric	Proportion of abundance as recruits	0.44 (0.28–0.61)	0.54 (0.27–0.63)	0.40 (0.25–0.67)
Variables				
	Number of sites sampled	17	8	9
	Total number of species	12	10	10
	Number of native species	7	6	5
	Number of predicted species	16	6	16
	Number of alien species	5	4	5
	Mean number of fish per site	65	92	42
	Biomass/site all species (g)	7251	6447	7966
	Mean native biomass/fish (g)	11	9	16
	Mean alien biomass/fish (g)	181	127	257

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Table AVC 4: Avoca Valley number of fish by zone.

Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone	
		Slopes	Lowland
Sites sampled	17	8	9
Native species			
Australian smelt	140	74	66
Bony herring	0		0
Dwarf flathead gudgeon	0		0
Flathead gudgeon	63	27	36
Freshwater catfish	0		0
Golden perch	2	1	1
Gudgeon	0		0
Murray cod	1		1
Murray hardyhead	0		0
Murray jollytail	0		0
Murray–Darling rainbowfish	0		0
Obscure galaxias complex	230	230	0
River blackfish	20	19	1
Silver perch	0		0
Southern pygmy perch	1	1	0
Unspecked hardyhead	0		0

Continued/...

Fish species	Valley	Zone	
		Slopes	Lowland
Alien species			
Common carp	148	53	95
Gambusia	422	310	112
Goldfish	26	1	25
Redfin perch	57	18	39
Tench	1		1

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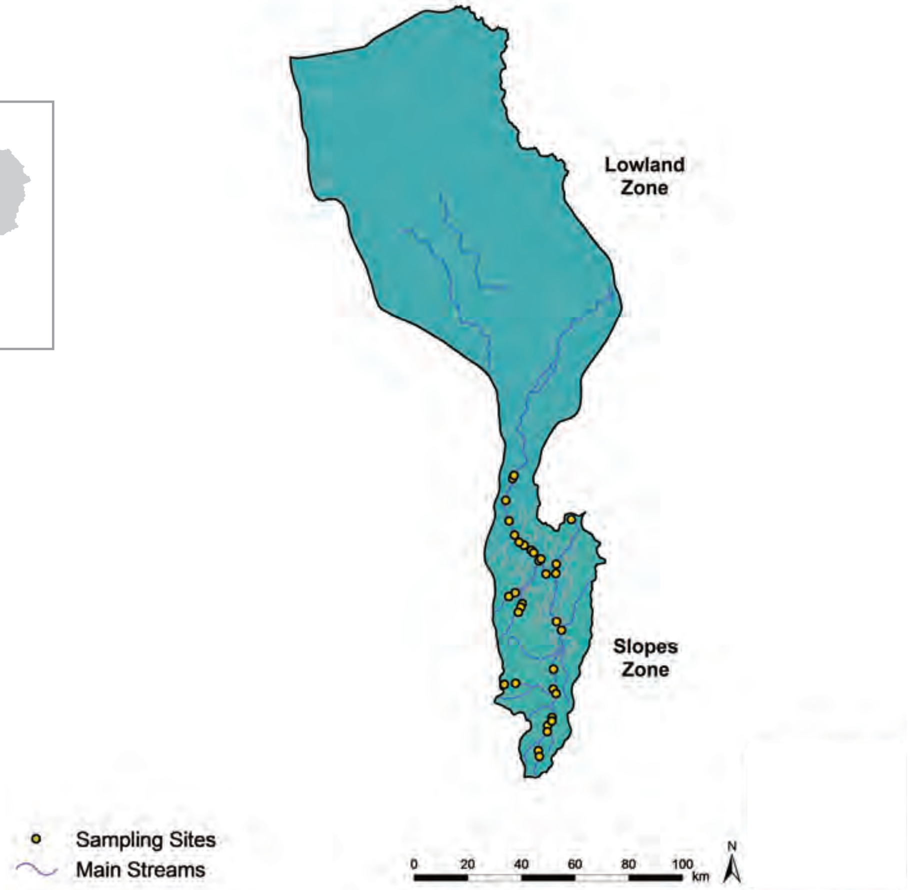

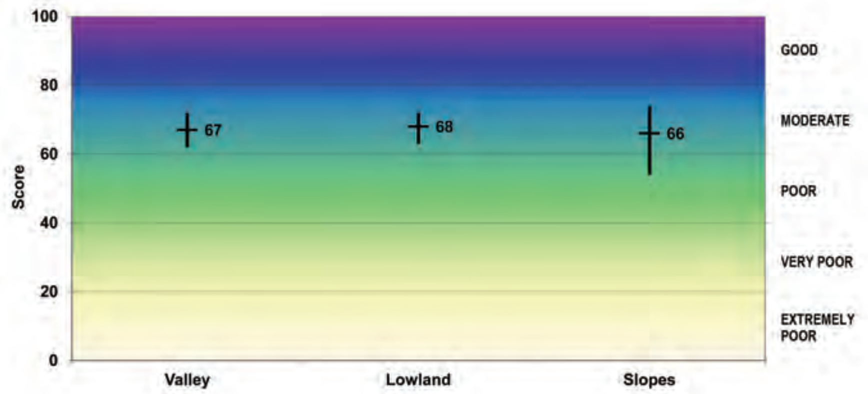

Figure AVC 3: Avoca Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Avoca Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 67. The condition of the macroinvertebrate community in the zones was as follows: Slopes Moderate; Lowland Moderate. The proportion of sites in Moderate condition was high across both zones (63% overall), and only four of the 30 rated sites (13%) were in Good condition. Family richness generally was low, and was reduced compared to Reference Condition.

Thirty-three sites were surveyed across the Avoca Valley in October–November 2008 yielding 5,477 macroinvertebrates in 43 families (46% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 67 (CL 62–72), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 46 (CL 44–48) indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate condition was high across both zones (63% overall), and six of the 30 rated sites (20%) were in Good condition (three in each zone).
- The number of families found was highest in the Slopes zone (41 families) and lowest in the Lowland zone (35 families), the Slopes zone also had the highest average number of families per site (18).

Figure AVC 3 shows sampling sites, zones and SR–MI values, and Table AVC 5 shows Index and metric values. The SR–MI score for the Avoca Valley indicated Moderate condition of macroinvertebrate communities, rating 16th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Lowland and Slopes zones showed moderate differences from Reference Condition (SR–MI = 68 and 66, respectively). A wide confidence interval (20 points) for the Slopes zone SR–MI value indicates more variability there, though most sites showed either a large or moderate difference from Reference Condition. Expectedness (simOE) was low to moderate and varied by up to 30 points among sites.

Table AVC 6 shows that most sites in both zones had moderate SR–MI values, though six sites were rated in Good condition. Each zone had only one site with a low simOE score (<40 points). Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

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Family richness generally was reduced compared to Reference Condition. Diversity was low (average 16 families per site), with the Slopes zone being most diverse at site scale (average of 18 families per site). The valley contained 46% of the families found across the Basin (Table AVC 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (>80%) of the fauna of the valley was found in each of the zones.

Table AVC 5: Avoca Valley Macroinvertebrate Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

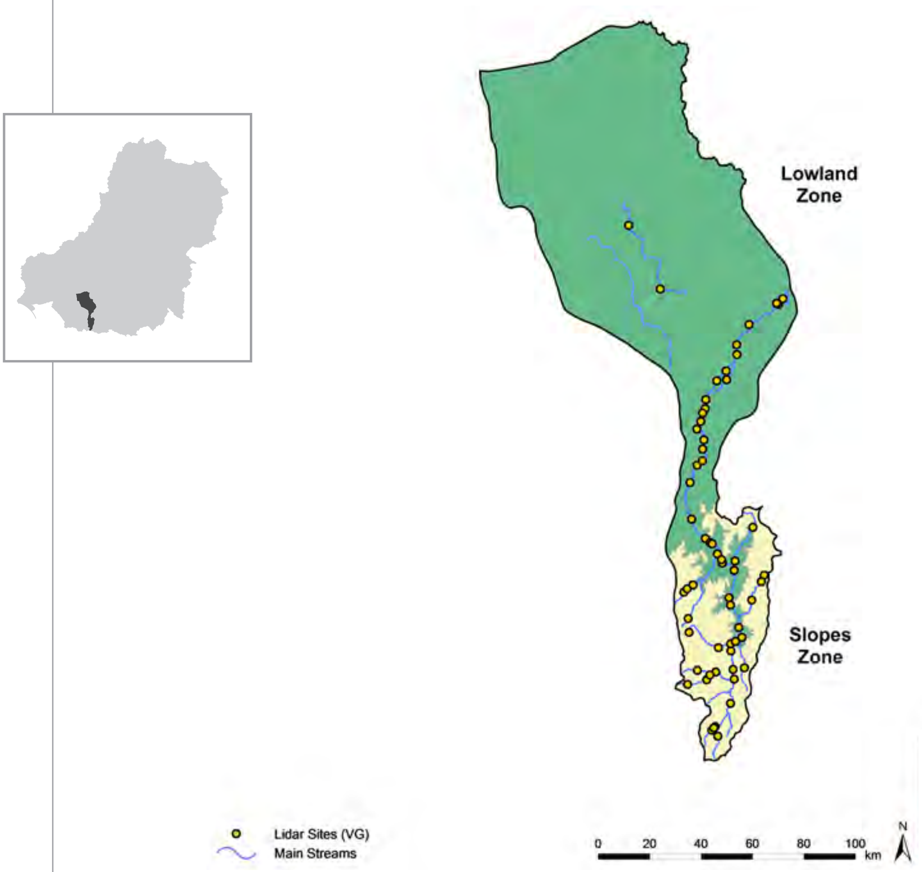
Indexes Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	67 (62–72)	66 (54–74)	68 (63–72)
Metric	SimOE	46 (44–48)	46 (40–50)	47 (45–48)

Table AVC 6: Avoca Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone	
		Slopes	Lowland
Sites			
Number of sites sampled	33	14	19
Number of sites with index values*	30	12	18
N sites by SR–MI condition band			
Good (80–100)	6	3	3
Moderate (60–80)	17	6	11
Poor (40–60)	6	2	4
Very or Extremely Poor (0–40)	1	1	
Families			
Number of families sampled	43	41	35
No. families/site (min–max)	16 (7–26)	18 (7–26)	14 (8–22)
Percent of families in Basin	46	44	37
Percent of families in valley	100	95	81

*simOE values could occasionally not be derived for every sample site.

AVOCA VALLEY



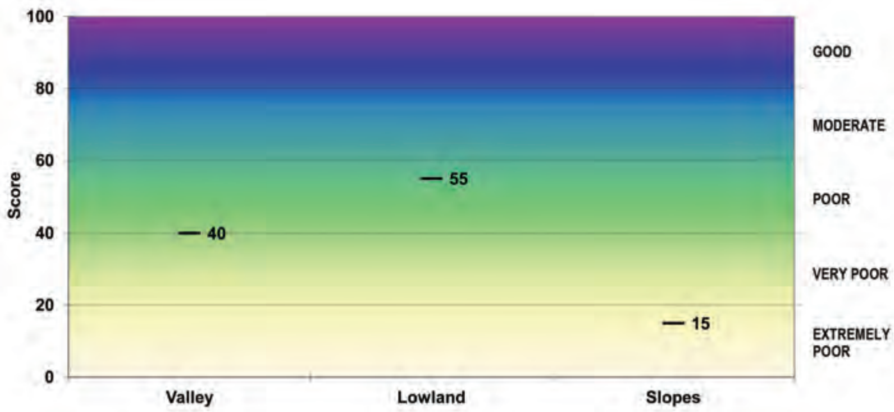


Figure AVC 4: Avoca Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Avoca Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 40. Overall condition for the two zones in this valley was: Slopes Extremely Poor; Lowland Poor.

The Abundance and Diversity indicator score was 54 for the valley, indicating a Poor rating overall. In the two zones it was: Slopes Very Poor; Lowland Moderate.

The Quality and Integrity indicator score was 45 for the valley, indicating a Poor rating overall. In the two zones it was: Slopes Very Poor; Lowland Poor.

The SRA Vegetation assessment for the Avoca Valley considers riverine vegetation in two spatial domains: Near Riparian, along 651 km of stream, and Lowland Floodplain, for 160 km^2 of flooding land which is part of the floodplain in the Lowland zone. Most (63%) of the stream length in the valley is in the Lowland zone, and the length of stream assessed per zone is as follows: Slopes, 243 km; and Lowland 408 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 60 sites set back 50 m from the top of the channel bank. LiDAR sites are distributed along the network in each zone as follows: Slopes, 22 sites; Lowland, 38 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure AVC 4 shows values of the Vegetation Index (SR–VI) for the Avoca Valley. Table AVC 7 shows the Index, indicator and sub-indicator values. Tables AVC 8 and AVC 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a large difference from Reference Condition for the Avoca Valley with:

- SRA Vegetation Index (SR–VI) = 40, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 54, indicating a large difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 45, indicating a large difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is moderately affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is moderately different from Reference Condition.

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The Abundance and Diversity of valley riverine vegetation is in Poor condition overall, with a very large difference from Reference Condition in the Slopes zone, and a moderate difference in the Lowland zone. The Poor rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of major vegetation groups as given in NVIS 3.0. Valley-wide abundance shows a very large difference from Reference Condition in the Near Riparian domain, and the Lowland Floodplain domain shows a moderate difference. MVG richness is maintained near Reference Condition in both Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 73% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Poor condition overall, showing a very large difference from Reference Condition for the Slopes zones and a large difference for the Lowland zone. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table AVC 8 as well as other native but non-specific MVGs. Valley-wide Nativeness shows a very large difference from reference in the Near Riparian domain, and a moderate difference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain domain shows a moderate difference from reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show no loss of any MVG in any of the zones from the Near Riparian domain, and no loss of any MVG from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Poor condition overall and the metrics show differences between zones and domains. Abundance in the Near Riparian domain shows a very large difference from Reference Condition in the Slopes zone and a large difference in the Lowland zone; and in the Lowland Floodplain domain it shows a moderate difference from Reference Condition.

Stability

- Floodplain areas in the Lowland Floodplain domain are in Moderate condition, with moderate evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Poor condition overall, and the metrics show differences between zones and domains. Nativeness in the Near Riparian domain shows a very large difference from Reference Condition in the Slopes zone, and a large difference from reference in the Lowland zone; and in the Lowland Floodplain domain, nativeness shows a moderate difference from reference.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with differences between zones. Structure is near Reference Condition in the Slopes zone, and moderately different from reference in the Lowland zone. Structure refers only to height of the upper canopy of individual patches of woody vegetation types 50 metres or more away from the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of MVGs is in Moderate condition. The most affected MVGs are Eucalypt Woodlands, which was the most extensive MVG under Reference Condition, and Eucalypt Open Forests. Both show an increase number of patches concurrent with a decrease in mean patch area relative to Reference Condition.

Under Reference Conditions, the riverine vegetation in the Avoca Valley was characterised as follows:

- Slopes zone: The Near Riparian domain was mostly (90% of domain area) Eucalypt Woodlands, with two other MVGs also present, only one of which was greater than 5% of the area.

- Lowland zone: The Near Riparian domain was mostly (71%) Eucalypt Woodlands, with seven other MVGs present, of which three were as much as 5% of the area.

- Lowland zone: The Floodplain Lowland domain was mostly (62%) Eucalypt Woodlands, with seven other MVGs present, of which five covered greater than 5% of the area.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced. The effect on MVGs is diverse, but Eucalypt Woodlands is the most affected MVG: Eucalypt Open Forests much less so.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG, although reduced (now 14% of the domain area). About 79% of the Slopes Near Riparian is cleared or non-native vegetation, and all MVGs are affected: Eucalypt Woodlands are now 16% of their reference area, and the other two MVGs are present at 65% and 69% of their reference area.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG although reduced in extent (now 28% of the domain area). About 54% of the Lowland Near Riparian is cleared or non-native vegetation. All MVGs are affected. The most affected MVG is Eucalypt Woodlands, the most extensive MVG under Reference Condition, now 39% of its reference area.

- Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands are still the most extensive MVG though reduced in extent (now 46% of the domain area). About 27% of the Lowland Floodplain is now cleared or non-native vegetation. The most affected MVG is Tussock Grasslands, at 38% of its reference area; in contrast, Eucalypt Open Forests are now 88% of their reference area.

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Unlike the other Themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up-to-date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the current NVIS 3.0 mapping has an on-ground date of 2004, whereas LiDAR was flown in March–May 2010.

Most metrics used to assess the Avoca Valley are based on vegetation mapping. This is not perfectly current and can be variable in quality: for example, about 4% of the Near Riparian domain in the Montane zone is not assigned to an MVG. The condition of either or both of the Near Riparian and Lowland Floodplain domains, and hence of the two zones and of the valley itself, may have changed since the source mapping was compiled.

The mapping metrics focus on extent, whereas the Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees present. Also, in each mapping polygon being assessed, the trees may be only a remnant clump or scattered isolates. This means that the various Near Riparian metrics and sub-indicator, that is abundance, richness, nativeness and structure, are off-set slightly in time and space.

The riverine vegetation of the Avoca Valley is notable for the low abundance of MVGs and low nativeness in the Near Riparian domain, particularly in the Slopes zone. The Lowland Floodplain domain, with moderate scores for abundance, stability, nativeness, fragmentation and structure, is in better condition. The total area of these two domains is similar, but they assess different although slightly overlapping parts of the landscape: the Lowland Floodplain domain is land that is flooded near the main river channels, whereas the Near Riparian domain is centred on all channels in the network.

Table AVC 7: Avoca Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.
LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Vegetation Condition (SR–VI)	40	15	55
Indicator	Abundance and diversity	54	32	68
Metric	LF stability	0.73		0.73
Sub-ind.	NRLF richness	100		100
Metric	NR richness	1	1	1
Metric	LF richness	1		1
Sub-ind.	NRLF abundance	53		53
Metric	NR abundance	0.37	0.20	0.46
Metric	LF abundance	0.73		0.73
Indicator	Quality and integrity	45	32	53
Sub-ind.	NRLF nativeness	53		53
Metric	NR nativeness	0.37	0.20	0.46
Metric	LF nativeness	0.73		0.73
Sub-ind.	NR structure	76 (71–81)	86 (82–89)	70 (62–78)
Sub-ind.	LF fragmentation	66		66

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Table AVC 8: The most abundant MVGs in the Near Riparian domain in the Avoca Valley.

Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone	
	Slopes	Lowland
MVG		
3. Eucalypt Open Forests	9	8
5. Eucalypt Woodlands	90	71
8. Casuarina Forests and Woodlands		8
14. Mallee Woodlands and Shrublands		7

Table AVC 9: Most abundant MVGs in the Lowland Floodplain domain in the Avoca Valley.
Showing percentage of domain area under Reference Condition, and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
3. Eucalypt Open Forests	10	1.69	0.52
5. Eucalypt Woodlands	61	1.61	0.46
8. Casuarina Forests and Woodlands	8	0.78	0.72
14. Mallee Woodlands and Shrublands	6	0.73	0.87
17. Other Shrublands	7	1.03	0.80
22. Chenopod Shrublands, Samphire Shrublands and Forblands	5	0.90	0.66

AVOCA VALLEY

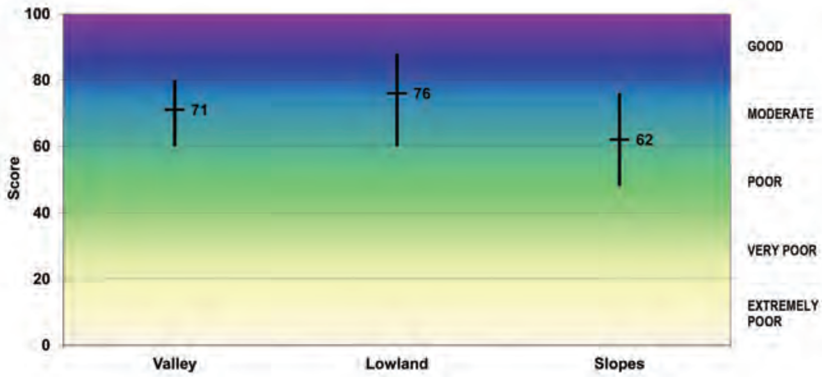

Figure AVC 5: Avoca Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Avoca Valley river system was rated in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 71. The condition of Physical Form in the zones was: Slopes and Lowland Moderate. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics was rated as Poor. Floodplain Dynamics was rated as Moderate. Overall, the valley's physical form since European settlement was characterised by gully erosion in headwater streams, producing elevated sediment loads and associated sedimentation both on the floodplain and within the channel. There was also evidence of channel enlargement in the Lowland zone.

The SRA Physical Form assessment considers physical form and processes along 651 km of streams across the valley. It is based on LiDAR data collected at 57 sites along river channels, as well as modelling of all 54 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment integrates four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure AVC 5 shows values of the Physical Form Index (SR–PI) for the Avoca Valley and Table AVC 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Avoca Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 71 (CL 60–80), indicating Moderate condition
- the Channel Form indicator = 84 (CL 77–89), showing near Reference Condition
- the Bed Dynamics indicator = 41 (CL 30–51), showing a large difference from Reference Condition
- the Bank Dynamics indicator = 94 (CL 90–98), showing near Reference Condition
- the Floodplain indicator = 61 (CL 48–77), showing a moderate difference from Reference Condition.

Slopes zone

There were 20 LiDAR survey sites and 8 SedNet river segments in the Slopes zone of the Avoca Valley. Based on these samples, Channel Sediment Ratio, Channel Sediment Deposition and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases), there was a large increase in Channel Sediment Deposition across 80% of the zone for the post-European period and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Depth and Bank Variability were modified from Reference Condition for less than half of the Slopes zone. At these sites Channel Depth was generally increased and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width, Channel Width Variability, Sinuosity and Meander Wavelength were largely unmodified from Reference Condition in the Slopes zone.

Lowland zone

There were 37 LiDAR survey sites and 46 SedNet river segments in the Lowland zone of the Avoca Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period. Channel Depth was modified from Reference Condition in more than half of the Lowland zone. At these sites Channel Depth was generally increased (many sites having large increases). Channel Width, Meander Wavelength and Channel Sediment Deposition were modified from Reference Condition for approximately half of the Lowland zone. At these sites Channel Width was generally increased, Meander Wavelength was generally increased (a few sites having large increases) and there was a large increase in Channel Sediment Deposition across 40% of the zone for the post-European period. Channel Width Variability, Sinuosity and Bank Variability were modified from Reference Condition for less than half of the Lowland zone. At these sites Channel Width Variability was generally reduced, Sinuosity was generally reduced and Bank Variability was generally reduced indicating enhanced bank stability.

Channel Form

There was little change from Reference Condition in Channel Form in the Slopes zone. There was widespread evidence of channel simplification but small deviations from Reference Condition had little influence on scores when aggregated at the zone scale.

The above results are consistent with field observations indicating that a large proportion of streams in the Slopes zone are gullied (Rutherfurd and Smith 1992). An analysis of data from North Central CMA (2006) by Gippel *et al*. (2008) indicated that for 87% of the stream lengths in the upper Avoca the level of bank stability was at Reference Condition or a slight deviation from Reference Condition, while 97% of stream lengths were not incised (Gippel *et al*., 2008). This is consistent with this SRA assessment result of little change from reference in Channel Width in the Slopes zone, but inconsistent with the result of a significant proportion of sites having deepened.

The 2004 Index of Stream Condition (ISC) surveys <www.vicwaterdata.net/vicwaterdata> of bank stability indicated an average score of 1.24 and a range of 0.3 to 2.0 on a scale of 0 (Extreme) to 4 (Stable) for sites located in the Slopes zone. This does not contradict this SRA assessment result of little change from Reference Condition in Channel Width.

There was a minor change from Reference Condition in Channel Form in the Lowland zone. The more serious change was channel enlargement. An enlarged channel was indicated at 60% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

These observations of channel adjustments in the Lowland zone are consistent with field observations (Rutherfurd, pers. comm.). In contrast, an analysis of data from the North Central CMA (2006) by Gippel *et al*. (2008) indicated that for 97% of the stream lengths in the lower Avoca the level of bank stability was either in Reference Condition or showed a slight deviation from Reference Condition, while 71% of stream lengths were not incised, and 29% had a low level of incision (Gippel *et al.*, 2008). This is inconsistent with this SRA assessment result of widening at half of the Lowland sites, and deepening at more than half of the Lowland sites. The 2004 ISC surveys <www.vicwaterdata.net/vicwaterdata/> of bank stability indicated an average score of 2.23 and range of 0.7 to 3.3 on a scale of 0 (Extreme) to 4 (Stable) for sites located in the Lowland zone. This is not inconsistent with the SRA assessment result of widening at about half of the Lowland sites.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Slopes and Lowland zones. There was substantial change from reference in Bed Dynamics in the Slopes zone as a result of widespread sedimentation (90% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). There was considerable change from reference in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (50% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Lowland zone, the indication of widespread sedimentation based on SedNet modelling is at odds with the evidence of bed degradation from measurements of Channel Form.

This assessment of extensive sediment deposition in the Slopes zone is consistent with observations that large quantities of sediment were released from the upper catchment in association with: (i) extensive gold mining in the upland areas which was most active in the 1850s, and (ii) the development of extensive gullying associated with clearing for agriculture of upland areas with erodible sodic duplex soils (Rutherfurd and Smith 1992, Ford *et al.* 1993, SKM 2002, SKM 2005b, Earth Tech 2006). However, field observations suggest that the large sand loads generated by erosion in the Slopes zone have not reached the Lowland zone, and that the lowland streams have enlarged by erosion (Rutherfurd, pers. comm.).

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There has been considerable change in floodplain dynamics in the Slopes zone as a result of widespread sedimentation (100% of SedNet river segments). There has been minor change in floodplain dynamics in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments). The floodplains of the Lowland zone are narrow and confined, and they have been considerably aggraded by fine sediment coming from upstream gullies (Rutherfurd and Smith, 1992).

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Table AVC 10: Avoca Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.
(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Physical Form Condition (SR–PI)	71 (60–80)	62 (48–76)	76 (60–88)
Indicator	Channel Form (volume and flow events)	84 (77–89)	96 (84–100)	76 (68–84)
Sub-ind.	Cross-section Form	79 (71–87)	94 (81–99)	71 (62–81)
Metric	Channel Depth (mean)	1.30 (1.20–1.43)	1.09 (1.01–1.24)	1.43 (1.29–1.62)
Metric	Channel Width (mean)	1.04 (0.98–1.11)	1.06 (1.00–1.17)	1.03 (0.95–1.14)
Sub-ind.	Cross-section Form (variability)	95 (89–99)	100 (99–100)	92 (82–98)
Metric	Channel Width (CV)	0.96 (0.93–0.99)	1.01 (0.99–1.03)	0.94 (0.89–0.98)
Sub-ind.	Channel Planform	90 (84–94)	93 (83–99)	87 (80–93)
Metric	Sinuosity	0.99 (0.98–1.01)	0.98 (0.96–1.00)	1.00 (0.98–1.03)
Metric	Meander Wavelength	1.04 (1.00–1.09)	1.04 (0.98–1.15)	1.05 (0.99–1.10)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Indicator	Bed Dynamics	41 (30–51)	34 (13–54)	45 (34–55)
Metric	Channel Sediment Ratio	310 (254–384)	411 (320–534)	250 (169–368)
Metric	Channel Sediment Depth	0.01 (0.01–0.02)	0.01 (0.003–0.03)	0.01 (0.005–0.01)
Indicator	Bank Dynamics	94 (90–98)	100 (99–100)	91 (84–98)
Metric	Bank Variability (longitudinal)	1.00 (0.96–1.03)	1.04 (1.01–1.08)	0.97 (0.92–1.01)
Indicator	Floodplain	61 (48–77)	56 (29–91)	64 (42–79)
Metric	Floodplain Sediment Deposition	3.00 (1.90–5.00)	2.00 (1.10–4.00)	4.00 (1.71–6.00)

AVOCA VALLEY

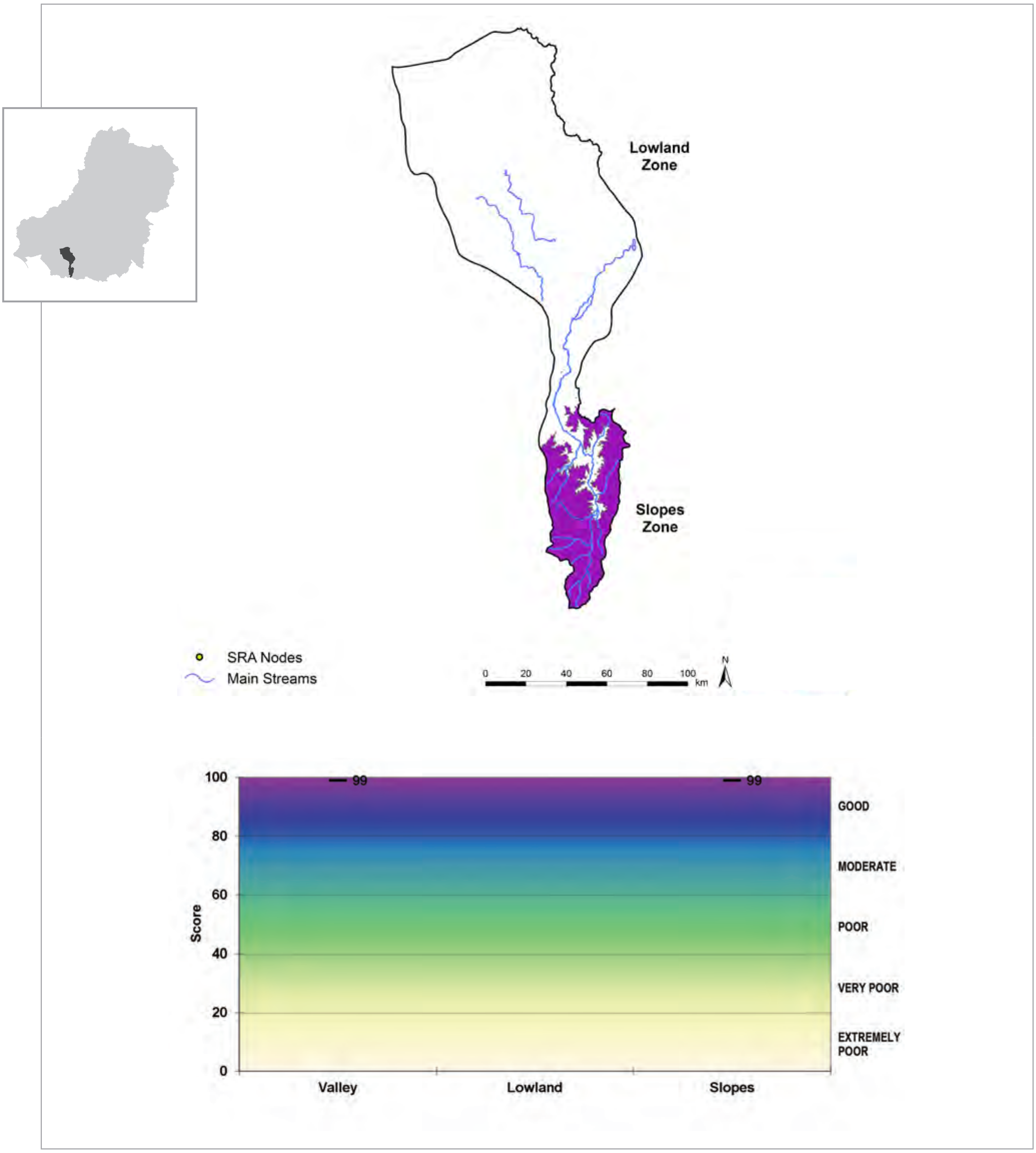

Figure AVC 6: Avoca Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Avoca Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 99. The headwater streams of the Avoca Valley were rated in Good condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased with increased high flows in some reaches. Flow alteration in the Avoca River and larger tributaries are not assessed because they are not represented in basin-wide water resource modelling.

The Avoca River flows from the Great Dividing Range northward to the Murray, terminating in the Avoca Marshes and Lake Bael Bael, at the edge of the Kerang Wetlands. Floodwaters are dissipated across a wide area—the Avoca Floodway. There are no instream storages apart from 12 low-level weirs that extend the local water-supply during low-flow periods (Vlok *et al.* 2007). There is some irrigation of vines in the southern region (upstream of Charlton) and pasture in the north. Irrigation in the upper reaches is often supported by runoff-harvesting stored in farm dams rather than by direct diversions.

In the Avoca Valley, hydrological condition is assessed using metrics of hydrological alteration available for 709 km of headwater streams. There is no mainstem river in the Avoca Valley. There is 709 km of headwater stream with 404 km in the Slopes zone and 305 km in the Lowland zone. For these headwater streams, hydrological metrics represent the effects of farm dams and tree cover change since European settlement.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these tributary streams. These tributaries are not included in this assessment. In the Avoca Valley there are 562 km of these mid-size tributaries (45 km in the Slopes zone; 517 km in the Lowland zone), which is 0.8 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for a period of approximately the last 40 years. Importantly, these models have used current farm dam densities and tree cover levels for the entire period of simulation.

Figures AVC 6 and AVC 7 show values of the Hydrology Condition Index (SR–HI) for the Avoca Valley and its river network, and Table AVC 11 and AVC 12 show the Index, sub-index, indicator and metric values. Analyses showed near Reference Condition for the Avoca Valley, with:

- The Hydrology Condition Index for the whole valley = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for the Slopes zone = 99 indicating Good hydrological condition.
- The Hydrology Condition Index for headwater streams (valley-wide) = 99, indicating Good hydrological condition.

AVOCA VALLEY

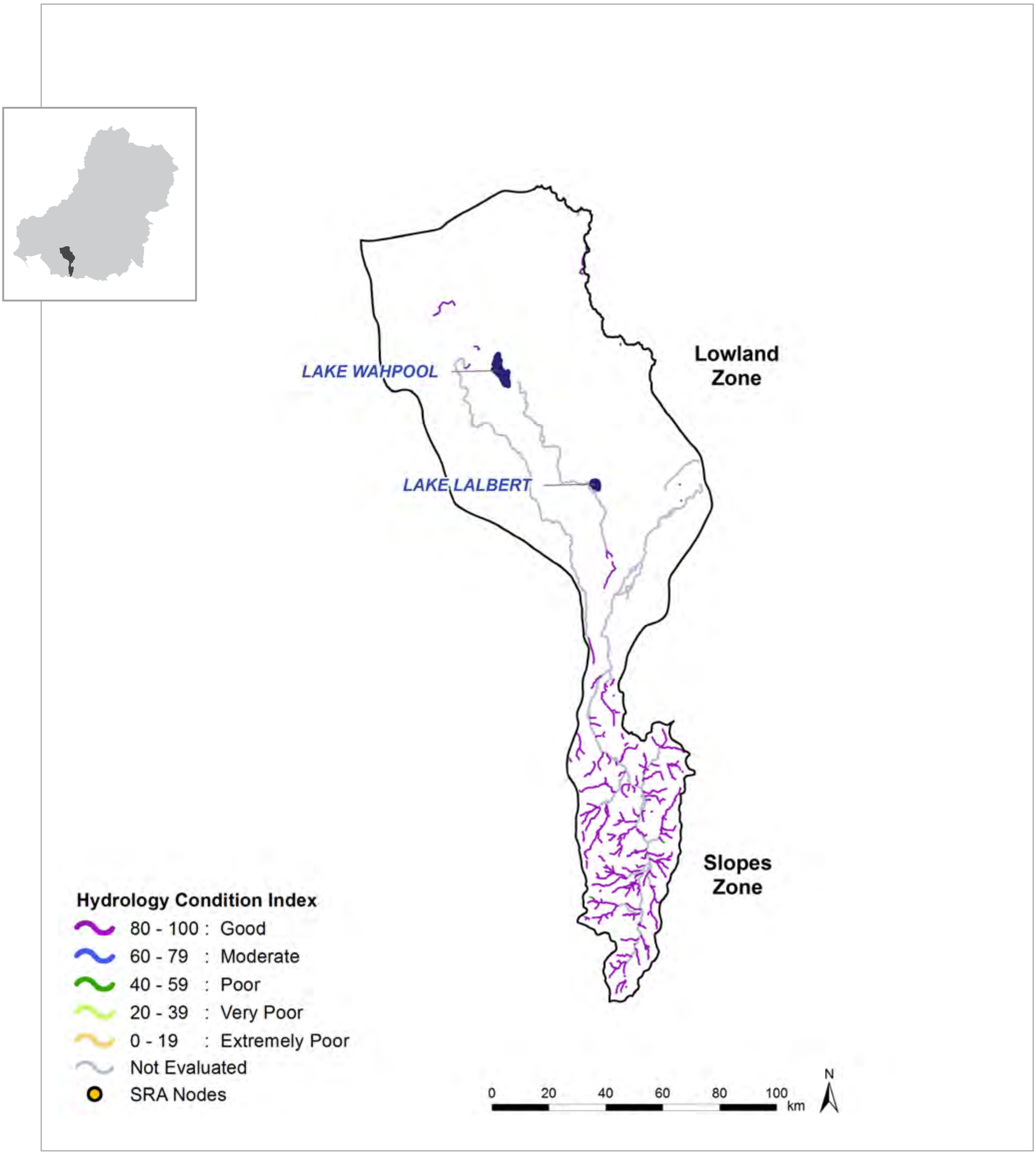

Figure AVC 7: Avoca Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). In addition, results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to Reference Condition.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 3% of the headwater river length (mostly associated with increased flows) and a significant alteration from Reference Condition in 30% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference regime. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to Reference Condition.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a significant alteration from Reference Condition in 16% of the headwater river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone. Results for the Zero Flows Proportion metric showed no significant variations from Reference Condition.

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Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to the reference flow regime. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to Reference Condition.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 10% of the headwater river length (mostly an increased amplitude) and a significant alteration from Reference Condition in 56% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 3% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone.

Summary: mainstem rivers

Flow alteration in the Avoca River and larger tributaries are not assessed because they are not represented in basin-wide water resource modelling. However, the 2004 Index of Stream Condition indicates altered low flows along much of the Avoca River.

Summary: headwater streams

The headwater streams of the Avoca Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume, relative to Reference Condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased. Throughout some of the headwater streams high flows were increased.

Table AVC 11: Avoca Valley SRA Hydrology Condition Index at valley and zone scales.
Values derived by aggregation of headwater stream values.

Index	Valley		
		Slopes	Lowland
Hydrology Condition SR–HI	99	99	

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Table AVC 12: Avoca Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for headwater stream reaches.
(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Headwater streams	Zone	
			Slopes	Lowland
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**99 (30–100)**	**99**	**100**
Sub-index	In-Channel Flow Regime	99 (30–100)	99	100
Indicator	In-Channel Flow Regime A (volume and flow events)	100 (64–100)	99	100
Sub-ind.	Flow Gross Volume	98 (92–100)	98	98
Metric	Mean Annual Flow	1.06 (0.82–1.17)	1.06	1.05
Metric	Flow Duration	1.01 (0.87–1.10)	1.02	0.99
Sub-ind.	High Flow Events	96 (43–100)	95	96
Metric	High Flow	1.13 (0.31–1.84)	1.17	1.08
Metric	High Flow Spells			
Sub-ind.	Low and Zero Flow Events	97 (73–99)	97	97
Metric	Zero Flows Proportion	0.99 (0.96–1.00)	0.99	0.99
Metric	Low Flow	1.00 (0.40–1.44)	1.02	0.98
Metric	Low Flow Spells			
Indicator	In-Channel Flow Regime B (seasonality & variability)	97 (27–100)	97	98
Sub-ind.	Flow Seasonality	88 (60–100)	87	88
Metric	Flow Seasonal Amplitude	1.27 (0.91–1.74)	1.29	1.25
Metric	Flow Seasonal Period	0.97 (0.87–1.00)	0.97	0.96
Sub-ind.	Flow Variability	91 (27–100)	92	90
Metric	Flow Variation	0.92 (0.65–1.00)	0.93	0.91
Sub-index	Over Bank Flow Regime	Not assessed		
Indicator	Over Bank Floods Low			
Metric	OB Flow Duration (ARI 1)			
Metric	OB Flow Spells (ARI 1)			
Indicator	Over Bank Floods High			
Metric	OB Flow Duration (ARI 8)			
Metric	OB Flow Spells (ARI 8)			

BORDER RIVERS VALLEY

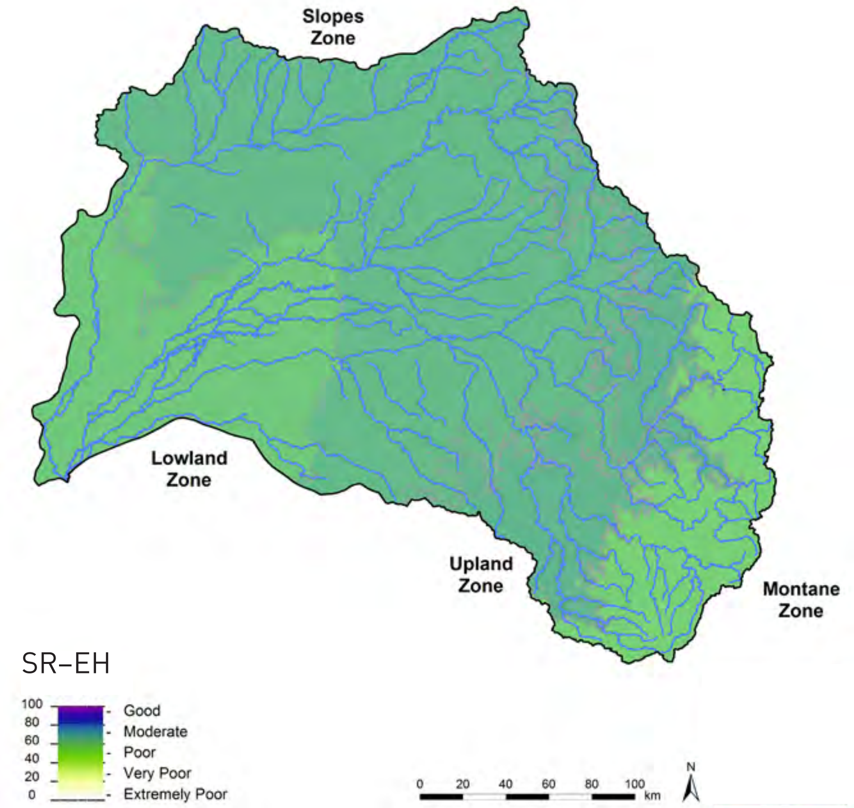

Figure BRD 1: Border Rivers Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure BRD 1 shows the Ecosystem Health ratings for the Border Rivers Valley and Tables BRD 1 and BRD 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Border Rivers Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine communities were in Moderate, Moderate and Poor condition respectively, while Hydrology and Physical Form were in Moderate and Good condition respectively.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Border Rivers Valley river system. River Ecosystem Health was rated as Poor (Lowland zone: Poor; Slopes zone: Poor; Upland zone: Poor; Montane zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Border Rivers Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Montane, Upland, Slopes and Lowland Poor. The Fish community was in Moderate condition. Some expected species were absent. Species count and abundance were dominated by native species but biomass was dominated by aliens; and recruitment levels among the remaining native species were high. The Macroinvertebrate community was in Moderate condition, with moderate to substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Poor condition overall; with reduced abundance, stability and nativeness in the Near Riparian and Lowland Floodplain areas; and high fragmentation in the Lowland Floodplain. The Physical Form of the river system was in Moderate condition with channel form in Good condition and bank and bed dynamics in Moderate condition. There were high levels of floodplain and channel sediment deposition. The river system's Hydrology was in Good condition, with minor alteration in high over bank floods, flow seasonality and low and zero flow events in mainstem reaches relative to Reference Condition.

Ecosystem health

The Border Rivers ranked in the lower 50% of valleys in terms of Physical Form, Vegetation, and Macroinvertebrates. It ranked in the mid-range of the 15 valleys rated as being in Poor River Ecosystem Health (see Table 5.2). It ranked third, behind the Paroo and Condamine valleys for Fish condition, with the majority of expected fish species present and showing evidence of recruitment across a range of native species. At the time of fish and macroinvertebrate sampling, in 2008 and 2009 respectively, the Border Rivers had experienced several years of low rainfall and the extent of surface water in the system had been significantly reduced—perhaps resulting in increased local population densities, particularly of long-lived species. It is also possible that those samples represent the condition of refugial communities within the major river channels and, as such, provide an indication of the capacity of those systems to respond to more benign climatic conditions in the future.

Fish Theme

The Fish Condition Index SR–FI = 63, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Good; Montane zone: Very Poor). The Expectedness indicator = 63, indicating Moderate condition, and a moderate difference from Reference Condition. The Nativeness indicator = 64, indicating Moderate condition, and a moderate difference from Reference Condition. The Recruitment indicator = 67, indicating Moderate condition, and a moderate difference from Reference Condition.

Overall the valley had retained much of its native species richness, though the Lowland zone lacked almost 50% of its predicted native species. Native fish contributed more than 63% of total fish biomass in the valley, though native fish recruitment was Poor in the Montane zone and moderate in the other three zones.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 68, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate; Upland zone: Moderate; Montane zone: Moderate). The simOE metric = 47 indicating a moderate difference from Reference Condition in both presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Moderate condition was high, especially in the Slopes to Montane zones, and eight sites (22%) were rated in Good condition.

Family richness was generally reduced compared to Reference Condition. The valley contained 70% of the families found across the Basin. Most (>80%) of the fauna of the valley was found in the Upland and Slopes zones.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 52, indicating Poor condition (Lowland zone: Moderate; Slopes zone: Poor; Upland zone: Very Poor; Montane zone: Very Poor). The Vegetation Abundance and Diversity indicator = 58, indicating Poor condition and a large difference from reference for the abundance and stability of vegetation groups within Near Riparian and Lowland Floodplain areas. The Vegetation Quality and Integrity indicator = 60, indicating Moderate condition and a moderate difference from Reference Condition for the structure, nativeness and fragmentation of vegetation communities and groups within Near Riparian and Lowland Floodplain areas.

The Lowland Floodplain domain is considerably affected by clearing with large differences from Reference Condition in the abundance and degree of fragmentation of major vegetation groups.

Physical Form Theme

The Physical Form Condition Index SR–PI = 74, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate; Upland zone: Moderate; Montane zone: Good).

The Channel Form indicator = 78, indicating Moderate condition and showing a minor difference from Reference Condition. The Bed Dynamics indicator = 60, indicating Moderate condition and showing a minor difference from Reference Condition. The Bank Dynamics indicator = 99, indicating Good condition and showing near Reference Condition. The Floodplain Form indicator = 57 indicating Poor condition and showing a moderate difference from Reference Condition.

The valley's riverine Physical Form was characterised by elevated sediment loads since European settlement resulting in sedimentation on the floodplain and within the channel. Channels were simplified, with reduced variability in channel width, particularly in the Upland zone, and increased meander wavelength.

Hydrology Theme

The Hydrology Condition Index SR–HI = 83, indicating Good condition (Lowland zone: Moderate; Slopes zone: Good; Upland zone: Good; Montane zone: Good). The mainstem river reaches were generally characterised by moderate alteration in High Over Bank Floods, Flow Seasonality and Low and Zero Flow Events and little or no alteration in Low Over Bank Floods, Flow Variability, High Flow Events and Flow Gross Volume. Headwater stream reaches were characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume.

Table BRD 1: Border Rivers Valley Ecosystem Health and condition assessments.

Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	MONTANE	UPLAND	SLOPES	LOWLAND
		Poor	Poor	Poor	Poor	Poor

THEME		VALLEY	ZONE			
			MONTANE	UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	63 (48–68) Moderate	39 (22–56) Very Poor	83 (47–92) Good	75 (53–88) Moderate	47 (31–56) Poor
Macro-invertebrates	SCORE RATING	68 (63–73) Moderate	71 (63–79) Moderate	75 (69–84) Moderate	69 (62–76)Moderate	60 (46–72) Moderate
Vegetation	SCORE RATING	52 Poor	34 Very Poor	34 Very Poor	51 Poor	72 Moderate

Table BRD 2: Border Rivers Valley Physical Form and Hydrology condition assessments.

Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE			
			MONTANE	UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	74 (67–78) Moderate	88 (73–91) Good	68 (59–83) Moderate	74 (64–79) Moderate	70 (50–85) Moderate
Hydrology	SCORE RATING	83 Good	97 Good	99 Good	85 Good	75 Moderate

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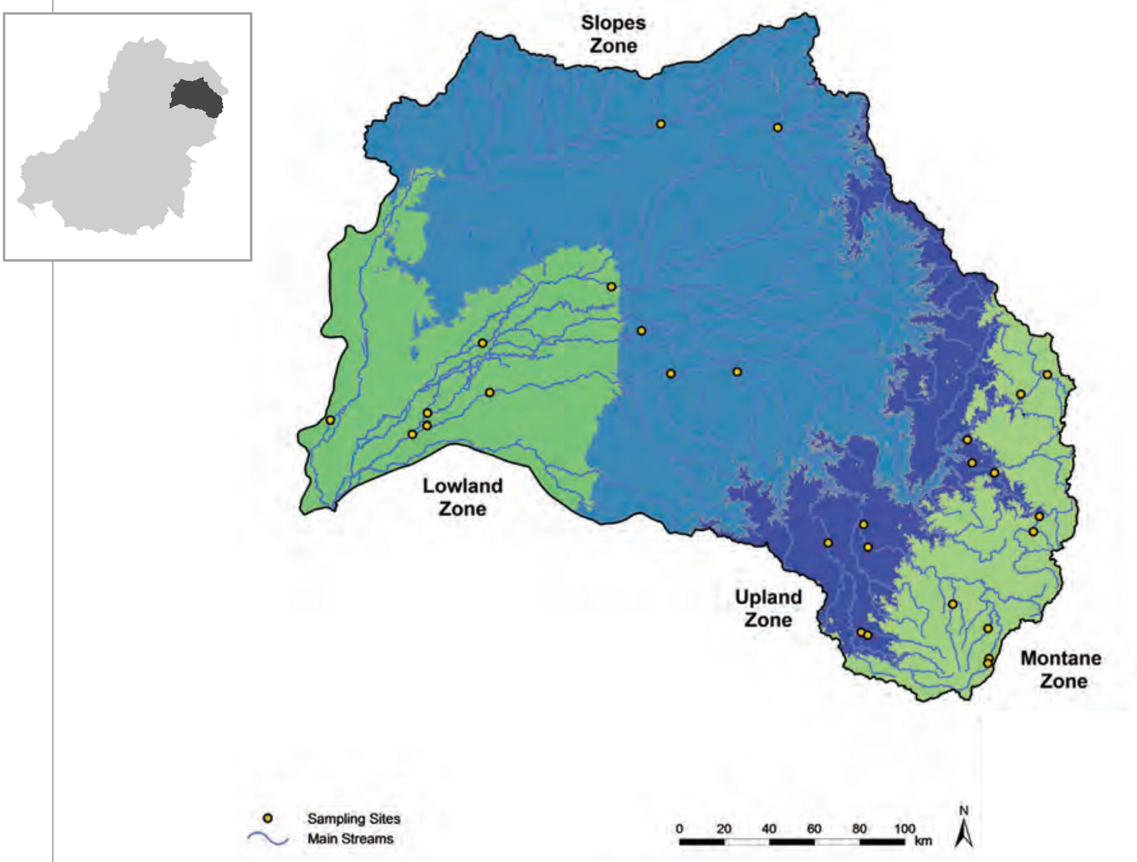

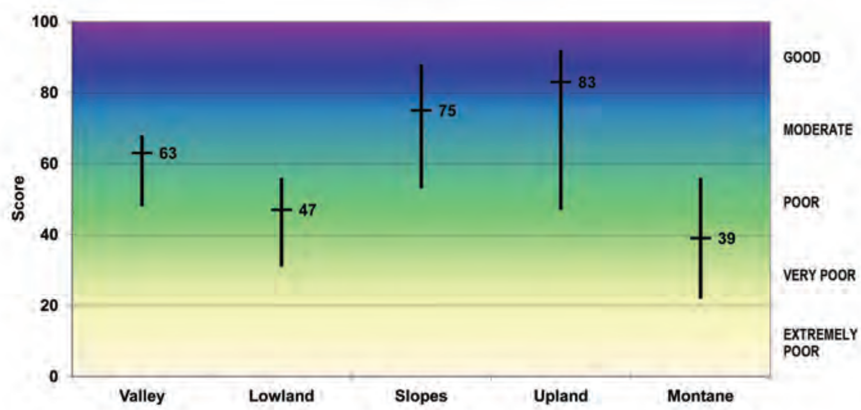

Figure BRD 2: Border Rivers Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the of the Border Rivers Valley river system was in Moderate condition, with an aggregate Fish Index score (SR–FI) of 63. The condition of the fish community in the zones was as follows: Montane Very Poor, Upland Good; Slopes Moderate and Lowland Poor. The fish community was characterised by a Moderate score for expected native fish species, a Moderate score for nativeness and a Moderate score for native fish recruitment. Overall the valley had retained much of its native species richness, though the Lowland zone in particular had fewer fish and lacked almost 50% of the predicted native species. Native fish outnumbered alien species and contributed more than 63% of total fish biomass in the valley. Native fish recruitment was Poor in the Montane zone and Moderate in the other three zones.

Twenty-eight sites were surveyed across the Border Rivers Valley in January–April 2008, yielding 3,982 fish. Analyses showed a moderate difference from Reference Condition for the Border Rivers Valley, with:

- SRA Fish Index (SR–FI) = 63 (CL 48-68), indicating Moderate condition of the fish community.
- The Expectedness indicator = 63 (CL 57-70), indicating Moderate condition, and a moderate difference from Reference Condition. 93% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 64 (CL 56-74), indicating Moderate condition, and a moderate difference from Reference Condition.
- The Recruitment indicator = 67 (CL 46-71), indicating Moderate condition, and a moderate difference from Reference Condition. Evidence of recruitment was observed for 11 of the 14 native species observed in the valley.

Figure BRD 2 shows sampling sites, zones and corresponding SR–FI values, and Table BRD 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Border Rivers Valley was the third highest for all valleys, and close to that for the Condamine Valley. The fish communities in the Montane and Lowland zones were in considerably worse condition (SR–FI = 39 and 47 respectively) than those in the other two zones (SR–FI = 83 in the Upland zone and 75 in the Slopes zone).

Nativeness, expectedness, and recruitment varied amongst zones. Expectedness was lower in the Lowland zone than in the other zones, whereas the Montane zone scored lowest for Nativeness and Recruitment.

Only four of the seven native species observed in the Montane zone showed evidence of recruitment in at least one site. In the Upland, Slopes, and Lowland zones these ratios were eight of ten; eight of ten; and six of six respectively.

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On average 142 fish were captured per site representing a biomass of 7.4 kg/site. Of these, 109 fish belonged to native species with a combined weight of 4.7 kg on average. The Border Rivers had the fourth highest number of fish caught per site amongst the 23 valleys sampled but their total biomass was twelfth highest, indicating a predominance of small-bodied fish.

In the Slopes and Lowland zones alien fish were larger than the native fish on average. In the Montane and Upland zones the dominant alien species was gambusia; the large-bodied alien, common carp, was not present in samples from the Montane zone. The 53 redfin perch that were caught in the Montane zone, and are potentially a large alien fish, weighed a total of only 447 grams.

Table BRD 4 shows native species abundances in the Border Rivers Valley compared with Reference Condition. No more than three alien species were captured in any zone and numbers of common carp, not captured in the Montane zone, were low throughout the valley. Valued native species including Murray cod, freshwater catfish, and silver perch were not captured in the Lowland zone. Murray cod and golden perch were captured in the Montane zone where they were not predicted to occur under Reference Condition. Golden perch was present in all four zones.

At the valley scale, the fish community of the Border Rivers had almost all of expected native species present. Half of the expected species were missing from the Lowland zone however. Recruitment was notably lower in the Montane zone compared to the rest of the valley.

Table BRD 3: Border Rivers Valley SRA Fish Condition Index, indicators, metrics and derived variables.

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	63 (48–68)	39 (22–56)	83 (47–92)	75 (53–88)	47 (31–56)
Indicator	Expectedness	63 (57–70)	59 (51–78)	79 (66–91)	78 (64–91)	40 (32–47)
Metric	O/E	0.51 (0.41–0.61)	0.35 (0.10–0.60)	0.68 (0.50–0.87)	0.60 (0.42–0.81)	0.36 (0.25–0.46)
Metric	O/P (Zone level)	0.63 (0.63–0.63)	0.71 (0.71–0.71)	0.67 (0.67–0.67)	0.71 (0.71–0.71)	0.50 (0.50–0.50)
Indicator	Nativeness	64 (56–74)	40 (10–67)	71 (58–92)	71 (59–87)	58 (42–73)
Metric	Proportion biomass native	0.54 (0.41–0.68)	0.42 (0.13–0.83)	0.69 (0.38–0.95)	0.56 (0.37–0.77)	0.48 (0.25–0.72)
Metric	Proportion abundance native	0.64 (0.52–0.74)	0.39 (0.12–0.76)	0.60 (0.34–0.84)	0.73 (0.55–0.88)	0.59 (0.40–0.77)
Metric	Proportion species native	0.57 (0.51–0.63)	0.34 (0.10–0.56)	0.67 (0.61–0.72)	0.62 (0.54–0.71)	0.52 (0.41–0.63)
Indicator	Recruitment	67 (46–71)	44 (8–72)	76 (27–79)	65 (40–76)	73 (40–88)
Metric	Proportion of sites with native recruits	0.64 (0.48–0.65)	0.58 (0.19–0.60)	0.71 (0.34–0.72)	0.67 (0.47–0.71)	0.58 (0.40–0.73)
Metric	Proportion of native taxa with recruits	0.85 (0.78–0.95)	0.60 (0.33–1.00)	0.80 (0.57–0.89)	0.80 (0.67–1.00)	1.00 (1.00–1.00)
Metric	Proportion of abundance as recruits	0.65 (0.53–0.68)	0.49 (0.28–0.91)	0.70 (0.48–0.76)	0.54 (0.46–0.67)	0.80 (0.52–0.83)

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Table BRD 3: Border Rivers Valley SRA Fish Condition Index, indicators, metrics and derived variables.

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Variables						
	Number of sites sampled	28	7	7	7	7
	Total number of species	18	10	13	13	9
	Number of native species	14	7*	10	10	6
	Number of predicted species	15	7	15	14	12
	Number of alien species	4	3	3	3	3
	Mean number of fish per site	142	301	92	107	69
	Biomass/site all species (g)	7381	2842	15961	8198	2524
	Mean native biomass/fish (g)	43	11	204	35	18
	Mean alien biomass/fish (g)	81	4	122	330	90

Table BRD 4: Border Rivers Valley number of fish by zone.

Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks. Numbers in brackets are counts of native species not expected under Reference Condition.

Fish species	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Sites sampled	28	7	7	7	7
Native species					
Australian smelt	59	3	38	17	1
Bony herring	523		0	243	280
Darling River hardyhead	44	0	44	0	
Freshwater catfish	25	11	13	1	0
Golden perch	50	[5]	12	13	20
Gudgeon	2108	1602	218	285	3
Mountain galaxias	2	2	0	0	
Murray cod	93	[15]	50	28	0
Murray–Darling rainbowfish	54		22	30	2
Olive perchlet	2		2	0	0
River blackfish	0	0	0		
Silver perch	2		2	0	0
Southern purple-spotted gudgeon	6	2	0	4	0
Spangled perch	66		0	15	51
Unspecked hardyhead	12		7	5	0
Alien species					
Common carp	112		21	34	57
Gambusia	660	395	147	53	65
Goldfish	111	22	67	18	4
Redfin perch	53	53			

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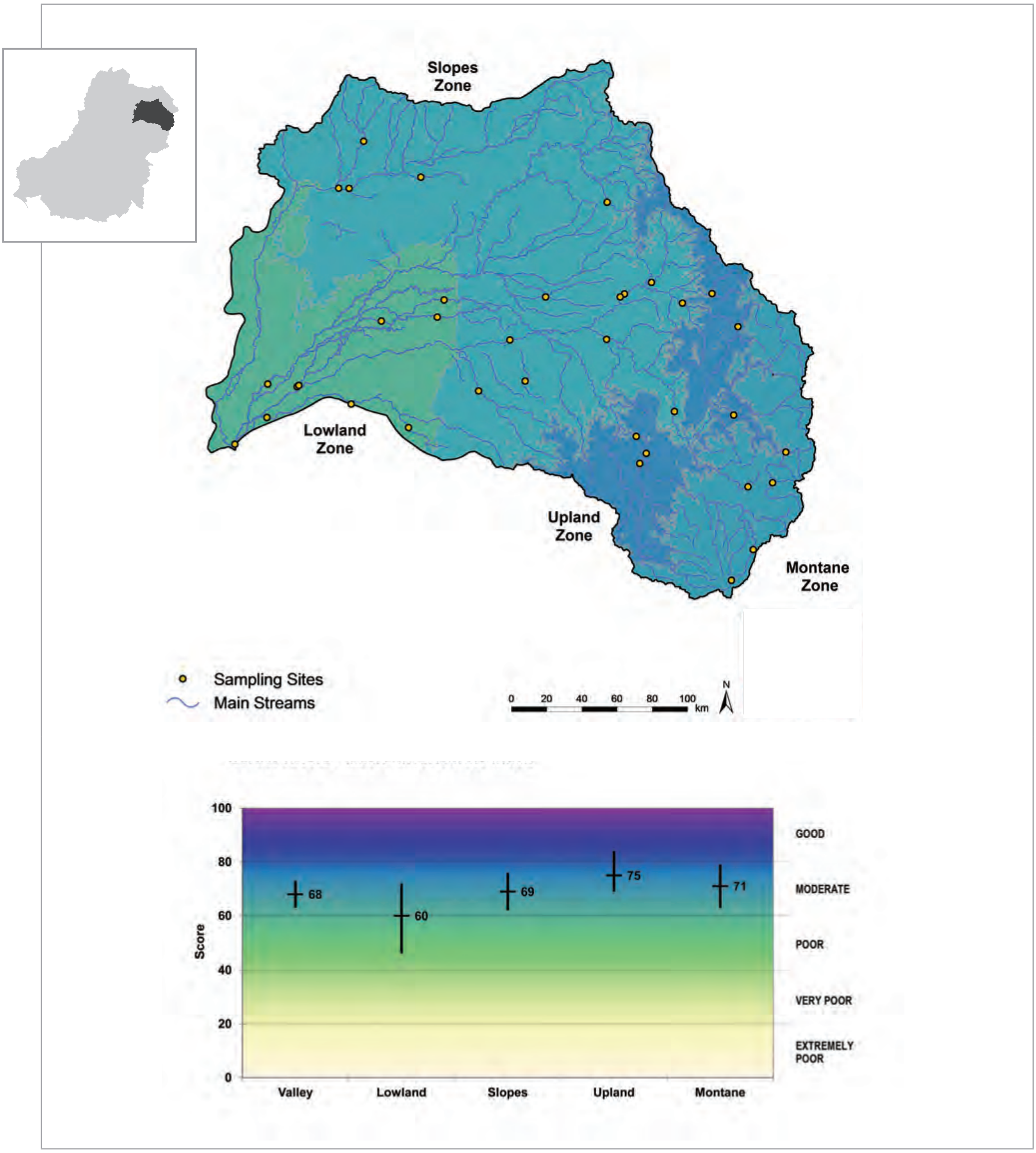

Figure BRD 3: Border Rivers Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.

Graph shows mean SR-MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Border Rivers Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 68. The condition of the macroinvertebrate community in the zones was as follows: Montane Moderate; Upland Moderate; Slopes Moderate; Lowland Moderate. The proportion of sites in Moderate condition was high (50%), especially in the Slopes to Montane zones, and eight sites (22%) were rated in Good condition. Family richness generally was high though reduced compared to Reference Condition.

Thirty-six sites were surveyed across the Border Rivers Valley in April–May 2009, yielding 6,162 macroinvertebrates in 66 families (70% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 68 (CL 63–73), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 47 (CL 45–49) indicating a moderate difference from Reference Condition in both presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate condition was high (47%), especially in the Slopes to Montane zones, and nine sites (25%) were rated in Good condition (five of which were in the Slopes zone and two in the Lowland zone).
- The number of families found was lowest in the Lowland zone (38 families) and highest in the Slopes zone (55 families), though the Montane zone had the highest average number of families per site (35).

Figure BRD 3 shows sampling sites, zones and SR–MI values, and Table BRD 5 shows Index and metric values. The SR–MI score for the Border Rivers Valley indicated Moderate condition of macroinvertebrate communities, rating 15th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the Slopes to Montane zones all showed moderate to small differences from Reference Condition (median SR–MI = 69 to 75, respectively). An SR–MI score on the boundary between Poor and Moderate condition for the Lowland zone (60) was associated with a wide confidence interval (26 points) indicating more variability there (with two sites in very poor and Extremely Poor condition). Expectedness (simOE) was low to moderate and varied by up to 23 points among sites. Expectedness (simOE) was generally low to moderate, varying most among the Slopes and Lowland zone sites.

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Table BRD 6 shows that most sites had moderate SR-MI values, though nine sites were rated in Good condition. Four sites had a low simOE score (<40 points) and were in Poor condition, two each in the Slopes and Lowland zones. Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

Family richness generally was reduced compared to Reference Condition. Diversity was high (average 28 families per site), with sites in the Montane zone being most diverse (average 35 families per site). The valley contained 70% of the families found across the Basin (Table BRD 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (>80%) of the fauna of the valley was found in the Upland and Slopes zones.

Table BRD 5: Border Rivers Valley Macroinvertebrate Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR-MI)	68 (63–73)	71 (63–79)	75 (69–84)	69 (62–76)	60 (46–72)
Metric	SimOE	47 (45–49)	48 (44–51)	49 (46–54)	48 (45–51)	44 (39–49)

Table BRD 6: Border Rivers Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Sites					
Number of sites sampled	36	4	4	18	10
Number of sites with index values*	36	4	4	18	10
N sites by SR–MI condition band					
Good (80–100)	9	1	1	5	2
Moderate (60–80)	17	3	3	9	2
Poor (40–60)	8			4	4
Very or Extremely Poor (0–40)	2				2
Families					
Number of families sampled	66	43	53	55	38
No. families/site (min–max)	28 (11–49)	35 (29–38)	34 (28–49)	30 (18–39)	19 (11–30)
Percent of families in Basin	70	46	56	59	40
Percent of families in valley	100	65	80	83	58

*simOE values could occasionally not be derived for every sample site.

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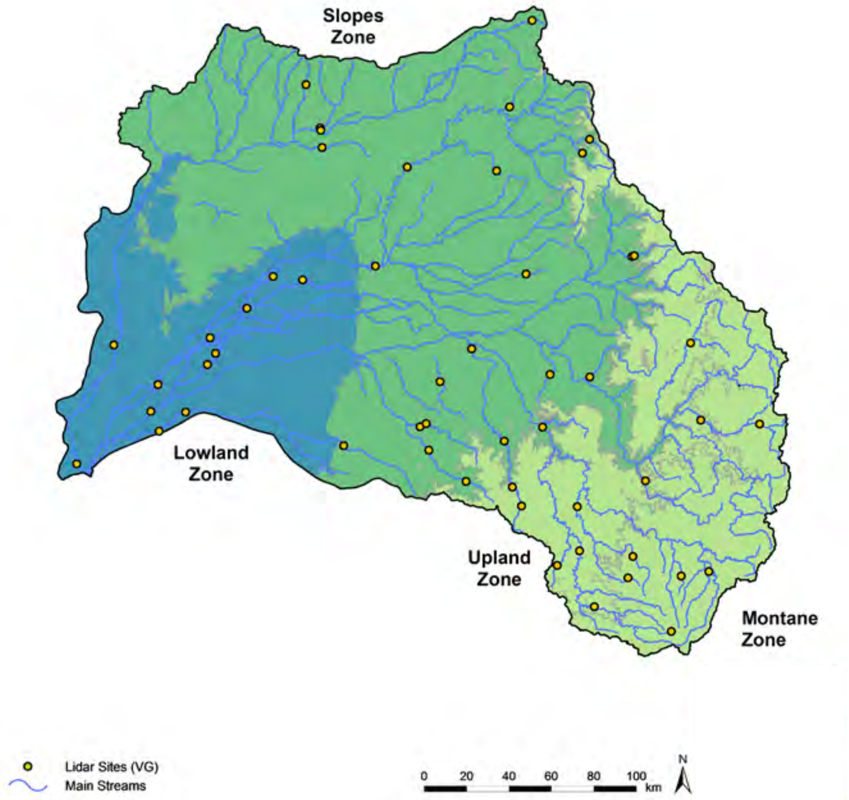

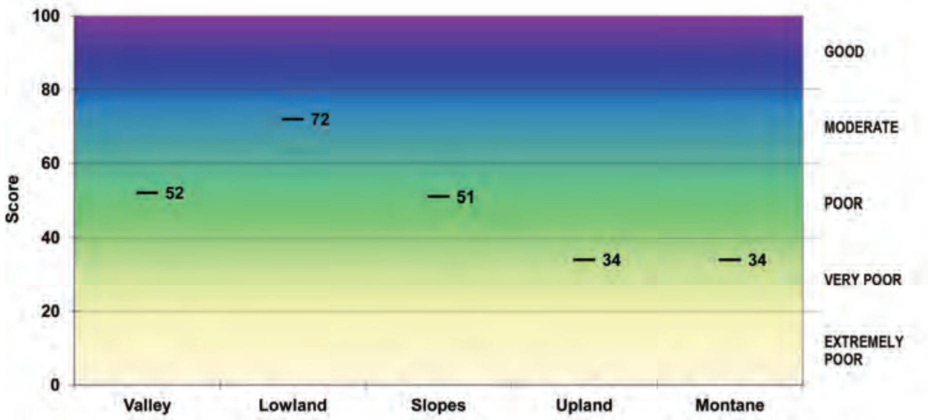

Figure BRD 4: Border Rivers Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Border Rivers Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 52. Overall condition for the four zones in this valley was: Montane Very Poor; Upland Very Poor; Slopes Poor; and Lowland Moderate.

Abundance and Diversity was 58 for the valley, indicating a Poor rating overall. In the four zones it was: Montane Poor; Upland Poor; Slopes Poor; Lowland Moderate.

Quality and Integrity was 60 for the valley, indicating a Moderate rating overall. In the four zones it was: Montane Poor; Upland Poor; Slopes Moderate; Lowland Moderate.

The SRA Vegetation assessment for the Border Rivers Valley considers riverine vegetation in two spatial domains: Near Riparian along 8,748 km of stream, and Lowland Floodplain, for 628 km^2 of flooding land in the Lowland zone which is a part of the floodplain. Most (52%) of the stream length in the valley is in the Slopes zone, and the length of stream assessed per zone is as follows: Montane 1,034 km; Upland, 1,073 km; Slopes, 4,554 km; and Lowland, 2,086 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVG) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 52 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream amongst the four zones as follows: Montane, six sites; Upland, seven sites; Slopes, 26 sites and Lowland, 13 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups (MVGs), for an area that is only part of the actual floodplain.

Figure BRD 4 shows values of the Vegetation Index (SR–VI) for the Border Rivers Valley and Table BRD 7 shows the Index, indicator and sub-indicator values. Tables BRD 8 and BRD 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a large difference from Reference Condition for the Border Rivers Valley with:

- SRA Vegetation Index (SR–VI) = 52, indicating Poor condition for riverine vegetation.
- the Vegetation Abundance and Diversity indicator = 58, indicating a large difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- the Vegetation Quality and Integrity indicator = 60, indicating a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- the Lowland Floodplain domain is considerably affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area shows a large difference from Reference Condition.

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The Abundance and Diversity of valley riverine vegetation is in Poor condition overall, with a large difference from Reference Condition in the Montane, Upland and Slopes zones, and a moderate difference in the Lowland zone. The Poor rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wide abundance in both the Near Riparian and Lowland Floodplain domains shows a large difference from reference. MVG richness is maintained as no MVG has been completely reduced. Vegetation in the Lowland Floodplain domain has 54% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, showing a large difference from Reference Condition in the Montane and Upland zones, and a moderate difference from reference in the Slopes and Lowland zones. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table BRD 8 as well as other native but non-specific MVGs. Valley nativeness shows a large difference from reference in the Near Riparian domain, and a moderate difference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain domain shows a large difference from Reference Condition.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain, is in Good condition overall, and the metrics show no loss of MVGs in any of the zones from the Near Riparian domain, and no loss of MVGs from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Moderate condition overall, and the metrics show differences between zones and domains. Abundance in the Near Riparian domain shows a very large difference from Reference Condition in the Montane zone, a large difference from Reference Condition in the Upland and Slopes zone, and a moderate difference from Reference Condition in the Lowland zone; and in the Lowland Floodplain domain it shows a large difference from reference.

Stability

- Floodplain areas within the Lowland Floodplain domain are in Poor condition, with considerable evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Moderate condition overall, and the metrics show differences between zones and domains. Nativeness in the Near Riparian domain shows a large difference from Reference Condition in the Montane, Upland and Slopes zones and a moderate difference in the Lowland zone; and in the Lowland Floodplain domain, nativeness shows a moderate difference from Reference Condition.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with differences between zones. It is near Reference Condition in the Montane and Slopes zones, and moderately different from reference in the Upland and Lowland zones which were also the most variable, as indicated by the confidence limits.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of MVGs is in Poor condition. The most affected MVG is Acacia Forests and Woodlands, with a substantial reduction in the number of patches and a severe reduction in mean patch area relative to Reference Condition. Least affected are Eucalypt Tall Open Forests and Other Shrublands, which have patch number and mean patch area close to reference.

Under Reference Conditions, the riverine vegetation in the Border Rivers Valley was characterised as follows:

- Montane: The Near Riparian domain was mostly Eucalypt Woodlands (60% of domain) and Eucalypt Open Forests (35%) with small areas of two other MVGs.
- Upland: The Near Riparian domain was mostly Eucalypt Woodlands (74%) and Eucalypt Open Forests (23%) with very small areas of three other MVGs.
- Slopes: The Near Riparian domain was mostly Eucalypt Woodlands (72%) and nine other MVGs, only three of which were more than 5% of the domain.
- Lowland zone: The Near Riparian domain was mostly Eucalypt Open Woodlands (35%) and Eucalypt Woodlands (28%) with seven other MVGs, of which three were more than 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was Eucalypt Open Woodlands (38%) and Eucalypt Tall Open Forests (28%) with six other MVGs of which two covered 5% or more of the domain.

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Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced, in all zones, and the effect on individual MVGs is quite variable:

- Montane zone: In the Near Riparian domain, Eucalypt Woodlands have been extensively cleared (now 14% of the domain area) and Eucalypt Open Forests are now the most extensive MVG (23% of domain). About 57% of the Montane Near Riparian is either cleared or non-native vegetation. Eucalypt Woodlands are the most reduced MVG in area relative to Reference Condition.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands are reduced to just 17% of the domain, and Eucalypt Open Forests are now the most extensive MVG (21% of domain). About 57% of the Upland Near Riparian is cleared or non-native vegetation. Eucalypt Woodlands, and Acacia Forests and Woodlands are the most reduced MVGs in area.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG (now 26% of the domain) although reduced. About 51% Slopes Near Riparian is cleared or non-native vegetation. Eucalypt Open Woodlands, and Acacia Forests and Woodlands are the most reduced MVGs in area.

- Lowland zone: In the Near Riparian domain, although cleared, Eucalypt Tall Open forests, Eucalypt Open Woodlands and Eucalypt Woodlands are still the most extensive MVGs (now 18%, 14% and 11% of the domain). About 34% Lowland Near Riparian of the domain is cleared or non-native vegetation. Eucalypt Woodlands and Eucalypt Open Woodlands are the most reduced MVGS in area, and Other Shrublands are near Reference Condition.

- Lowland zone: In the Lowland Floodplain domain, the Eucalypt woodlands are reduced and Eucalypt Open Woodlands and Eucalypt Woodlands are now 12% and 6% of the domain respectively. About 30% of the Lowland Floodplain domain is cleared or non-native vegetation. Three MVGs are substantially reduced, their current area being less than 40% of Reference Condition. Five MVGs cover areas that the same as reference, and this includes the taller forests: Eucalypt Tall Open Forests and Eucalypt Open Forests.

Unlike the other Themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up-to-date, The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the NVIS 3.0 mapping has an on-ground mapping date that ranges from 1997 to 2004, whereas LiDAR was flown in 2009-2010. This means that the Structure Sub-indicator and three metrics (abundance, richness and nativeness) are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

Most metrics used to assess condition in the Border Rivers Valley are based on vegetation mapping. This is not current and can be variable in quality: about 4% of the Near Riparian domain in the Montane zone is not assigned to an MVG. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of any of the zones and of the valley itself, may have changed since the source mapping was compiled.

Riverine vegetation is in best condition in the Lowland zone where it is in Moderate condition overall, and has higher scores for the two indicators, Quality and Integrity, and Abundance and Diversity, than any of the other three zones. The Slopes zone, which is in Poor condition overall, has more stream length than the other zones, and its condition has more influence on the overall riverine Vegetation Index for the valley.

The riverine vegetation of the Border Rivers is notable for the low abundance of MVGs and low nativeness in the Near Riparian domain of the Montane, Upland and Slopes zones, and for the marked contrast with the condition of the Near Riparian and Lowland Floodplain domains in the Lowland zone. Within the Lowland zone, the abundance and nativeness metrics imply differing dynamics in these two domains, with regrowth in the Lowland Floodplain. These two domains assess differing but slightly overlapping parts of the landscape: the Lowland Floodplain is land that floods near the main river channels, whereas the Near Riparian domain is a continuous swath centred on all types of channels and covers a larger area.

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Table BRD 7: Border Rivers SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for structure). V alley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	52	34	34	51	72
Indicator	Abundance and diversity	58	48	50	57	70
Metric	LF stability	0.54				0.54
Sub-ind.	NRLF richness	100				100
Metric	NR richness	1	1	1	1	1
Metric	LF richness	1				1
Sub-ind.	NRLF abundance	60				60
Metric	NR abundance	0.48	0.39	0.40	0.45	0.61
Metric	LF abundance	0.57				0.57
Indicator	Quality and integrity	60	51	50	62	67
Sub-ind.	NRLF nativeness	76				76
Metric	NR nativeness	0.51	0.41	0.42	0.49	0.66
Metric	LF nativeness	0.71				0.71
Sub-ind.	NR structure	79 (74–85)	92 (85–96)	78 (49–94)	83 (75–89)	68 (54–80)
Sub-ind.	LF fragmentation	57				57

Table BRD 8: The most abundant MVGs in the Near Riparian domain in the Border Rivers Valley.

Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone			
	Montane	Upland	Slopes	Lowland
MVG				
2. Eucalypt Tall Open Forests				17
3. Eucalypt Open Forests	35	23	6	6
5. Eucalypt Woodlands	60	74	72	28
6. Acacia Forests and Woodlands			9	
11. Eucalypt Open Woodlands			6	35
17. Other Shrublands				6

Table BRD 9: Most abundant MVGs in the Lowland Floodplain domain in the Border Rivers Valley.

Showing percentage of domain area under Reference Condition and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
2. Eucalypt Tall Open Forests	28	0.96	1.08
3. Eucalypt Open Forests	6	1.68	0.55
5. Eucalypt Woodlands	18	1.43	0.22
11. Eucalypt Open Woodlands	38	1.07	0.28

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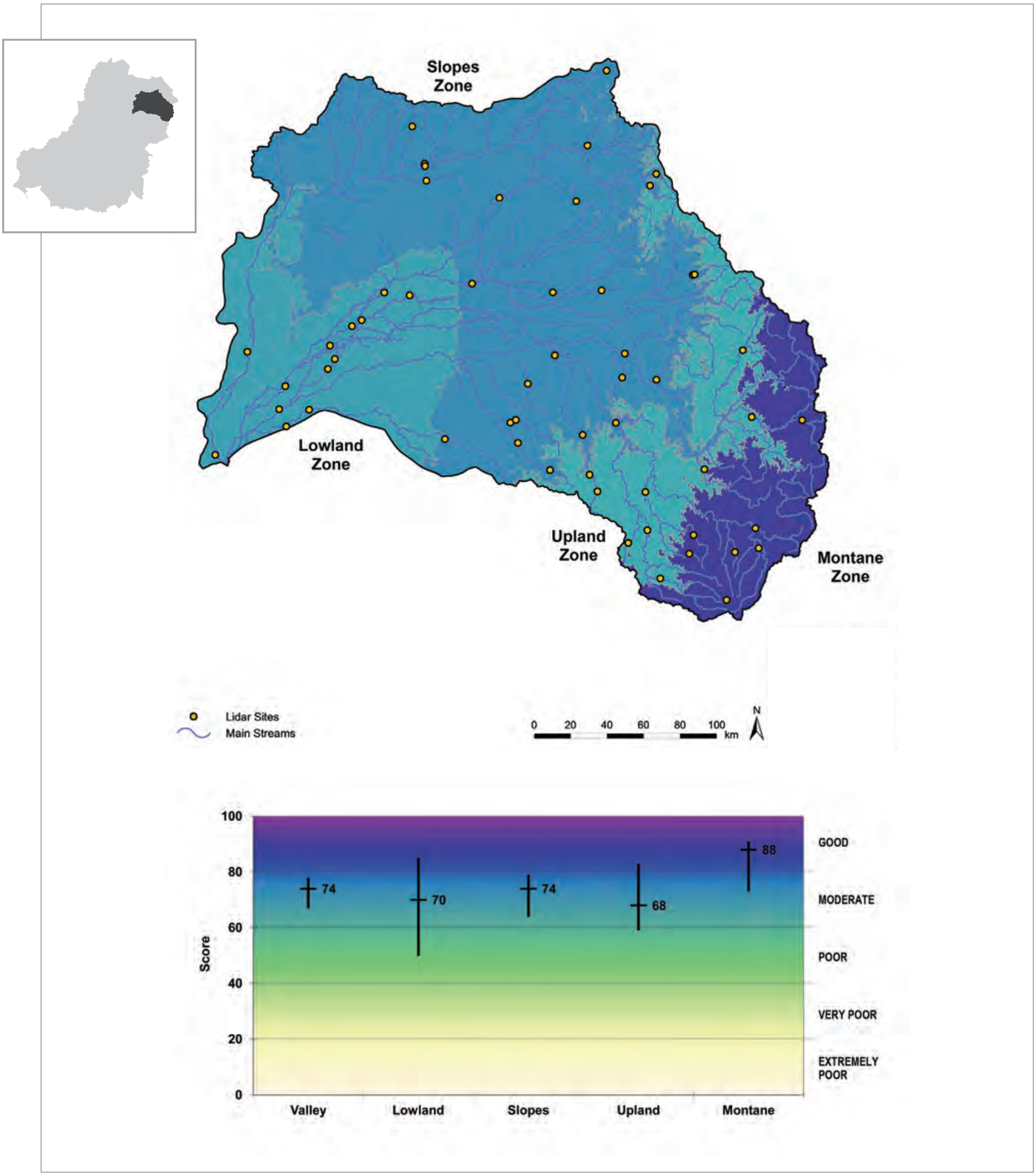

Figure BRD 5: Border Rivers Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Border Rivers Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 74. The condition of Physical Form in the zones was: Montane Good; Upland, Slopes and Lowland Moderate. The valley's river Channel Form was rated as Moderate. Bank Dynamics was rated as Good. Bed Dynamics was rated as Moderate. Floodplain Dynamics was rated as Poor. The valley's riverine Physical Form was characterised by elevated sediment loads since European settlement resulting in sedimentation on the floodplain and within the channel. Channels were simplified, with reduced variability in channel width, particularly in the Upland zone, and increased Meander Wavelength.

The SRA Physical Form assessment considers physical form and processes along 8,748 km of stream across the valley. It is based on LiDAR data collected at 56 sites along river channels, as well as modelling of all 458 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain Form (see Section 3).

Figure BRD 5 shows values of the Physical Form Index (SR–PI) for the Border Rivers Valley and Table BRD 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Border Rivers Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 74 (CL 67-78), indicating Moderate Physical Form condition
- the Channel Form indicator = 78 (CL 71–84), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 60 (CL 58-62), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 99 (CL 98–99), showing near Reference Condition
- the Floodplain indicator = 57 (CL 52–62), showing a large difference from Reference Condition.

Montane zone

There were seven LiDAR survey sites and 38 SedNet river segments in the Montane zone of the Border Rivers Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Montane zone. At these sites the Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Bank Variability was modified from Reference Condition in more than half of the Montane zone. At these sites Bank Variability was generally increased indicating enhanced Bank Dynamics.

Channel Width and Channel Depth were modified from Reference Condition for approximately half of the Montane zone. At these sites both Channel Width and Depth were generally increased. Channel Width Variability, Sinuosity and Meander Wavelength were modified from reference for less than half of the Montane zone. At these sites Channel Width Variability and Sinuosity were generally reduced and Meander Wavelength was generally increased (a few sites having large increases). Channel Sediment Deposition was largely unmodified from reference in the Montane zone.

Upland zone

There were 7 LiDAR survey sites and 68 SedNet river segments in the Upland zone of the Border Rivers Valley. Based on these samples, Meander Wavelength, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upland zone. At these sites Meander Wavelength was generally increased (many sites having large increases), Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period.

Channel Width and Channel Width Variability were modified from Reference Condition in more than half of the Upland zone. At these sites Channel Width was generally increased (a few sites having large increases) and Channel Width Variability was generally reduced. Channel Depth and Bank Variability were modified from reference for approximately half of the Upland zone. At these sites Channel Depth was generally increased and Bank Variability was generally increased indicating enhanced Bank Dynamics. Sinuosity was modified from reference for less than half of the Upland zone. At these sites Sinuosity was generally reduced. Channel Sediment Deposition was largely unmodified from reference in the Upland zone.

Slopes zone

There are 28 LiDAR survey sites and 253 SedNet river segments in the Slopes zone of the Border Rivers Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period.

Channel Sediment Deposition was modified from Reference Condition in more than half of the Slopes zone. At these sites there was a large increase in Channel Sediment Deposition across 40% of the zone for the post-European period. Channel Width and Meander Wavelength were modified from reference for approximately half of the Slopes zone. At these sites results show both increases and decreases in Channel Width across the zone and Meander Wavelength was generally increased (many sites having large increases).

Channel Depth, Channel Width Variability, Sinuosity and Bank Variability were modified from Reference Condition for less than half of the Slopes zone, with both increases and decreases in Channel Depth across the zone, Channel Width Variability was generally reduced (with a large reduction at over half of these sites), Sinuosity was generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics.

Lowland zone

There were 14 LiDAR survey sites and 99 SedNet river segments in the Lowland zone of the Border Rivers Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 30% of the zone for the post-European period.

Channel Width Variability and Meander Wavelength were modified from Reference Condition in more than half of the Lowland zone. At these sites Channel Width Variability was generally smaller and Meander Wavelength was generally larger than reference (many sites having large increases). Channel Depth was modified from reference for approximately half of the Lowland zone. At these sites Channel Depth was generally increased. Bank Variability and Channel Sediment Deposition were modified from reference for less than half of the Lowland zone. At these sites results show both increases and decreases in Bank Variability across the zone and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Channel Width and Sinuosity were largely unmodified from reference in the Lowland zone.

Channel Form

There was little change from Reference Condition in Channel Form in the Montane zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was considerable change from reference in Channel Form in the Upland zone. The more serious impact was channel simplification. Channel simplification was indicated at 90% of sites as a result of both channel straightening and reduced longitudinal variability in channel cross-section. There was widespread evidence of channel enlargement and channel straightening but small deviations from reference had little influence on scores when aggregated at the zone scale.

Adjustments to Channel Planform in the Montane and Upland zone will be constrained by bedrock. Local knowledge is required to interpret any departures from reference planform in bedrock channels.

There was little change from Reference Condition in Channel Form in the Slopes zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

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There was minor change from Reference Condition in Channel Form in the Lowland zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from Reference Condition had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Montane zone. Bank variability exceeded Reference Conditions at 70% of sites. There was little change in Bank Dynamics in the Upland zone. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result. There was little change from Reference Condition in Bank Dynamics in the Slopes zone. There was little change in Bank Dynamics in the Lowland zone.

There was minor change in Bed Dynamics in the Montane zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was minor change from Reference Condition in Bed Dynamics in the Upland zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was considerable change from reference in Bed Dynamics in the Slopes zone as a result of widespread sedimentation (60% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Slopes zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Local knowledge is required to resolve these conflicting results. There was minor change from Reference Condition in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (30% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Lowland zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Local knowledge is required to resolve these conflicting results.

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was minor change in Floodplain Dynamics in the Slopes zone as a result of sedimentation (in 100% of SedNet river segments). There was considerable change in floodplain dynamics in the Lowland zone as a result of widespread sedimentation (also in 100% of SedNet river segments).

Table BRD 10: Border Rivers Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Physical Form Condition (SR–PI)	74 (67–78)	88 (73–91)	68 (59–83)	74 (64–79)	70 (50–85)
Indicator	Channel Form (volume and flow events)	78 (71–84)	84 (68–100)	60 (41–78)	80 (71–89)	78 (65–90)
Sub-ind.	Cross-section Form	90 (85–94)	92 (77–98)	82 (58–98)	91 (85–96)	89 (82–96)
Metric	Channel Depth (mean)	1.02 (0.96–1.07)	0.95 (0.78–1.05)	1.07 (1.00–1.18)	0.96 (0.89–1.03)	1.14 (1.02–1.28)
Metric	Channel Width (mean)	1.09 (1.04–1.16)	1.09 (1.02–1.15)	1.37 (1.09–1.77)	1.04 (0.99–1.09)	1.07 (0.98–1.21)
Sub-ind.	Cross-section Form (variability)	84 (76–92)	91 (73–100)	85 (70–97)	83 (70–94)	83 (66–95)
Metric	Channel Width (CV)	0.89 (0.85–0.93)	0.94 (0.84–1.00)	0.87 (0.77–0.96)	0.90 0.82–0.96)	0.87 (0.79–0.94)
Sub-ind.	Channel Planform	79 (72–86)	85 (64–99)	57 (36–78)	83 (73–92)	80 (64–93)
Metric	Sinuosity	1.01 (1.00–1.02)	0.97 (0.93–1.00)	0.98 (0.95–1.00)	1.03 (1.01–1.05)	1.00 (1.00–1.02)
Metric	Meander Wavelength	1.14 (1.09–1.21)	1.06 (1.00–1.14)	1.27 (1.13–1.44)	1.13 (1.04–1.24)	1.15 (1.04–1.31)
Indicator	Bed Dynamics	60 (58–62)	70 (7–70)	68 (66–71)	53 (50–57)	66 (63–68)
Metric	Channel Sediment Ratio	64 (60–68)	57 (47–68)	60 (50–67)	73 (68–79)	50 (43–59)
Metric	Channel Sediment Depth	0.003 (0.002–0.004)	0.00002 (0–0.00006)	0.002 (0.00006–0.006)	0.004 (0.003–0.005)	0.002 (0.0006–0.004)
Indicator	Bank Dynamics	99 (98–99)	99 (97–100)	98 (95–100)	98 (97–100)	100 (99–100)
Metric	Bank Variability (longitudinal)	1.07 (1.03–1.12)	1.12 (1.01–1.24)	1.16 (1.04–1.34)	1.06 (1.01–1.14)	1.03 (0.99–1.07)
Indicator	Floodplain	57 (52–62)	57 (45–72)	42 (32–54)	63 (57–71)	50 (39–62)
Metric	Floodplain Sediment Deposition	5 (4–7)	2 (1.73–3.00)	5 (3–7)	6 (4–8)	6 (4–8)

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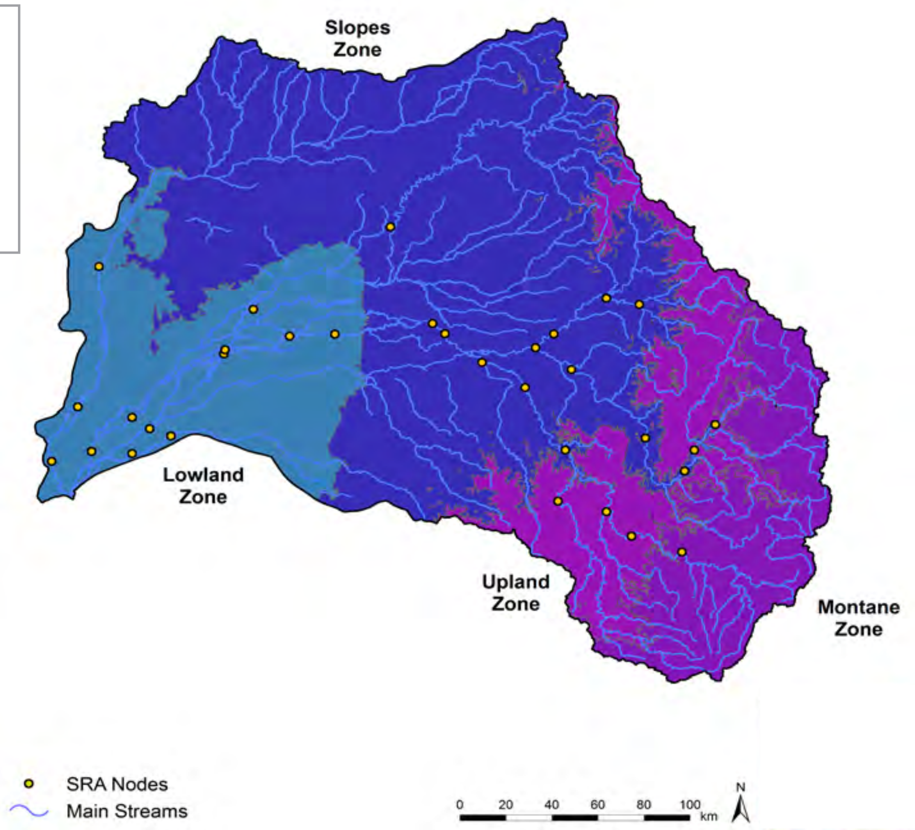

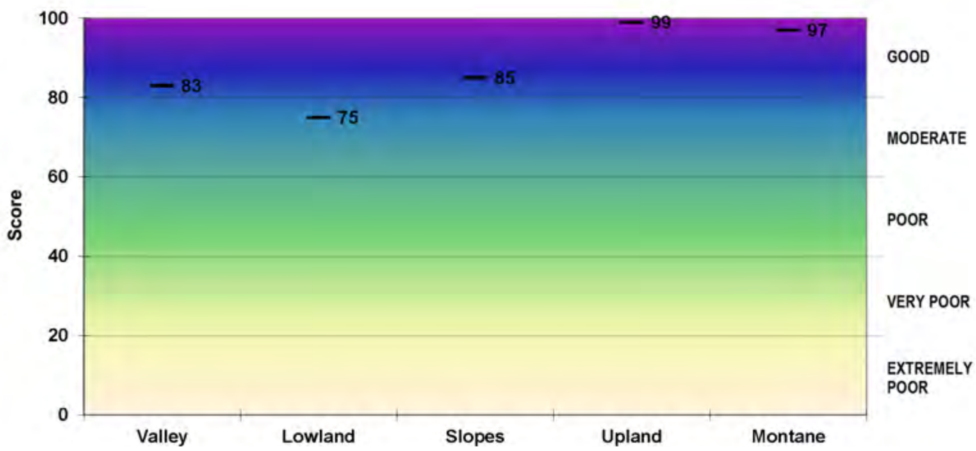

Figure BRD 6: Border Rivers Valley map with zones coloured by SRA Hydrology Index (SR-HI) scores.
Graph shows SR-HI scores as horizontal bars.

The Hydrology of the Border Rivers Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 83. The Slopes, Upland and Montane zones were in Good condition and the Lowland zone was in Moderate condition. The mainstem river system was rated in Moderate condition. There was reduced flooding relative to reference throughout most of the mainstem river system (increased duration of inter-flood periods and reduced durations). High flows were altered, with a reduction in the duration and frequency of high flow spells throughout much of the mainstem river length. There were widespread changes to flow seasonality, with altered timing and reduced amplitude of seasonal flow variations relative to Reference Condition. The headwater streams were rated in Good condition. Throughout some of the headwater streams the magnitude of low flows were reduced and the amplitude of seasonal flow variations was increased.

The Border Rivers catchment includes rivers rising on the western side of the Great Dividing Range, flowing to the Barwon River, at the head of the Darling Valley. The main tributaries are the Macintyre Brook and the Dumaresq and Macintyre rivers, combining as the Macintyre upstream of Goondiwindi. Downstream, the Macintyre flows through a broad floodplain before entering the upper reaches of the Barwon River near Mungindi. The Moonie River joins the Barwon separately, draining the north-west, and the Severn River drains the south, from New South Wales. There are four major instream storages, the Coolmunda, Glenlyon, Pindara and Rangers Valley dams, with a combined capacity of 641 GL. Irrigated agriculture occurs throughout the valley, but is centred on the Macintyre. Cotton is the major crop and horticulture is locally important. There is substantial offstream storage for harvesting high flows.

In the Border Rivers Valley, hydrological condition is assessed using metrics of hydrological alteration available for 7,928 km of mainstem rivers and headwater streams. There are 1,416 km of mainstem river extending across the Lowland, Slopes and Upland zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by monthly water resource modelling in 8% of river reaches and daily modelling in the remainder. In the Border Rivers Valley there is 6,512 km of headwater stream (Montane zone: 1,324 km zone; Upland zone: 1,312 km; Slopes zone: 3,430 km; Lowland zone: 446 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Border Rivers Valley there are 5,584 km of these mid-size tributaries (385 km in the Montane zone; 659 km in the Upland zone; 2,900 km in the Slopes zone; 1,640 km in the Lowland zone)—0.7 times the stream length for which SRA metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

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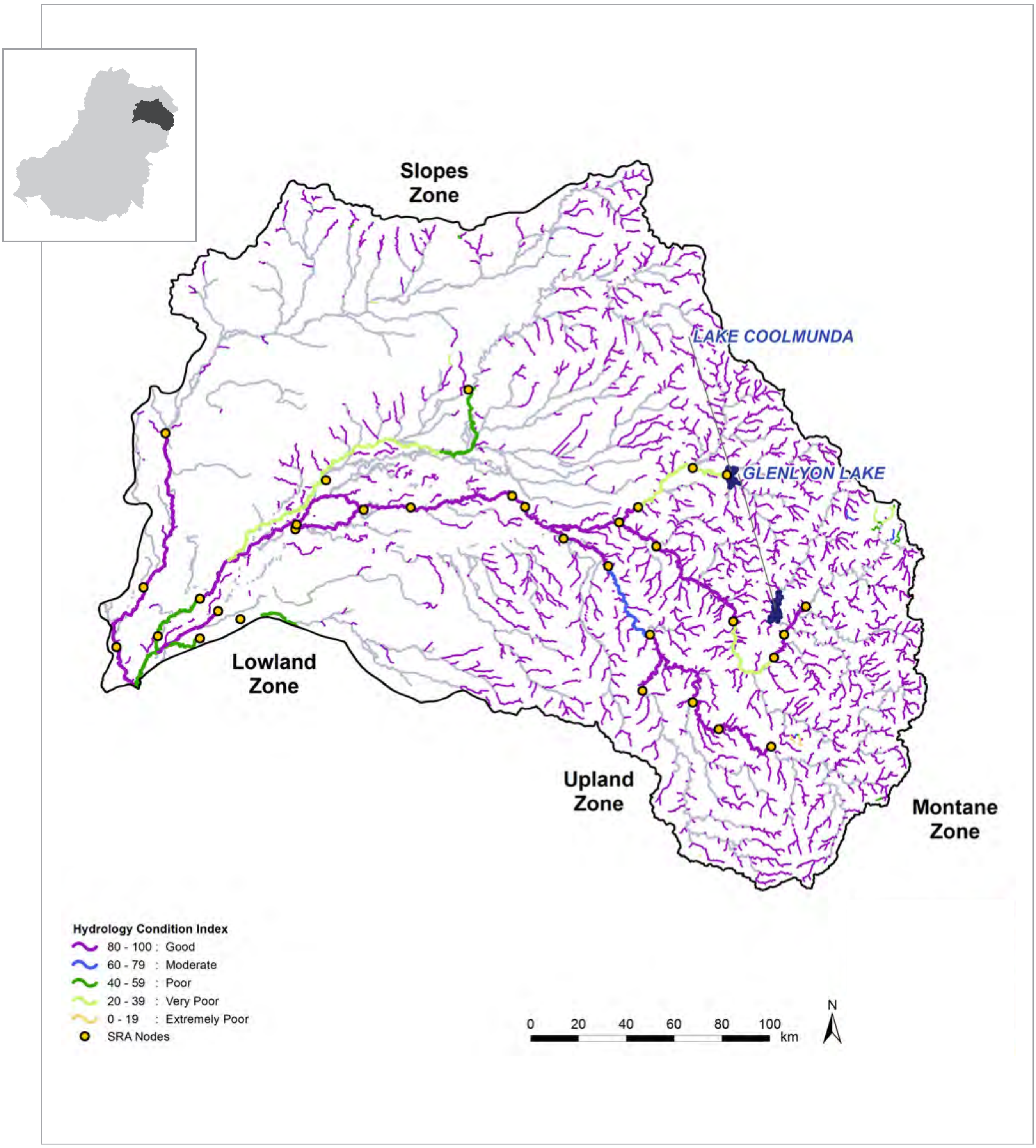

Figure BRD 7: Border Rivers Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures BRD .6 and BRD 7 show values of the Hydrology Condition Index (SR–HI) for the Border Rivers Valley river network, and Table BRD 11 and BRD 12 show the Index, sub-index, indicator and metric values. Analyses showed near Reference Condition for the Border Rivers Valley, with:

- The Hydrology Condition Index for the whole valley = 83, indicating Good hydrological condition.
- The Hydrology Condition Index for the Montane, Upland, Slopes and Lowland zones = 97, 99, 85 and 75 indicating Good, Good, Good and Moderate hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 78, indicating Moderate hydrological condition.
- The In-Channel Flow Regime indicator in the mainstem river reaches = 80, indicating Good condition and near Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 87, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a very significant alteration from Reference Condition in 13% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 13% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. In addition, results for the Flow Duration metric showed a very significant alteration from Reference Condition in 2% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a significant alteration from reference in 1% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone and some in the Upland zone. Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to Reference Condition.

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In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 21% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 26% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 21% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 48% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (associated with increased flows) and a significant alteration from reference in 15% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, some in the Upland zone, some in the Slopes zone and a small proportion in the Lowland zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to Reference Condition.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 23% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 17% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 19% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 36% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from Reference Condition in 14% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 28% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to the reference flow regime. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to the reference flow regime.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a moderate difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 13% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 18% of the mainstem river length (mostly associated with a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and most in the Lowland zone. Results for the Seasonal Period metric showed a significant alteration from reference in 44% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (mostly an increased amplitude) and a significant alteration from Reference Condition in 29% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, some in the Upland zone, some in the Slopes zone and a small proportion in the Lowland zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

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In the mainstem rivers, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 8% of the mainstem river length (mostly associated with reduced variability) and a significant alteration from Reference Condition in 15% of the mainstem river length (associated with both increased and reduced variability). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, a small proportion in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from Reference Condition in 2% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with most in the Montane zone.

Low Over Bank Floods

The Low Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 1-year flood in the reference regime. It is calculated from a combination of the Low Over Bank Flood Duration metric and the Low Over Bank Flood Spells metric. The Low Over Bank Flood Duration metric quantifies change in the duration of flooding of low-level floodplain areas relative to the reference flow regime. The Low Over Bank Flood Spells metric quantifies change in the duration of time between low-level floodplain inundation events relative to Reference Condition. The Low Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys since water resource models use a monthly rather than daily timestep.

In the mainstem rivers, the Low Over Bank Floods indicator showed near Reference Condition. Results for the Low Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 16% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 42% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 14% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 35% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

High Over Bank Floods

The High Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 8-year flood in the reference regime. It is calculated from a combination of the High Over Bank Flood Duration metric and the High Over Bank Flood Spells metric. The High Over Bank Flood Duration metric quantifies change in the duration of flooding of high-level floodplain areas relative to the reference flow regime. The High Over Bank Flood Spells metric quantifies change in the duration of time between high-level floodplain inundation events relative to Reference Condition.

The High Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly rather than daily timestep.

In the mainstem rivers, the High Over Bank Floods indicator showed a moderate difference from Reference Condition. Results for the High Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 23% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 57% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone. Results for the High Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 28% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 26% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Border Rivers Valley was generally characterised by moderate alteration from Reference Condition in High Over Bank Floods, Flow Seasonality and Low and Zero Flow Events and little or no alteration in Low Over Bank Floods, Flow Variability, High Flow Events and Flow Gross Volume. There was reduced flooding relative to Reference Condition throughout most of the mainstem river system, with increased duration of inter-flood periods and reduced flood durations relative to Reference Conditions. Also, high flows were altered with a reduction in the duration and frequency of high flow spells throughout much of the mainstem river length. There was also widespread change to flow seasonality, with altered timing and reduced amplitude of seasonal flow variations relative to reference.

Summary: headwater streams

The headwater streams of the Border Rivers Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume, relative to Reference Condition. Throughout some of the headwater streams the magnitude of low flows were reduced and the amplitude of seasonal flow variations was increased relative to reference.

Table BRD 11: Border Rivers Valley SRA Hydrology Index at valley and zone scales.

Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	83	97	99	85	75

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Table BRD 12: Border Rivers Valley SRA Hydrology Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**78 (22–100)**	**99 (12–100)**
Sub-index	In-Channel Flow Regime	80 (6–100)	99 (12–100)
Indicator	In-Channel Flow Regime A (volume and flow events)	74 (0–100)	100 (40–100)
Sub-ind.	Flow Gross Volume	85 (0–100)	98 (53–100)
Metric	Mean Annual Flow	0.81 (0–1.23)	1.05 (0.48–1.22)
Metric	Flow Duration	1.01 (0.94–1.07)	1.00 (0.69–1.29)
Sub-ind.	High Flow Events	81 (0–99)	98 (62–100)
Metric	High Flow	0.85 (0–1.54)	1.06 (0.49–1.72)
Metric	High Flow Spells	0.71 (0.31–1.00)	
Sub-ind.	Low and Zero Flow Events	72 (11–98)	96 (31–99)
Metric	Zero Flows Proportion	0.89 (0–1.51)	0.99 (0.96–1.00)
Metric	Low Flow	0.97 (0.11–2.00)	0.89 (0.09–1.38)
Metric	Low Flow Spells	1.17 (0.34–2)	
Indicator	In-Channel Flow Regime B (seasonality & variability)	90 (20–100)	99 (18–100)
Sub-ind.	Flow Seasonality	77 (19–100)	94 (69–100)
Metric	Flow Seasonal Amplitude	0.76 (0–1.02)	1.14 (0.89–1.59)
Metric	Flow Seasonal Period	0.81 (0.51–1.00)	0.97 (0.67–1.00)
Sub-ind.	Flow Variability	88 (9–100)	94 (0–100)
Metric	Flow Variation	1.00 (0.58–1.38)	0.94 (0.20–1.00)
Sub-index	Over Bank Flow Regime	87 (10–100)	
Indicator	Over Bank Floods Low	87 (28–99)	
Metric	OB Flow Duration (ARI 1)	0.75 (0–1.08)	
Metric	OB Flow Spells (ARI 1)	0.88 (0.03–1.23)	
Indicator	Over Bank Floods High	74 (7–98)	
Metric	OB Flow Duration (ARI 8)	0.62 (0–0.82)	
Metric	OB Flow Spells (ARI 8)	0.64 (0.19–1.00)	

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
	99	**78**	**75**	**97**	**100**	**100**
	92	78	80	97	100	100
	98	77	68	99	100	100
	100	99	72	97	97	99
	0.99	0.96	0.69	1.08	1.08	1.04
	1.01	1.03	0.99	1.01	1.02	1.00
	90	91	72	97	97	99
	1.14	1.10	0.64	1.16	1.14	1.00
	0.79	0.75	0.66			
	92	68	73	95	97	96
	1.02	0.99	0.81	0.98	0.99	0.99
	1.10	1.13	0.84	0.89	0.98	0.86
	0.86	1.35	1.06			
	84	94	87	95	99	99
	89	83	72	93	92	95
	0.96	0.86	0.66	1.18	1.19	1.11
	0.81	0.76	0.86	0.94	0.97	0.98
	82	91	86	89	96	95
	0.90	0.92	1.08	0.91	0.95	0.95
	97	92	81			
	89	82	90			
	0.79	0.77	0.72			
	0.91	0.79	0.95			
	62	80	70			
			0.62			
			0.64			

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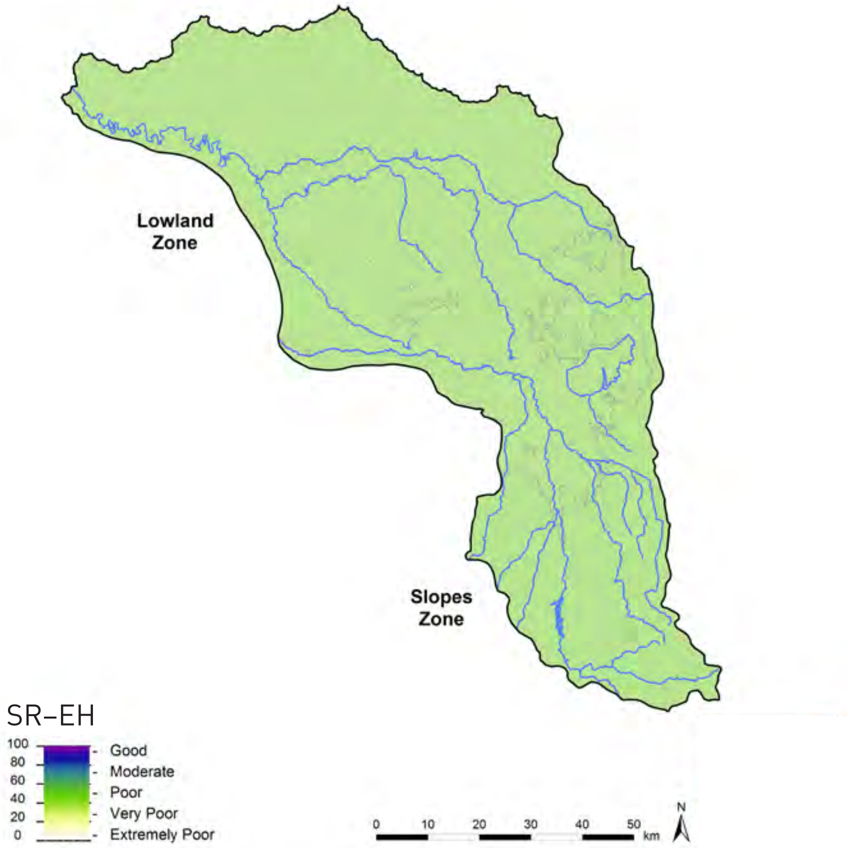

Figure BRK 1: Broken Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure BRK 1 shows the Ecosystem Health ratings for the Broken Valley and Table BRK 1 and BRK 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a very large difference from Reference Condition for the Broken Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Good and Very Poor condition respectively, while Physical Form and Hydrology were both in Good condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Broken Valley river system. River Ecosystem Health was rated as Very Poor (Lowland zone: Very Poor; Slopes zone: Very Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Broken Valley river ecosystem was in Very Poor health. River Ecosystem Health for the zones was as follows: Slopes and Lowland Very Poor. The Fish community was in Extremely Poor condition. Many expected species were absent; recruitment levels among the remaining native species were low and numbers and biomass were dominated by aliens. The Macroinvertebrate community was in Good condition, with frequency and occurrence of expected macroinvertebrate families generally near Reference Condition. Riverine Vegetation was in Very Poor condition overall; with reduced abundance, stability and nativeness in the Near Riparian and Lowland Floodplain domains, and a large increase in fragmentation in the Lowland Floodplain. The Physical Form of the river system was in Good condition with channel form and bank dynamics in Good condition and bed dynamics in Moderate condition. There were moderate levels of floodplain sediment deposition. The river system's Hydrology was in Good condition, with both mainstem and headwater reaches showing little or no change from Reference Condition in flow variability, flow seasonality, low and zero flow events, high flow events and flow gross volume.

Ecosystem Health

The Broken Valley was equal lowest of the 23 Basin valleys (with the Lachlan Valley) in terms of River Ecosystem Health (see Table 5.2). It was equal second lowest in Fish condition (SR–FI =7) and third lowest in Vegetation condition (SR–VI = 21). Of the three biotic Indices, only Macroinvertebrates ranked well, falling within the top 50% for all valleys. The physical environment of the Broken, as evidenced by the Hydrology and Physical Form indices which both ranked equal sixth for all valleys, appeared to be in much better condition.

The low ranking for Vegetation condition in part reflects the degree of rural development throughout the valley; grazing and cereal cropping for much of the river's length and fruit and dairy irrigation in the lower reaches.

The Broken Valley has experienced an extended period of extreme drought, as has much of the Murray–Darling Basin, particularly in the southern half. It is quite possible that, in a relatively low-volume stream such as the Broken, this can lead to a loss of longitudinal connectivity and a severe reduction in habitat heterogeneity, particularly as rates of sedimentation are elevated.

Fish Theme

The Fish Condition Index SR–FI = 7, indicating Extremely Poor condition (Lowland zone: Extremely Poor; Slopes zone: Extremely Poor). The Expectedness indicator = 10, indicating Extremely Poor condition, and an extreme difference from Reference Condition. The Nativeness indicator = 29, indicating Very Poor condition, and a very large difference from Reference Condition. The Recruitment indicator = 30, indicating Very Poor condition, and a very large difference from Reference Condition.

Overall, the fish community had reduced numbers of expected native species and low population densities, with abundance, species numbers and biomass dominated by alien species. Only five of the 11 native species recorded showed any evidence of recruitment.

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Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 80, indicating Good condition (Lowland zone: Good; Slopes zone: Good). The simOE metric = 52 indicating a small to moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Moderate or Good condition was high across both zones (97% overall), with 22 of the 34 sites (65%) rated in Good condition.

The proportion of sites in Good condition was high across both zones (59%). Family richness generally was high, and showed minor reductions compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 21, indicating Very Poor condition (Lowland zone: Extremely Poor; Slopes zone: Very Poor). The Vegetation Abundance and Diversity indicator = 40, indicating Poor condition and a large difference from Reference Condition for the abundance and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 35, indicating Very Poor condition and a very large difference from Reference Condition for the structure, nativeness and fragmentation of vegetation communities and groups in the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is moderately affected by clearing, with a moderate decrease in abundance but a large increase in fragmentation of major vegetation groups compared to Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 89, indicating Good condition (Lowland zone: Good; Slopes zone: Good). The Channel Form indicator = 82, indicating Good condition and showing near Reference Condition. The Bed Dynamics indicator = 63, indicating Moderate condition and showing moderate difference from Reference Condition. The Bank Dynamics indicator = 96, indicating Good condition and showing near Reference Condition. The Floodplain Form indicator = 78, indicating Moderate condition and showing a moderate difference from Reference Condition.

Overall, the valley's riverine physical form was characterised by widespread channel enlargement, particularly in the Slopes zone. Elevated sediment loads since European settlement are associated with sedimentation of river channels within the Lowland zone.

Hydrology Theme

The Hydrology Condition Index SR–HI = 97, indicating Good condition (Lowland zone: Good; Slopes zone: Good) relative to Reference Condition. The In-Channel Flow Regime indicator = 97, indicating Good condition and near Reference Condition for the in-channel flow regime.

Both the mainstem river reaches and headwater streams were generally characterised by little or no alteration from Reference Condition in the indices of Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume.

Table BRK 1: Broken Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	SLOPES	LOWLAND
		Very Poor	Very Poor	Very Poor

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Fish	SCORE RATING	7 (3–12) Extremely Poor	6 (1–10) Extremely Poor	8 (2–15) Extremely Poor
Macro-invertebrates	SCORE RATING	80 (77–83) Good	81 (73–87) Good	80 (76–83) Good
Vegetation	SCORE RATING	21 Very Poor	34 Very Poor	15 Extremely Poor

Table BRK 2: Broken Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Physical Form	SCORE RATING	89 (78–95) Good	91 (75–95) Good	87 (73–96) Good
Hydrology	SCORE RATING	97 Good	99 Good	95 Good

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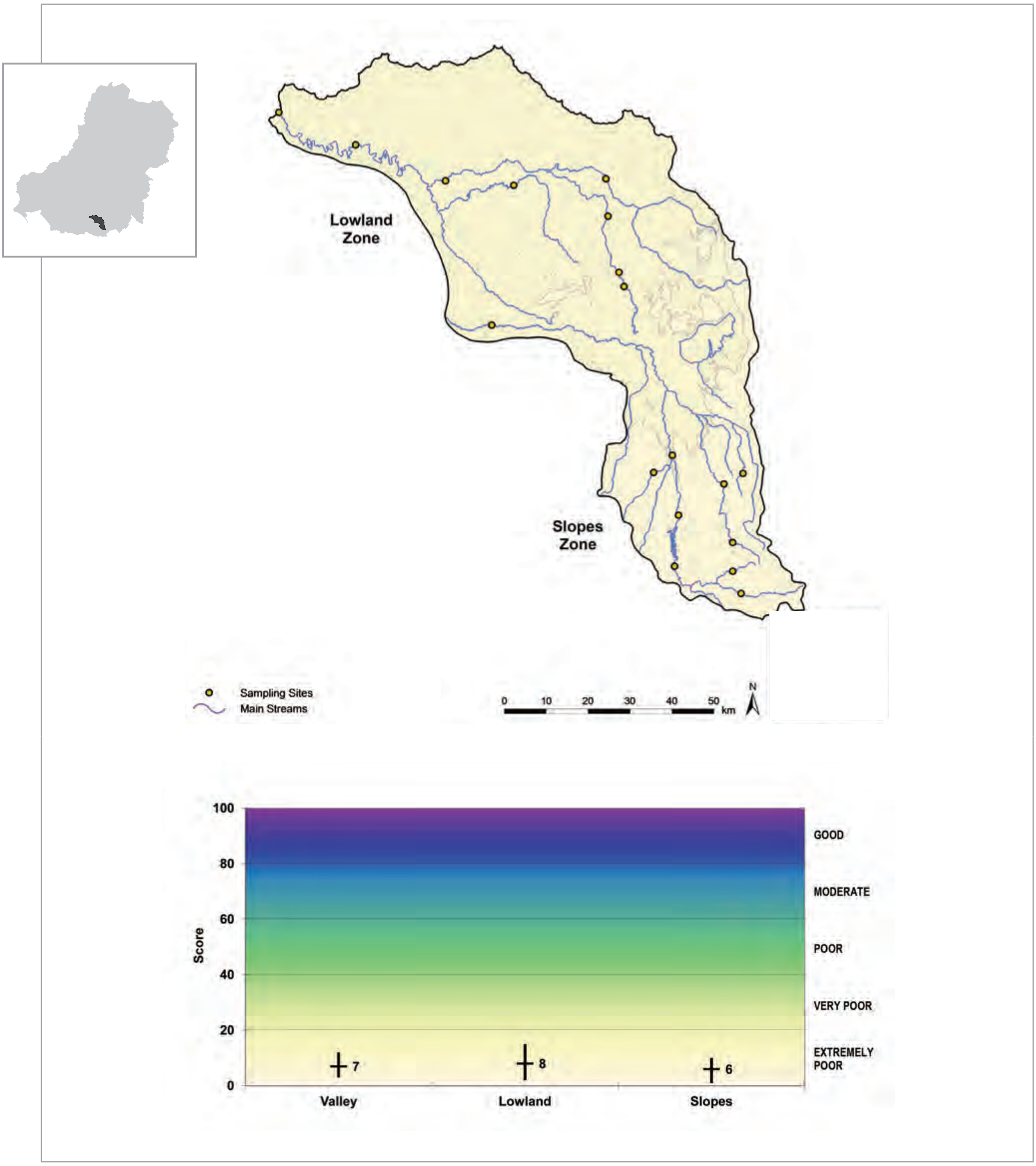

Figure BRK 2: Broken Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Broken Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 7. The condition of the fish community in both the Slopes and Lowland zones was Extremely Poor. The fish community was characterised by an Extremely Poor score for expected native fish species, a Very Poor score for Nativeness and a Very Poor score for native fish recruitment. Both zones had one third or less of their expected species present and these were mostly in low numbers. Alien species contributed 78% of the biomass in samples. Native fish recruitment was Extremely Poor in the Slopes zone and Poor in the Lowland zone.

Eighteen sites were surveyed across the Broken Valley in November–December 2007, yielding 488 fish. Analyses showed an extreme difference from Reference Condition for the Broken Valley, with:

- SRA Fish Index (SR–FI) = 7 (CL 3–12), indicating Extremely Poor condition of the fish community.
- The Expectedness indicator = 10 (CL 8–18), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Only 48% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 29 (CL 19–40), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 30 (CL 17–40), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for five of the 11 native species observed in the valley.

Figure BRK 2 shows sampling sites, zones and corresponding SR–FI values, and Table BRK.3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Broken Valley was the third lowest for all valleys, and close to that for the Macquarie and Lachlan valleys. The fish community of both zones was in Extremely Poor condition (SR–FI = 6 and 8 for the Slopes zone and Lowland zone respectively).

Only six of 16 predicted (RC–F) native fish were recorded in the Slopes zone, with three alien species recorded. In the Lowland zone, seven of 21 RC–F species were recorded, with four alien species. Likewise the Expectedness Score was Extremely Poor for both zones (eight and eleven respectively).

In terms of Nativeness the Slopes zone scored more highly (55) than the Lowland zone (18). The Slopes zone had the third lowest number of native fish per site (3.1) of all zones in the Basin but the numbers and diversity of alien fish were also low. The Lowland zone had a significantly larger number and biomass of alien fish representing four species.

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72% of the fish caught in the Broken Valley belonged to alien species. They made up 78% of the total biomass. On average, 14 fish were captured per site in the Slopes zone, of which 78% were aliens. In the Lowland zone 37.6 fish per site were captured, 70% of which were alien species. Common carp was the dominant species in terms of biomass, contributing 84% and 70% of the total fish biomass in the Slopes and Lowland zones respectively.

The Lowland zone scored more highly than did the Slopes zone in terms of Recruitment (42 versus 1).

Table BRK 4 shows native species abundances in the Broken Valley compared with Reference Condition. Southern pygmy perch, though predicted to occur, was not caught at any site. Other species not caught, but predicted to be rare or moderately rare in one or more zones under Reference Condition, included silver perch and freshwater catfish.

The popular native species—silver perch, trout cod and freshwater catfish—predicted to occur under Reference Condition, were not captured. Three specimens of the climbing galaxias, not predicted to occur in the Broken Valley, were caught in the Slopes zone.

Evidence of recruitment was observed in five of the 11 native species in at least some parts of the Broken Valley. Only one native species—Australian smelt—showed evidence of recruitment in the Slopes zone. This contrasts with the five alien species which all showed evidence of recruitment in each zone in which they occurred.

In general, the fish community of the Broken had reduced numbers of expected native species and low population densities. Only five of the 11 native species recorded showed any evidence of recruitment —though this did include Murray cod at two sites in the Lowland zone.

Table BRK 3: Broken Valley SRA Fish Condition Index, indicators, metrics and derived variables.
Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zones	
			Slopes	Lowland
Index	Fish Condition (SR-FI)	7 (3–12)	6 (1–10)	8 (2–15)
Indicator	Expectedness	10 (8–18)	8 (7–15)	11 (8–21)
Metric	O/E	0.18 (0.11–0.27)	0.15 (0.04–0.26)	0.19 (0.10–0.31)
Metric	O/P (zone level)	0.33 (0.33–0.33)	0.31 (0.31–0.31)	0.33 (0.33–0.33)
Indicator	Nativeness	29 (19–40)	55 (31–78)	18 (8–32)
Metric	Proportion biomass native	0.25 (0.11–0.38)	0.41 (0.14–0.75)	0.18 (0.05–0.33)
Metric	Proportion abundance native	0.33 (0.21–0.46)	0.55 (0.25–0.84)	0.24 (0.14–0.38)
Metric	Proportion species native	0.43 (0.32–0.55)	0.57 (0.31–0.82)	0.38 (0.25–0.50)
Indicator	Recruitment	30 (17–40)	1 (0–8)	42 (22–55)
Metric	Proportion of sites with native recruits	0.35 (0.21–0.45)	0.08 (0.00–0.20)	0.46 (0.27–0.58)
Metric	Proportion of native taxa with recruits	0.57 (0.41–0.67)	0.20 (0.00–0.33)	0.71 (0.57–0.83)
Metric	Proportion of abundance as recruits	0.45 (0.33–0.55)	0.20 (0.00–0.33)	0.55 (0.44–0.68)
Variables				
	Number of sites sampled	18	8	10
	Total number of species	16	9	11
	Number of native species	11*	6*	7
	Number of predicted species	23	16	21
	Number of alien species	5	3	4
	Mean number of fish per site	27	14	38
	Biomass/site all species (g)	9065	2840	14045
	Mean native biomass/fish (g)	255	72	296
	Mean alien biomass/fish (g)	366	240	407

* including one species (Climbing Galaxias) not expected under Reference Condition.

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Table BRK 4: Broken Valley number of fish by zone.

Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks. Numbers in brackets are counts of native species not expected under Reference Condition.

Fish species	Valley	zones	
		Slopes	Lowland
Sites sampled	18	8	10
Native species			
Australian smelt	19	1	18
Bony herring	0		0
Climbing galaxias	[3]	[3]	
Dwarf flathead gudgeon	0		0
Flathead gudgeon	9	0	9
Freshwater catfish	0	0	0
Galaxias	0	0	0
Golden perch	10	0	10
Gudgeon	19	0	19
Macquarie perch	1	1	0
Mountain galaxias	0	0	
Murray cod	37	0	37
Murray hardyhead	0		0
Murray jollytail	0	0	0

Fish species	Valley	zones	
		Slopes	Lowland
Murray–Darling rainbowfish	0	0	0
Obscure galaxias complex	4	4	0
River blackfish	26	14	12
Shortheaded lamprey	0		0
Silver perch	0		0
Southern purple-spotted gudgeon	0		0
Southern pygmy perch	0	0	0
Trout cod	0	0	0
Two-spined blackfish	2	2	
Unspecked hardyhead	8		8
Alien species			
Brown trout	8	8	
Common carp	169	60	109
Gambusia	29		29
Goldfish	91		91
Redfin perch	53	19	34

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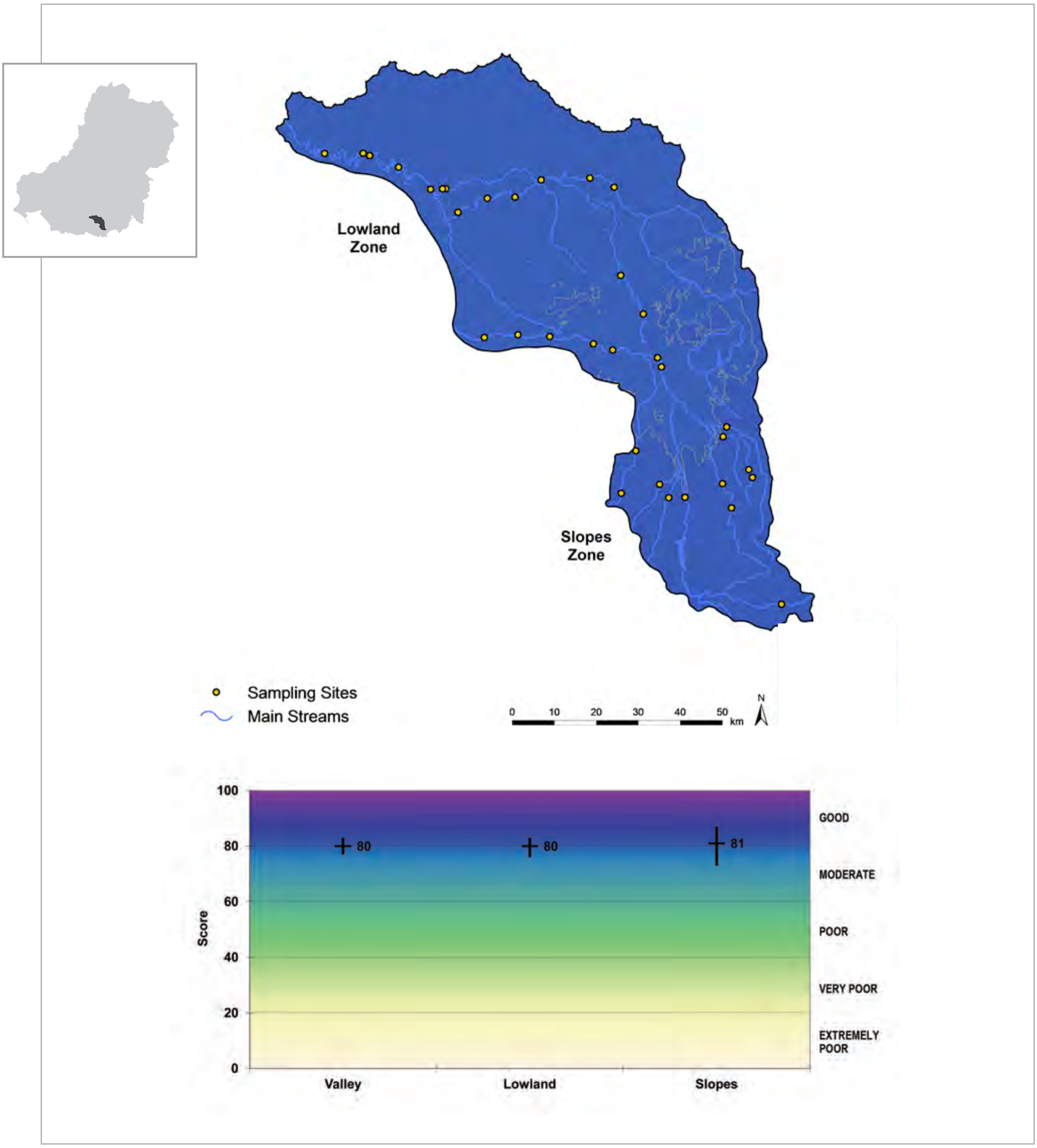

Figure BRK 3: Broken Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.

Graph shows mean SR-MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Broken Valley river system was in Good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 80. Both zones (Lowland and Slopes) were rated in Good condition. The proportion of sites in Good condition was high across both zones (59%). Family richness generally was high, and showed minor reductions compared to Reference Condition.

Thirty-four sites were surveyed across the Broken Valley in the October–November 2008 yielding 6,136 macroinvertebrates in 75 families (80% of Basin families). Analyses showed a minor difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 80 (CL 77–83), indicating Good condition of benthic macroinvertebrate communities.
- The simOE metric = 52 (CL 51–54) indicating a only minor differences from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate or Good condition was high across both zones (91% overall), with 20 of the 34 sites (59%) rated in Good condition (13 of which were in the Lowland zone).
- The number of families found was highest in the Slopes zone (66 families), and this zone had a substantially higher average number of families per site (37) than the Lowland zone (24).

Figure BRK 3 shows sampling sites, zones and SR–MI values, and Table BRK 5 shows Index and metric values. The SR–MI score for the Broken Valley indicated Good condition of macroinvertebrate communities, rating 6th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the both the Slopes and Lowland zones showed minor differences from Reference Condition (SR–MI = 81 and 80, respectively). Small confidence intervals (4 and 7 points) for both zone SR–MI values indicates relatively low spatial variability across the zones. Expectedness (simOE) was relatively high across both zones, varying by up to 18 points among sites.

Table BRK 6 shows that most sites in both zones had high SR–MI values, with only two of the 34 sites rated in Poor condition. No sites had a low simOE score (<40 points). Most sites had all or most expected macroinvertebrates families, though with some reduction in frequency of occurrence.

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Family richness generally was slightly reduced compared to Reference Condition. Diversity was high (average 28 families per site), with the Slopes zone being most diverse (average 37 families per site). The valley contained 80% of the families found across the Basin (Table BRK 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (88%) of the fauna of the valley was found in the Slopes zone, while only 54% of the valley's families were found in the Lowland zone.

Table BRK 5: Broken Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	80 (77–83)	81 (73–87)	80 (76–83)
Metric	SimOE	52 (51–54)	53 (50–56)	52 (50–53)

Table BRK 6: Broken Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone	
		Slopes	Lowland
Sites			
Number of sites sampled	34	11	23
Number of sites with index values*	34	11	23
N sites by SR–MI condition band			
Good (80–100)	20	7	13
Moderate (60–80)	11	2	9
Poor (40–60)	3	2	1
Very or Extremely Poor (0–40)			
Families			
Number of families sampled	75	66	51
No. families/site (min–max)	28 (15–48)	37 (20–48)	24 (15–37)
Percent of families in Basin	80	70	54
Percent of families in valley	100	88	68

*simOE values could occasionally not be derived for every sample site.

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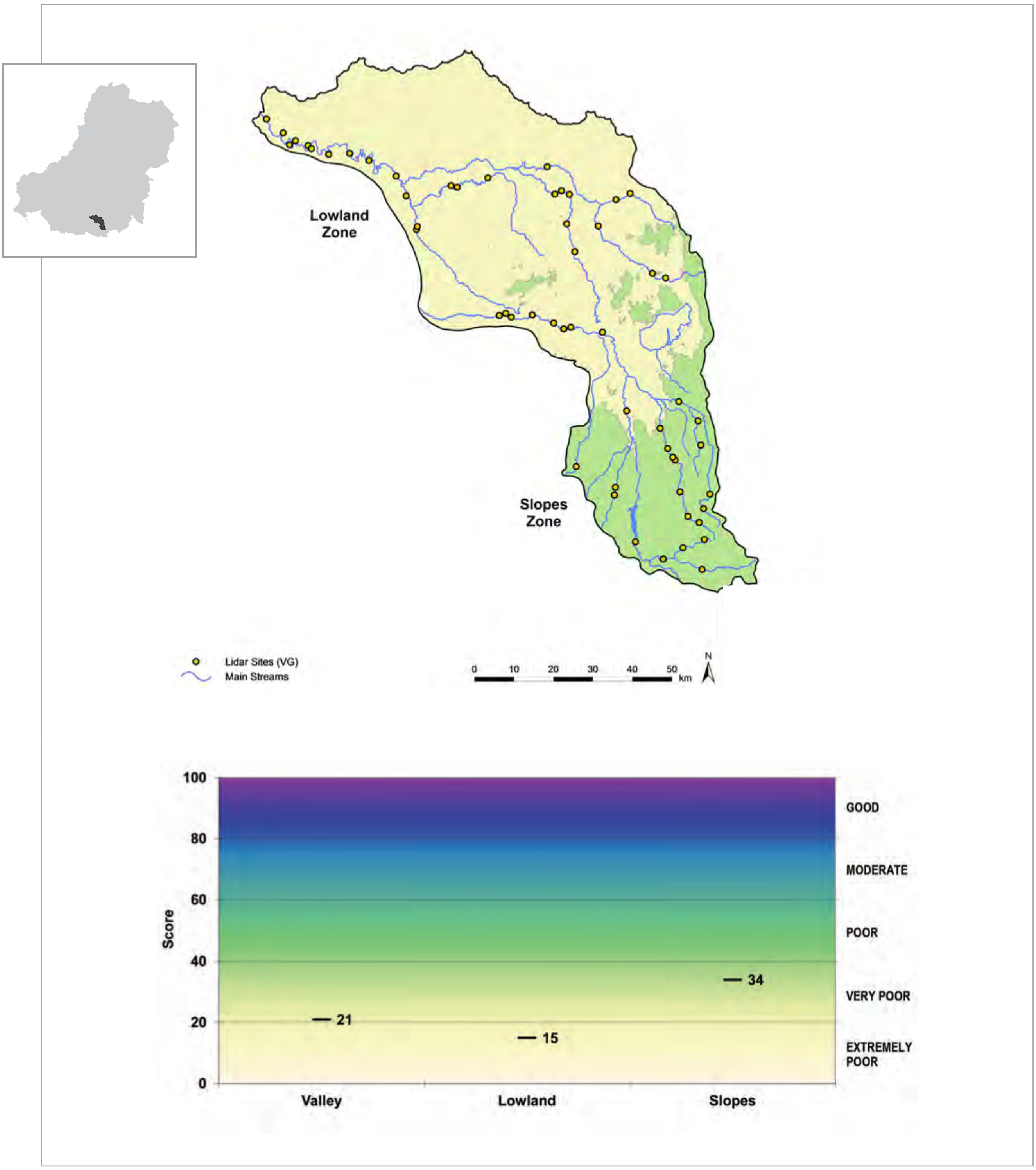

Figure BRK 4: Broken Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Broken Valley river system was in Very Poor condition, with an aggregate Vegetation Index score (SR–VI) of 21. Overall condition for the two zones in this valley was: Slopes Very Poor; Lowland Extremely Poor.

The Abundance and Diversity score was 40 for the valley, indicating a Poor rating overall. In the two zones it was: Slopes Poor; Lowland Very Poor.

The Quality and Integrity score was 35 for the valley, indicating a Very Poor rating overall. In the two zones it was: Slopes Poor; Lowland Very Poor.

The SRA Vegetation assessment for the Broken Valley considers riverine vegetation in two spatial domains: Near Riparian, along 871 km of stream, and Lowland Floodplain, for 172 km^2 of flooding land in the Lowland zone which is part of the floodplain. Most of the stream length (69%) in the valley is in the Lowland zone, and the length of stream assessed per zone is as follows: Slopes, 269 km; and Lowland, 602 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVG) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 56 sites set back 50 m from the top of the bank. LiDAR sites are along the stream network, distributed amongst the two zones as follows: Slopes, 19 sites; and Lowland, 37 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups (MVGs), for an area that is only part of the actual floodplain.

Figure BRK 4 shows values of the Vegetation Index (SR–VI) for the Broken Valley and Table BRK 7 shows the Index, indicator and sub-indicator values. Tables BRK 8 and BRK 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a very large difference from Reference Condition for the Broken Valley with:

- SRA Vegetation Index (SR–VI) = 21, indicating Very Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 40, indicating a large difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 35, indicating a very large difference from Reference Condition for the, structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is moderately affected by clearing. The abundance of major vegetation groups in the sampled area shows a moderate difference from Reference Condition, and the degree of fragmentation shows a large difference.

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The Abundance and Diversity of valley riverine vegetation is in Poor condition overall, with MVGs showing a large difference from Reference Condition in the Slopes zone and a very large difference in the Lowland zone. The Poor rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of major vegetation groups as given in NVIS 3.0. Valley-wide abundance shows a very large difference from Reference Condition in the Near Riparian domain, and a moderate difference in the Lowland Floodplain. MVG richness is maintained and is near reference in the Near Riparian and Lowland Floodplain domains, as no MVG has been completely reduced. Vegetation in the Lowland Floodplain domain has 60% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Very Poor condition overall, showing a large difference from Reference Condition in the Slopes zone and a very large difference from reference in the Lowland zone. The Quality and Integrity indicator is strongly influenced by nativeness, which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table BRK 8 as well as other native but non-specific MVGs. In the Near Riparian domain, nativeness shows a very large difference from reference, and a moderate difference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain domain shows a large difference from reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre-1750s MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain, is in Good condition overall, and the metrics show no loss of any MVG in either of the two zones from the Near Riparian domain, and no loss of any MVG from the Lowland Floodplain domain when mapped at this scale.

Abundance

- The Abundance of pre-1750s MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Very Poor condition overall, and the metrics show differences between zones and domains. Abundance in the Near Riparian domain shows a large difference from Reference Condition in the Slopes zone and an extreme difference in the Lowland zone; and in the Lowland Floodplain domain, it shows a moderate difference from Reference Condition.

Stability

- Floodplain areas within the Lowland Floodplain domain are in Moderate condition, with moderate evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain spatial domain (NRLF) is in Very Poor condition overall, and the metrics show differences between zones and domains. Nativeness in the Near Riparian domain shows a large difference from Reference Condition in the Slopes zone, and an extreme difference in the Lowland zone; and in the Lowland Floodplain domain, nativeness shows a moderate difference from Reference Condition.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with little difference between zones as indicated by the overlapping confidence limits of the sub-indicators. Structure is near Reference Condition in the Slopes zone and moderately different in the Lowland zone. This sub-indicator refers only to the height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of native vegetation is in Poor condition, with extensive patch dissection and clearing. In Eucalypt Woodlands, the number of patches has more than doubled and mean patch area reduced to less than a quarter relative to Reference Condition. Fragmentation is biased as another MVG present, Other Grasslands, Herblands, Sedgelands and Rushlands, has both patch number and size close to reference.

Under Reference Conditions, the riverine vegetation in the Broken Valley was characterised as follows:

- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (50%) and Eucalypt Open Forests (42%) with very small areas of four other MVGs.
- Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (95%) with very small areas of three other MVGs.
- Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (97%) with a small area of one other MVG.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced, and the proportional effect on individual MVGs is quite variable:

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands have been reduced to the extent that they are now only 6% of the domain area, and Eucalypt Open Forests are the most extensive MVG (30%). About 55% of the Slopes Near Riparian is cleared or non-native vegetation. The proportional reduction is greatest in Eucalypt Woodlands and Acacia Forests and Woodlands.
- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands have been reduced and are now 15% of the domain. About 79% of the Lowland Near Riparian is cleared or non-native vegetation. The proportional reduction of all MVGs relative to Reference Condition in this domain is severe, except for Eucalypt Open Forests which is moderately reduced in area.

- Lowland zone: In the Lowland Floodplain domain, although reduced, Eucalypt Woodlands are still the most extensive MVG (57% of the domain). About 36% of the Lowland Floodplain is cleared or non-native vegetation. The proportional reduction in Eucalypt Woodlands area is moderate.

Unlike the other Themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up-to-date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, the on-ground date for the current NVIS 3.0 mapping is 2004, whereas the LiDAR was flown in May 2010. This means that the Structure sub-indicator and three metrics (abundance, richness and nativeness) for the Near Riparian domain are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

Most metrics are based on vegetation mapping. This is not perfectly up-to-date and can be variable in quality. About 3% and 4% of the Near Riparian domain in the Slopes and Lowland zones was not assigned to an MVG. In addition the MVGs were subject to some re-interpretation resulting in an apparent increase in the number of MVGs present in the Lowland zone, and a shift in their identity. For the assessment, these apparent increases were treated as being at Reference Condition. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Broken Valley is notable for its low MVG abundance and low nativeness in the Near Riparian domain, particularly in the Lowland zone, and for having a Lowland Floodplain domain in generally better condition than the Near Riparian domain. These two domains assess differing but slightly overlapping parts of the landscape: the Lowland Floodplain is land that floods near the few main river channels towards the bottom of the valley, whereas the Near Riparian domain is a continuous strip centred on all streams in the zone, and covers a greater area.

The riverine vegetation is in better condition in the Slopes zone than in the Lowland zone, which is in Extremely Poor condition. Because it has considerably more stream length than the Slopes zone, it has a greater influence on the riverine Vegetation Index for the valley.

Table BRK 7: Broken Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.
LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley–scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zones	
			Slopes	Lowland
Index	Vegetation Condition (SR–VI)	21	34	15
Indicator	Abundance and diversity	40	50	35
Metric	LF stability	0.60		0.60
Sub-ind.	NRLF richness	100		100
Metric	NR richness	1	1	1
Metric	LF richness	1		1
Sub-ind.	NRLF abundance	25		25
Metric	NR abundance	0.24	0.40	0.17
Metric	LF abundance	0.64		0.64
Indicator	Quality and integrity	35	49	29
Sub-ind.	NRLF nativeness	25		25
Metric	NR nativeness	0.24	0.40	0.17
Metric	LF nativeness	0.64		0.64
Sub-ind.	NR structure	79 (73–84)	83 (77–87)	78 (70–84)
Sub-ind.	LF fragmentation	44		44

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Table BRK 8: The most abundant MVGs in the Near Riparian domain in the Broken Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone	
	Slopes	Lowland
MVG		
3. Eucalypt Open Forests	42	
5. Eucalypt Woodlands	50	95

Table BRK 9: Most abundant MVGs in the Lowland Floodplain domain in the Broken Valley.
Showing percentage of domain area under Reference Condition and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
5. Eucalypt Woodlands	97	2.67	0.22

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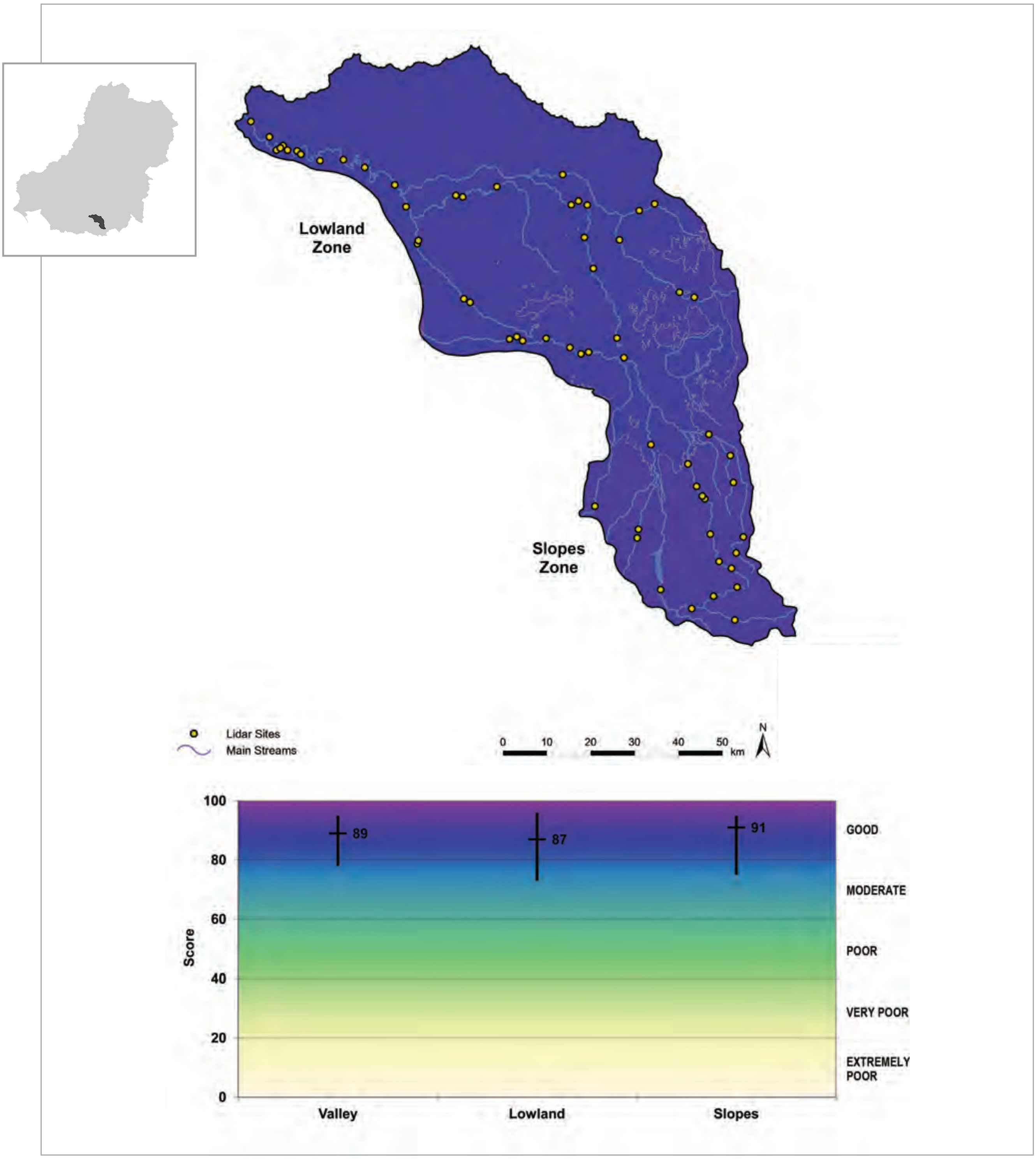

Figure BRK 5: Broken Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Broken Valley river system was rated in Good condition, with an aggregate Physical Form Index score (SR–PI) of 89. The condition of Physical Form in the zones was: Slopes and Lowland Good. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics and Floodplain Form were rated as Moderate. Overall, the valley's physical form was characterised by widespread channel enlargement, particularly in the Slopes zone, and elevated sediment loads since European settlement associated with sedimentation of river channels in the Lowland zone.

The SRA Physical Form assessment considers physical form and processes along 871 km of stream across the valley. It is based on LiDAR data collected at 61 sites along river channels, as well as modelling of all 44 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain Form (see Section 3).

Figure BRK 5 shows values of the Physical Form Index (SR–PI) for the Broken Valley and Table BRK 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a near Reference Condition for the Broken Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 89 (CL 78–95), indicating good Physical Form condition
- the Channel Form indicator = 82 (CL 74–87), showing near Reference Condition
- the Bed Dynamics indicator = 63 (CL 56–69), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 96 (CL 91–99), showing near Reference Condition
- the Floodplain indicator = 78 (CL 65–89), showing a moderate difference from Reference Condition.

Slopes zone

There were 19 LiDAR survey sites and 7 SedNet river segments in the Slopes zone of the Broken Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width and Bank Variability were modified from reference in more than half of the Slopes zone. At these sites Channel Width was generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Depth, Sinuosity and Meander Wavelength were modified from reference for less than half of the Slopes zone. At these sites Channel Depth and Meander Wavelength were generally increased (many sites having large increases), Sinuosity was generally reduced. Channel Width Variability and Channel Sediment Deposition were largely unmodified from reference in the Slopes zone. Field observations support the assessment that channels in the Slopes zone have widened and deepened, with larger streams filled by slugs of sand (Rutherfurd, pers. comm.).

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Lowland zone

There were 42 LiDAR survey sites and 37 SedNet river segments in the Lowland zone of the Broken Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width and Channel Depth were modified from Reference Condition in more than half of the Lowland zone. At these sites Channel Width was generally increased (a few sites having large increases) and results show both increases and decreases in Channel Depth across the zone. Bank Variability was modified from reference for approximately half of the Lowland zone. At these sites Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability, Sinuosity, Meander Wavelength and Channel Sediment Deposition were modified from reference for less than half of the Lowland zone. At these sites Channel Width Variability was generally reduced (with a large reduction at over half of these sites), Sinuosity was generally reduced, Meander Wavelength was generally increased (many sites having large increases) and there was a large increase in Channel Sediment Deposition across 30% of the zone for the post-European period. These results are generally consistent with field observations (Rutherfurd, pers. comm.; GBCMA, 2005).

Channel Form

There was little change from Reference Condition in Channel Form in the Slopes zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 70% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Lowland zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Slopes and Lowland zones. Bank variability exceeded Reference Conditions at 50% of sites. Elevated Bank Variability may indicate accelerated erosion of stream banks, and this is supported by field observations (Rutherfurd, pers. comm.).

There was minor change from Reference Condition in Bed Dynamics in the Slopes zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was minor change from Reference Condition in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (40% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Lowland zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Field observations suggest that smaller channels are eroding and liberating coarse sediment that is stored in the beds of larger streams (Rutherfurd, pers. comm.). Local knowledge is required to resolve these conflicting results.

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was little change in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (100% of SedNet river segments). There was minor change in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (90% of SedNet river segments).

Table BRK 10: Broken Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zones	
			Slopes	Lowland
Index	Physical Form Condition (SR-PI)	89 (78–95)	91 (75–95)	87 (73–96)
Indicator	Channel Form (volume and flow events)	82 (74–87)	84 (72–93)	81 (71–88)
Sub-ind.	Cross-section Form	83 (77–87)	79 (66–88)	84 (79–88)
Metric	Channel Depth (mean)	1.04 (0.97–1.12)	1.15 (1.04–1.31)	0.99 (0.90–1.06)
Metric	Channel Width (mean)	1.23 (1.16–1.31)	1.36 (1.21–1.57)	1.18 (1.12–1.25)
Sub-ind.	Cross-section Form (variability)	87 (77–93)	100 (100–100)	81 (67–90)
Metric	Channel Width (CV)	0.92 (0.87–0.96)	1.00 (1.00–1.00)	0.89 (0.81–0.94)
Sub-ind.	Channel Planform	87 (81–92)	87 (76–96)	87 (80–94)
Metric	Sinuosity	0.99 (0.97–1.02)	1.00 (0.97–1.04)	0.99 (0.97–1.03)
Metric	Meander Wavelength	1.03 (0.98–1.07)	1.06 (1.00–1.13)	1.02 (0.95–1.06)
Indicator	Bed Dynamics	63 (56–69)	67 (55–70)	61 (53–70)
Metric	Channel Sediment Ratio	73 (54–93)	48 (24–77)	84 (61–113)
Metric	Channel Sediment Depth	0.002 (0.001–0.004)	0.001 (0–0.007)	0.002 (0.001–0.003)
Indicator	Bank Dynamics	96 (91–99)	98 (96–100)	95 (88–99)
Metric	Bank variability (longitudinal)	1.07 (1.03–1.12)	1.11 (1.05–1.21)	1.06 (1.00–1.11)
Indicator	Floodplain	78 (65–89)	85 (66–92)	75 (59–91)
Metric	Floodplain Sediment Deposition	2.00 (1.20–3.00)	1.51 (1.07–3.00)	2.00 (1.08–4.00)

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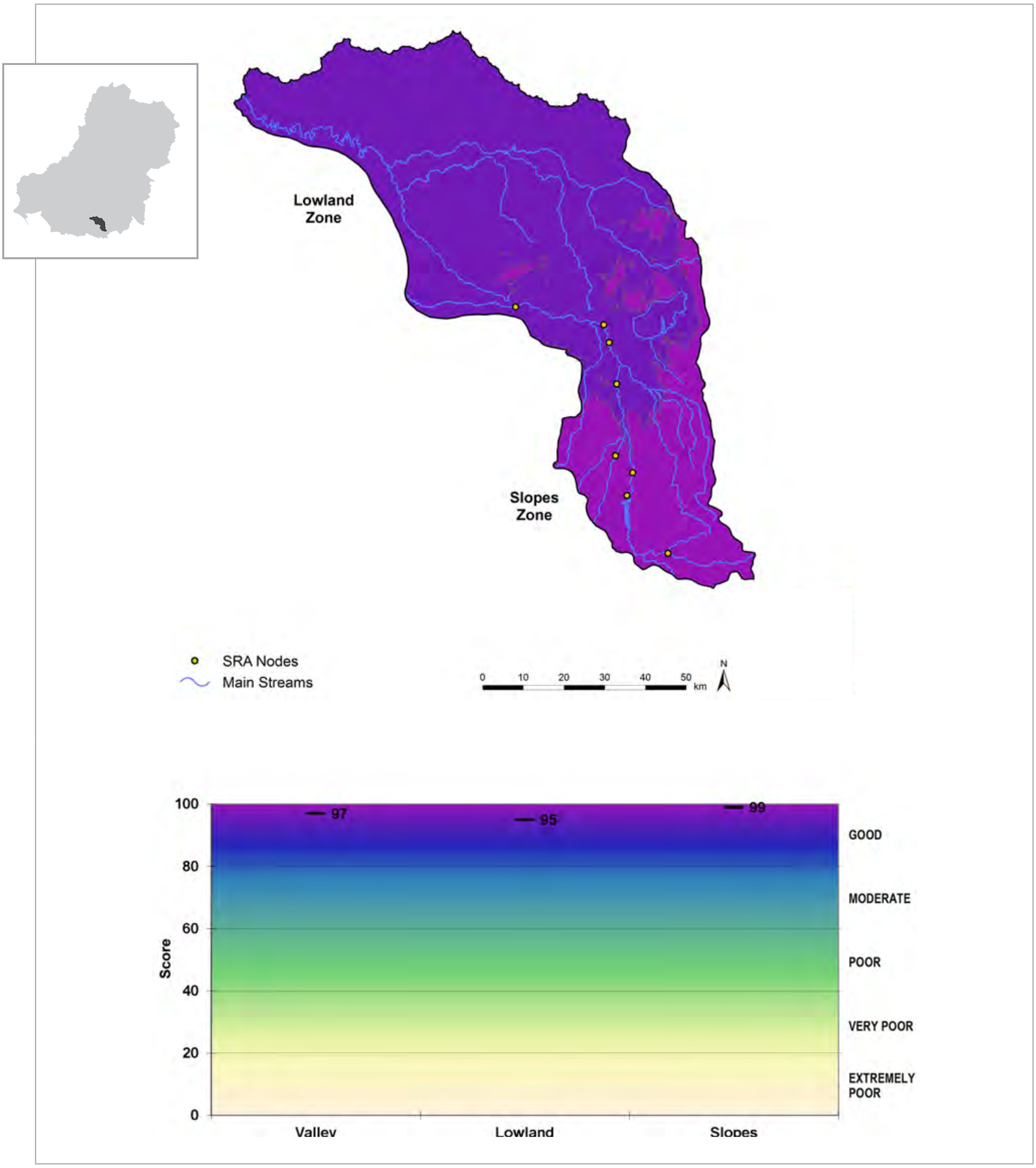

Figure BRK 6: Broken Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Broken Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 99. The Lowland and Slopes zones were in Good condition.

The mainstem river system of the Broken Valley was rated in Good condition. Throughout much of the mainstem river system the magnitude of low flows was altered relative to Reference Condition, with both increased and reduced magnitudes in different reaches, and the timing of seasonal flow variations was altered.

The headwater streams of the Broken Valley were rated in Good condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased and the magnitude of low flows was reduced relative to Reference Condition.

The Broken River rises in the Great Dividing Range east of Mansfield and flows west then north to Benalla, then west to join the Goulburn River above Shepparton. A substantial distributary, Broken Creek, flows north-west from the river downstream of Benalla, joining the Murray at the downstream end of Barmah Forest. There is one instream storage, Lake Nillahcootie (40 GL). Lake Mokoan, a wetland near Benalla, has been used as an offstream storage (26 GL) to augment irrigation diversions in summer and autumn, but is now decommissioned. Water is diverted into Broken Creek to enhance irrigation and stock and domestic supplies.

In the Broken Valley, hydrological condition is assessed using metrics of hydrological alteration available for 720 km of mainstem rivers and headwater streams. There are 137 km of mainstem river extending across the Lowland and Slopes zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by monthly water resource modelling. It is not possible to calculate the Over Bank Flow metrics, the High Flow Spells metric or the Low Flow Spells using monthly data. Consequently, these metrics have not been included in the analysis for this valley. There is 583 km of headwater stream with 244 km in the Slopes zone and 338 km in the Lowland zone. In these headwater streams, hydrological metrics represent the effects of farm dams and tree cover change since European settlement.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Broken Valley there are 643 km (40 km in the Slopes zone; 603 km in the Lowland zone) of these mid-size tributaries, 0.9 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures BRK 6 and BRK 7 show values of the Hydrology Condition Index (SR–HI) for the Broken Valley and its river network, and Table BRK 11 and BRK 12 show the Index, sub-index, indicator and

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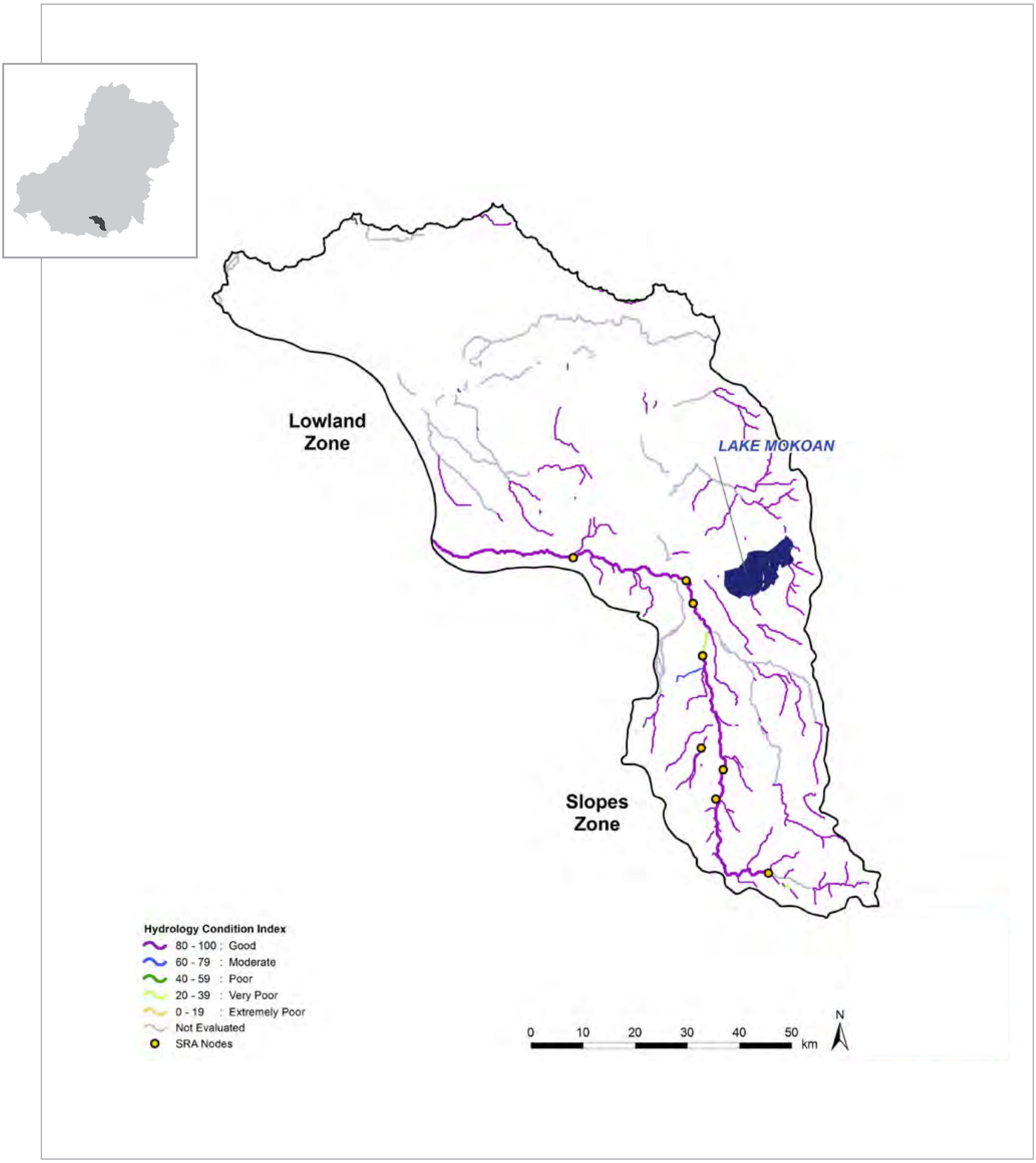

Figure BRK 7: Broken Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

metric values. Analyses showed near Reference Condition for the Broken Valley, with:

- The Hydrology Condition Index for the whole valley = 97, indicating Good hydrological condition.
- The Hydrology Condition Index for the Slopes and Lowland zones = 99 and 95, both indicating Good hydrological condition.
- The Hydrology Condition Index for headwater streams (valley-wide) = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 97, indicating Good hydrological condition.
- The In-Channel Flow Regime indicator in the mainstem river reaches = 97, indicating Good condition and near Reference Condition for the flow regime within the channels.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a significant alteration from reference in 4% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Slopes zone and most in the Lowland zone. In addition, results for the Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to Reference Condition.

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 4% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Slopes zone and most in the Lowland zone. The High Flow Spells metric could not be calculated for this valley.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a significant alteration from reference in 23% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

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Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 33% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 41% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Slopes zone and most in the Lowland zone. Results for the Zero Flows Proportion metric showed a significant alteration from reference in 4% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Slopes zone and most in the Lowland zone. The Low Flow Spells metric could not be calculated for this valley.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with reduced flows) and a significant alteration from reference in 25% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a significant alteration from reference in 4% of the mainstem river length (mostly associated with a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Slopes zone and most in the Lowland zone. Results for the Seasonal Period metric showed a significant alteration from reference in 70% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with a small portion in the Slopes zone and most in the Lowland zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 3% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 47% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed only small variations from Reference Condition throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 4% of the mainstem river length (mostly associated with increased variability). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Slopes zone and most in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 9% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and most in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Broken Valley was generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume relative to Reference Condition. Throughout much of the mainstem river system the magnitude of low flows was altered with both increased and reduced magnitudes in different reaches, and the timing of seasonal flow variations was altered.

Summary: headwater streams

The headwater streams of the Broken Valley were generally characterised by little or no alteration relative to Reference Condition in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased. The magnitude of low flows was significantly altered relative to Reference Condition in 25% of headwater streams.

Table BRK 11: Broken Valley: SRA Hydrology Condition Index at valley and zone scales.
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	97			99	95

BROKEN VALLEY

Table BRK 12: Broken Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.
(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HIh)**	**97 (21–100)**	**99 (38–100)**
Sub-index	In-Channel Flow Regime	97 (21–100)	99 (38–100)
Indicator	In-Channel Flow Regime A (volume and flow events)	**96 (52–100)**	**100 (76–100)**
Sub-ind.	Flow Gross Volume	99 (80–100)	98 (91–100)
Metric	Mean Annual Flow	0.96 (0.70–1.00)	1.05 (0.87–1.17)
Metric	Flow Duration	1.01 (0.95–1.04)	1.01 (0.89–1.15)
Sub-ind.	High Flow Events	97 (67–100)	98 (73–100)
Metric	High Flow	0.89 (0.47–1.00)	1.12 (0.83–1.63)
Metric	High Flow Spells		
Sub-ind.	Low and Zero Flow Events	85 (49–99)	96 (57–99)
Metric	Zero Flows Proportion	1.01 (0.78–1.04)	0.98 (0.96–1.01)
Metric	Low Flow	1.12 (0.22–1.61)	0.96 (0.26–1.39)
Metric	Low Flow Spells		
Indicator	In-Channel Flow Regime B (seasonality & variability)	**94 (25–100)**	**96 (33–100)**
Sub-ind.	Flow Seasonality	81 (60–100)	91 (66–100)
Metric	Flow Seasonal Amplitude	0.91 (0.53–1.00)	1.22 (0.90–1.64)
Metric	Flow Seasonal Period	0.76 (0.61–1.00)	0.96 (0.86–1.00)
Sub-ind.	Flow Variability	94 (30–100)	88 (33–100)
Metric	Flow Variation	1.07 (1.00–1.11)	0.91 (0.67–1.00)
Sub-Index	Over Bank Flow Regime	Not assessed	
Indicator	**Over Bank Floods Low**		
Metric	OB Flow Duration (ARI 1)		
Metric	OB Flow Spells (ARI 1)		
Indicator	**Over Bank Floods High**		
Metric	OB Flow Duration (ARI 8)		
Metric	OB Flow Spells (ARI 8)		

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
		100	**95**			**99**
		100	95			99
		100	**95**			**100**
		100	98			99
		1.00	0.95			1.05
		1.00	1.01			1.03
		100	96			98
		0.99	0.86			1.14
		98	80			96
		1.00	1.02			0.99
		1.04	1.15			1.03
		99	**92**			**98**
		97	75			92
		0.99	0.88			1.20
		0.97	0.68			0.98
		100	92			95
		1.00	1.10			0.96

CAMPASPE VALLEY

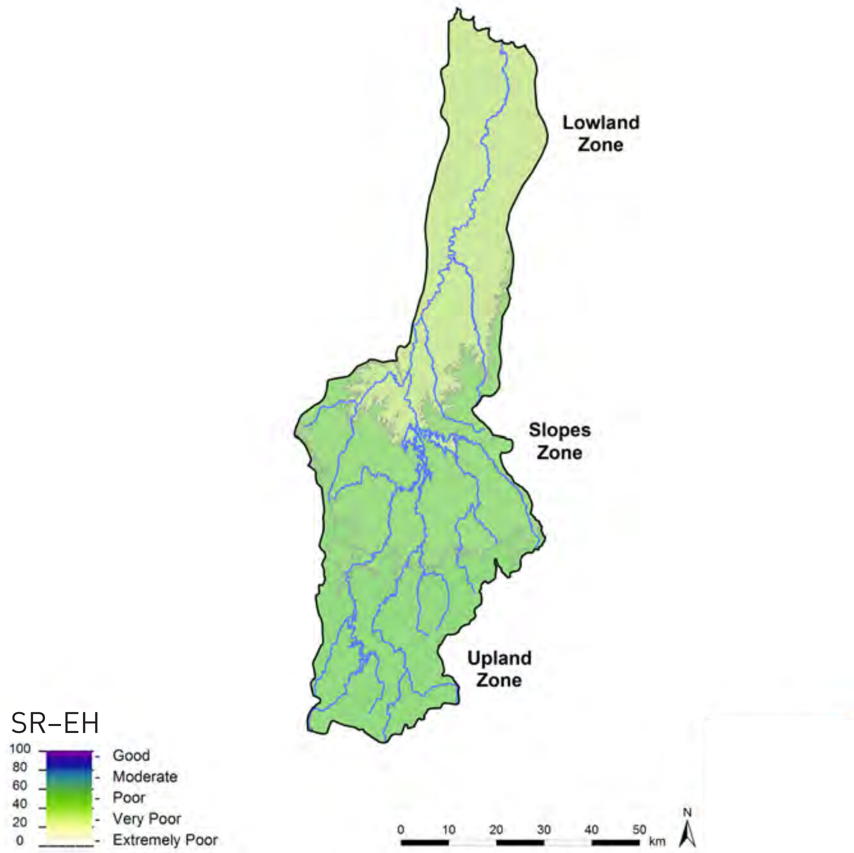

Figure CMP 1: Campaspe Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure CMP 1 shows the Ecosystem Health ratings for the Campaspe Valley and Table CMP.1 and CMP.2 also show the Index values and ratings for each theme. Ecosystem Health shows a very large difference from Reference Condition for the Campaspe Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Very Poor, Moderate and Extremely Poor condition respectively, while Physical Form and Hydrology were both in Moderate condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG assessed the Ecosystem Health of the Campaspe Valley river system. River Ecosystem Health was rated as Very Poor (Lowland zone: Very Poor; Slopes zone: Very Poor; Upland zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Campaspe Valley river ecosystem was in Very Poor health. River Ecosystem Health for the zones was as follows: Upland and Lowland Very Poor; Slopes Very Poor. The Fish community was in Very Poor condition. Many expected species were absent. Species counts, abundance and biomass were dominated by alien species and recruitment levels among the remaining native species were low. The Macroinvertebrate community was in Moderate condition, with small to moderate declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Extremely Poor condition overall; with reduced richness, abundance and nativeness in the Near Riparian domains. The Physical Form of the river system was in Moderate condition overall with bank dynamics in Good condition and channel form and bed dynamics in Moderate condition. There were high levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition; with changes in variability, seasonality and low and zero flows of mainstem rivers relative to Reference Condition.

Ecosystem Health

River Ecosystem Health was rated as Very Poor for the Campaspe Valley (see Table 5.2) indicating a very large difference from Reference Condition in the biotic component of the valley's river ecosystem. The Campaspe was in the lower 50% for all Themes except Macroinvertebrates, for which it ranked 11th of the 23 valleys.

At the time of sampling for fish (2009) and macroinvertebrates (2008) the valley had experienced some 10 years of very low rainfall which, amongst other things, had resulted in extended periods of low to zero flow (and severe curtailment of irrigation diversions). The effect of these conditions on longitudinal connectivity and refugial reaches is exacerbated by physical barriers in the lower reaches (SKM 2006), the influence of regional drainage on the quality of remaining pools (salinity, nutrient enrichment), and channel simplification and sedimentation. Dense stands of Typha and Phragmites have been reported (Cottingham *et al*. 2008), as possible indications of degraded conditions, particularly in pools, in lowland reaches, however these may be providing favourable habitat for macroinvertebrates despite drought conditions.

In all, the Campaspe Valley ecosystem shows signs of being in a refugial state, in response to extended drought, and threatened by impacts related to river and catchment management. The degree to which these impacts limit the capacity of the system to respond to more favourable climatic conditions may become apparent when analyzing data collected following the extensive rainfall in 2010–2011.

Fish Theme

The Fish Condition Index SR–FI = 20, indicating Very Poor condition (Lowland zone: Extremely Poor; Slopes zone: Very Poor; Upland zone: Very Poor). The Expectedness indicator = 17, indicating Extremely Poor condition, and an extreme difference from Reference Condition. The Nativeness indicator = 42, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 49, indicating Poor condition, and a large difference from Reference Condition.

CAMPASPE VALLEY

The fish community of the Campaspe had reduced numbers of expected native species and low numbers and biomass amongst those native fish populations present. Alien species comprised over 90% of the biomass. Native fish recruitment was Poor, Moderate and Extremely Poor in the Upland, Slopes and Lowland zones respectively. Large-bodied native fish were few, and showed no evidence of recruitment.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 72, indicating Moderate condition (Lowland zone: Good; Slopes zone: Moderate; Upland zone: Moderate). The simOE metric = 49 indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Moderate condition was high (57%) across all zones, and eight of the 33 sites (23%) were rated in Good condition.

Family richness generally was moderate, and was reduced compared to Reference Condition with Lowland zone site communities being the most diverse.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 18, indicating Extremely Poor condition (Lowland zone: Very Poor; Slopes zone: Extremely Poor; Upland zone: Very Poor). The Vegetation Abundance and Diversity indicator = 35, indicating Very Poor condition and a very large difference from Reference Condition for the abundance and richness of vegetation groups in the Near Riparian domain. The Vegetation Quality and Integrity indicator = 36, indicating Very Poor condition and a very large difference from Reference Condition for the structure and nativeness of communities and vegetation groups in the Near Riparian domain.

The Lowland Floodplain domain was not assessed in the Campaspe Valley.

Physical Form Theme

The Physical Form Condition Index SR–PI = 77, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Good; Upland zone: Good). The Channel Form indicator = 75, the Bed Dynamics indicator = 60 and the Floodplain Form indicator = 68; all indicating Moderate condition and moderate differences from Reference Condition. The Bank Dynamics indicator = 98, indicating Good (near Reference) Condition.

Overall, the valley's riverine physical form was characterised by channel enlargement and simplification. There was also indication of elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain.

Hydrology Theme

The Hydrology Condition Index SR–HI = 64, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Poor; Upland zone: Good). The In-Channel Flow Regime indicator = 55, indicating Poor condition and a major difference from Reference Condition for the flow regime within the channels.

The mainstem river reaches were generally characterised by considerable alteration in Flow Seasonality, moderate alteration in Flow Variability and Low and Zero Flow Events and little or no alteration in High Flow Events and Flow Gross Volume. The headwater streams were generally characterised by little or no alteration in any of these indicators.

Table CMP 1: Campaspe Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	UPLAND	SLOPES	LOWLAND
		Very Poor	Poor	Very Poor	Very Poor

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	20 (8–25) Very Poor	34 (10–50) Very Poor	26 (4–36) Very Poor	3 (1–7) Extremely Poor
Macro-invertebrates	SCORE RATING	72 (69–75) Moderate	61 (54–66) Moderate	72 (68–77) Moderate	80 (75–84) Good
Vegetation	SCORE RATING	18 Extremely Poor	22 Very Poor	13 Extremely Poor	21 Very Poor

Table CMP 2: Campaspe Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	77 (68–85) Moderate	82 (76–93) Good	82 (75–92) Good	67 (46–84) Moderate
Hydrology	SCORE RATING	64 Moderate	90 Good	51 Poor	61 Moderate

CAMPASPE VALLEY

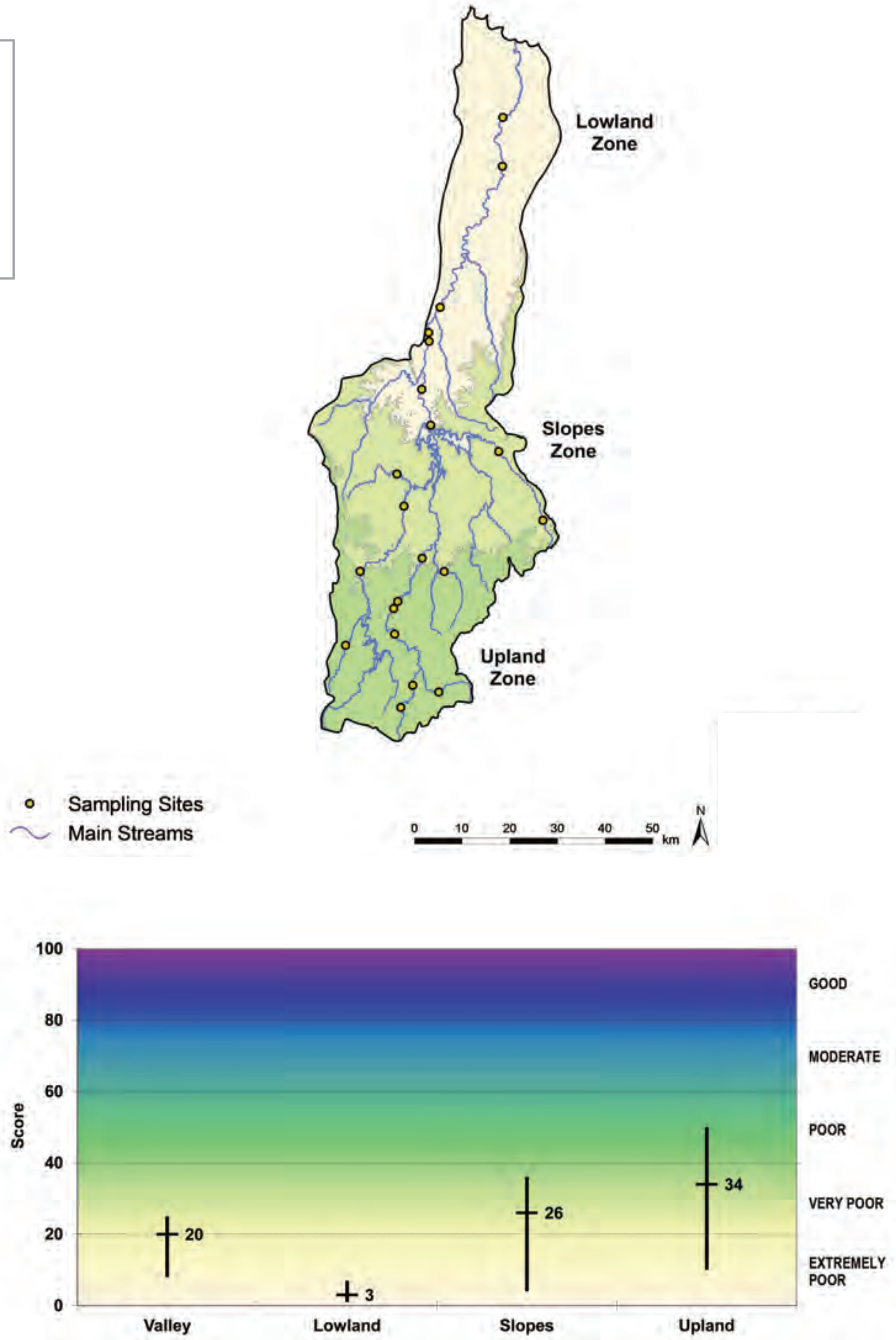

Figure CMP 2: Campaspe Valley map with sampling sites and zones coloured by SRA Fish Index (SR-FI) scores.

Graph shows mean SR-FI scores as horizontal bars and 95% confidence limits as vertical bars.

The fish community of the Campaspe Valley river system was in Very Poor condition, with an aggregate Fish Index score (SR–FI) of 20. The condition of the fish community in the zones was as follows: Upland and Slopes Very Poor, and Lowland Extremely Poor. The fish community was characterised by an Extremely Poor score for expected native fish species, a Poor score for nativeness and a Poor score for native fish recruitment. The Lowland zone in particular had few fish and lacked 76% of the predicted native species. The valley had lost much of its native species richness, and alien species contributed over 90% of the biomass in samples. Native fish recruitment was Poor, Moderate and Extremely Poor in the Upland, Slopes and Montane zones respectively.

Twenty-one sites were surveyed across the Campaspe Valley in November–December 2009, yielding 1,544 fish. Analyses showed a very large difference from Reference Condition for the Campaspe Valley, with:

- SRA Fish Index (SR–FI) = 20 (CL 8-25), indicating Very Poor condition of the fish community.
- the Expectedness indicator = 17 (CL 12-23), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Only 41% of fish species expected under Reference Condition were recorded.
- the Nativeness indicator = 42 (CL 26-56), indicating Poor condition, and a large difference from Reference Condition.
- the Recruitment indicator = 49 (CL 20–59), indicating Poor condition, and a large difference from Reference Condition. Evidence of recruitment was observed for 5 of the 9 native species observed in the valley.

Figure CMP. 2 shows sampling sites, zones and corresponding SR–FI values, and Table CMP.3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Campaspe Valley was below the average for all valleys, and close to that for the Avoca, Murray (Central and Upper) valleys. The Lowland zone community was in much worse condition (SR–FI = 3) than that in the Slopes or Upland zones (SR–FI = 26 and 34 respectively).

Expectedness was lower in the Slopes and Lowland zones (10 and 7 respectively) than it was in the Upland zone (38). Nativeness was similar in all three zones, but Recruitment was much lower in the Lowland zone (12) than in the Slopes (79) or Upland (58) zones.

The number of fish caught per site was 73.5, twelfth highest amongst the 23 valleys. Only 19% of these belong to native species (14.2 native fish/site – third lowest amongst the 23 valleys) and their combined biomass was equal to just 7% of the total fish biomass (443 g/site – the fourth lowest).

CAMPASPE VALLEY

Table CMP. 4 shows native species abundances in the Campaspe Valley compared with Reference Condition. Only Australian smelt, amongst the native species, occurred in every zone in which it was expected and this and other small-bodied native fish were in small numbers relative to small-bodied alien species. Freshwater catfish, Macquarie perch, river blackfish, silver perch, and trout cod were all expected to occur in the Campaspe Valley under Reference Condition but were not captured during the sampling and only one specimen of Murray cod was caught. Most of the native fish captured were small-bodied species and their mean biomass was less than a tenth of that of the alien fish. Over all, common carp constituted 67% of fish biomass in the Campaspe Valley. This is second only to the Avoca Valley at 86%. In the Lowland zone common carp constitute 85% of fish biomass.

Only two out of the five native species observed in the Lowlands zone, Australian smelt and gudgeon, exhibited some indication of recruitment, whilst in the Slopes zone all three native species present were considered to be recruiting. No large-bodied native fish were considered to be recruiting throughout the Campaspe Valley.

In general, the fish community of the Campaspe had reduced numbers of expected native species and low numbers and biomass amongst those native fish populations present. Large-bodied native fish were few, and showed no evidence of recruitment.

Table CMP 3: Campaspe Valley SRA Fish Condition Index, indicators, metrics and derived variables.
Values for Index and indicators are means (lower – upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	20 (8–25)	34 (10–50)	26 (4–36)	3 (1–7)
Indicator	Expectedness	17 (12–23)	38 (26–61)	10 (8–19)	7 (4–11)
Metric	O/E	0.22 (0.12–0.32)	0.32 (0.06–0.65)	0.15 (0.03–0.29)	0.21 (0.12–0.28)
Metric	O/P (Zone level)	0.35 (0.35–0.35)	0.50 (0.50–0.50)	0.33 (0.33–0.33)	0.24 (0.24–0.24)
Indicator	Nativeness	42 (26–56)	40 (7–64)	47 (14–75)	39 (23–59)
Metric	Proportion biomass native	0.34 (0.18–0.54)	0.34 (0.05–0.71)	0.43 (0.14–0.86)	0.26 (0.06–0.54)
Metric	Proportion abundance native	0.44 (0.27–0.62)	0.40 (0.11–0.73)	0.43 (0.14–0.86)	0.49 (0.26–0.71)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Metric	Proportion species native	0.43 (0.27–0.60)	0.39 (0.10–0.72)	0.43 (0.14–0.86)	0.47 (0.30–0.59)
Indicator	Recruitment	49 (20–59)	58 (10–85)	79 (20–100)	12 (3–22)
Metric	Proportion of sites with native recruits	0.47 (0.22–0.56)	0.61 (0.12–0.74)	0.61 (0.14–0.86)	0.20 (0.082–0.32)
Metric	Proportion of native taxa with recruits	0.72 (0.60–0.82)	0.75 (0.50–1.00)	1.00 (1.00–1.00)	0.40 (0.25–0.50)
Metric	Proportion of abundance as recruits	0.64 (0.48–0.78)	0.59 (0.29–1.00)	0.90 (0.61–1.00)	0.40 (0.25–0.50)
Variables					
	Number of sites sampled	21	7	7	7
	Total number of species	15	9	7	9
	Number of native species	9	5	3	5
	Number of predicted species	22	8	9	21
	Number of alien species	6	4	4	4
	Mean number of fish per site	73	33	166	22
	Biomass/site all species (g)	6352	3671	1696	13688
	Mean native biomass/fish (g)	31	2	0.40	121
	Mean alien biomass/ fish (g)	100	160	12	1112

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Table CMP 4: Campaspe Valley number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	valley	Zone		
		Upland	Slopes	Lowland
Sites sampled	21	7	7	7
Native species				
Australian smelt	146		135	11
Bony herring	0			0
Congolli	0			0
Dwarf flathead gudgeon	0			0
Flathead gudgeon	55	8	0	47
Freshwater catfish	0		0	0
Golden perch	5		0	5
Gudgeon	11			11
Macquarie perch	0	0	0	0
Mountain galaxias	45	45		
Murray cod	1	0	0	1
Murray hardyhead	0			0
Murray jollytail	0			0
Muray–Darling rainbowfish	0			0

Fish species	valley	Zone		
		Upland	Slopes	Lowland
Obscure galaxias complex	17	1	16	0
River blackfish	0	0	0	0
Shortheaded lamprey	0			0
Silver perch	0		0	0
Southern purple-spotted gudgeon	0			0
Southern pygmy perch	17	12	5	0
Spotted galaxias	2	2		
Troud cod	0	0	0	0
Unspecked hardyhead	0			0
Alien species	0			0
Common carp	71		18	53
Crucian carp	1	1		
Gambusia	1015	42	966	7
Goldfish	5			5
Redfin perch	105	79	13	13
Tench	48	42	6	

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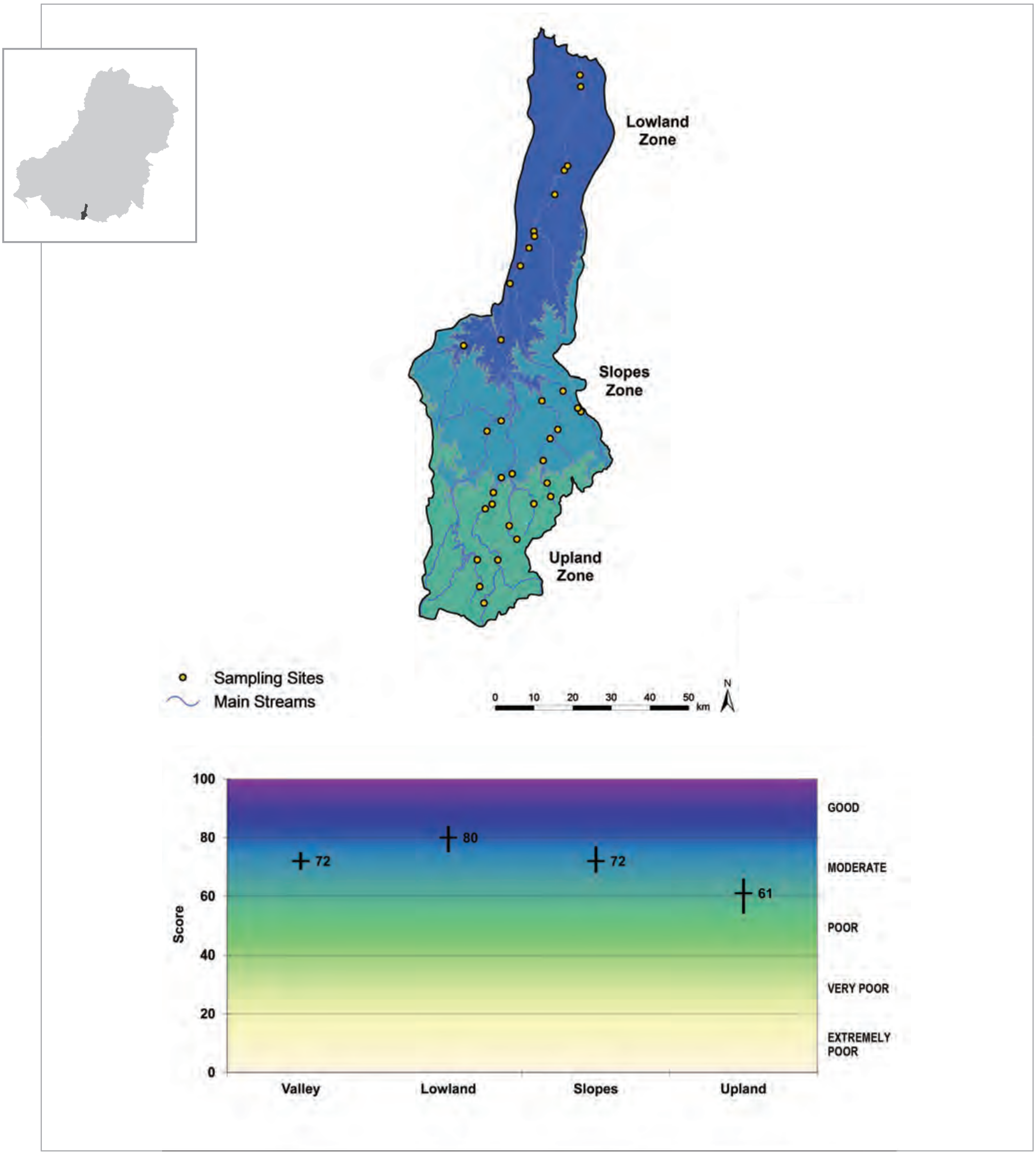

Figure CMP 3: Campaspe Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.

Graph shows mean SR-MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Campaspe Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 72. The condition of the macroinvertebrate community in the zones was as follows: Upland Moderate; Slopes Moderate; Lowland Good. The proportion of sites in Moderate condition was high across all zones (57% overall), and nine of the 35 rated sites (26%) were rated in Good condition. Family richness generally was moderate, and was reduced compared to Reference Condition.

Thirty-five sites were surveyed across the Campaspe Valley in October 2008 yielding 5,685 macroinvertebrates in 49 families (52% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 72 (CL 69–75), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 49 (CL 48–50) indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate condition was high (57%) across all zones, and nine of the 35 sites (26%) were rated in Good condition (seven of which were in the Lowland zone).
- The number of families found was lowest in the Upland zone (33 families) with 40 families found in each of the remaining two zones, with the Lowland zone having the highest average number of families per site (24).

Figure CMP. 3 shows sampling sites, zones and SR–MI values, and Table CMP. 5 shows Index and metric values. The SR–MI score for the Campaspe Valley indicated Moderate condition of macroinvertebrate communities, rating 11th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Upland and Slopes zones showed moderate differences from Reference Condition (SR–MI = 61 and 72, respectively), with the Upland zone falling close to the boundary between Moderate and Poor condition. The Lowland zone was rated as being near to Reference Condition overall, but fell on the boundary between Moderate and Good condition (SR–MI = 80). A high proportion (seven of 13 sites) in the Lowland zone had SR–MI scores ranging from 81 to 92 and rated in Good condition. Variability across the three zones was similar and low, with confidence interval ranges of 9–12. Expectedness (simOE) was Moderate to Good, and varied by up to 27 points among sites.

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Table CMP. 6 shows that the majority of sites in all zones had moderate to high SR–MI values, with nine sites rated in Good condition (though mainly in the lower range). Only one site, in the Upland zone, had a low simOE score (<40 points), and fell at the boundary between Very Poor and Poor condition. Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present. In the Lowland zone communities were mostly affected by reductions in frequency of occurrences rather than loss of excepted families.

Family richness generally was reduced compared to Reference Condition. Diversity was moderate (average 21 families per site), with Lowland zone sites being most diverse (average 24 families per site). The valley contained 52% of the families found across the Basin (Table CMP.6), with the Upland zone having the lowest representation of Basin-wide fauna. Most (82%) of the fauna of the valley was found in both the Slopes and Lowland zones.

Table CMP 5: Campaspe Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower – upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	72 (69–75)	61 (54–66)	72 (68–77)	80 (75–84)
Metric	SimOE	49 (48–50)	44 (42–46)	49 (47–51)	52 (50–55)

Table CMP 6: Campaspe Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone		
		Upland	Slopes	Lowland
Sites				
Number of sites sampled	35	11	11	13
Number of sites with index values*	35	11	11	13
N sites by SR–MI condition band				
Good (80–100)	9		2	7
Moderate (60–80)	20	6	8	6
Poor (40–60)	6	5	1	
Very or Extremely Poor (0–40)				
Families				
Number of families sampled	49	33	40	40
No. families/site (min–max)	21 (11–41)	16 (12–17)	22 (14–41)	24 (11–34)
Percent of families in Basin	52	35	43	43
Percent of families in valley	100	67	82	82

*simOE values could occasionally not be derived for every sample site.

CAMPASPE VALLEY

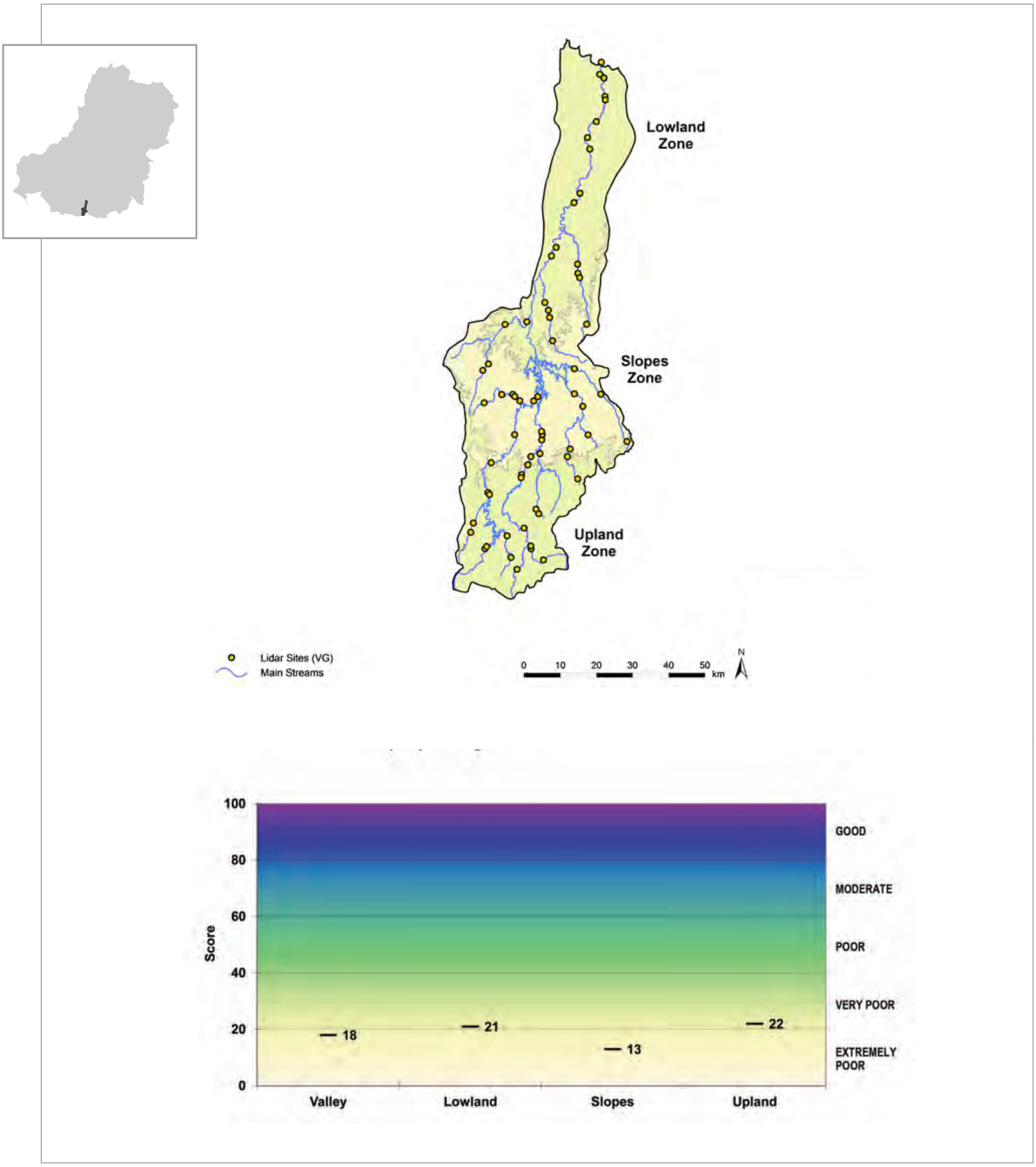

Figure CMP 4: Campaspe Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Campaspe Valley river system was in Extremely Poor condition, with an aggregate Vegetation Index score (SR–VI) of 18. Overall condition for the three zones in this valley was: Upland Very Poor; Slopes Extremely Poor; Lowland Very Poor.

The Abundance and Diversity score was 35 for the valley, indicating Very Poor condition overall. In the three zones it was: Upland Very Poor; Slopes Very Poor; Lowland Very Poor.

The Quality and Integrity Score was 36 for the valley, indicating Very Poor condition overall. In the three zones it was: Upland Very Poor; Slopes Very Poor; Lowland Very Poor.

The SRA Vegetation assessment for the Campaspe Valley considers riverine vegetation in one spatial domain only: Near Riparian, along 697 km of stream. Most (38% and 36%) of the stream length is in the Lowland and Slopes zones, and the length of stream assessed per zone is as follows: Upland, 182 km; Slopes, 251 km; and Lowland, 264 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVG) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 65 sites set back 50 m from the top of the bank. LiDAR sites are distributed amongst the three zones as follows: Upland, 18 sites; Slopes, 22 sites; and Lowland, 25 sites. There is no assessment of a Lowland Floodplain domain because the area identified as inundated within the Lowland zone from the existing GIS layer was considered too small (41 ha) for analysis.

Figure CMP.4 shows values of the Vegetation Index (SR–VI) for the Campaspe Valley and Table CMP.7 show the Index, indicator and sub-indicator values. Table CMP.8 shows key MVG variables and metrics for the valley and the zones.

Analyses showed an extreme difference from Reference Condition for the Campaspe Valley with:

- SRA Vegetation Index (SR–VI) = 18, indicating Extremely Poor condition for riverine vegetation.
- the Vegetation Abundance and Diversity indicator = 35, indicating a very large difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian domain.
- the Vegetation Quality and Integrity indicator = 36, indicating a very large difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian domain.
- The Lowland Floodplain domain is not assessed in the Campaspe Valley.

The Abundance and Diversity indicator is based on abundance and richness of Near Riparian domain only, there being no richness, abundance or stability metrics for a Lowland Floodplain domain. The Abundance and Diversity of valley riverine vegetation is in Very Poor condition overall, with MVGs showing a very large difference from Reference Conditon in the Upland, Slopes and

Lowland zones. The Very Poor rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of major vegetation groups as given in NVIS 3.0. Valley-wide abundance in the Near Riparian domain shows a very large difference from Reference Conditon. MVG richness is moderately different from Reference Conditon.

In addition, the Quality and Integrity of valley riverine vegetation is in Very Poor condition overall, with no difference between zones: Upland, Slopes and Lowland zones all show a very large difference from Reference Conditon. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation means the MVGs listed in Table CMP.8 as well as other native but non-specific MVGs. Valley-wide nativeness shows a very large difference from Reference Condition in the Near Riparian domain.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre-1750s MVGs in the valley Near Riparian spatial domain is in Moderate condition overall, near Reference Conditon in the Upland zone with no loss of any MVG, and in Moderate condition in the Slopes and Lowland zones, due to the loss of one out of three, and one out of four MVGs respectively.

Abundance

- The Abundance of pre-1750s MVGs in the Near Riparian spatial domain is in Very Poor condition overall, and Upland, Slopes and Lowland zones all show a very large difference from Reference Conditon.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

- Nativeness: The Nativeness of the Near Riparian spatial domain is in Very Poor condition overall, and Upland, Slopes and Lowland zones all show a very large difference from Reference Conditon.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR is in Moderate condition overall. The Upland zone shows a moderate difference from Reference Conditon, the Slopes zone is near Reference Condition, and the Lowland zones shows a moderate difference from Reference Condition. Overlapping confidence limits shows the differences between zones are not significant.

Under Reference Conditions, the riverine vegetation in the Campaspe Valley was characterised as follows:

- Upland zone: The Near Riparian domain was mostly Eucalypt Woodlands (61% of area) and Eucalypt Open Forests (22%) with two other MVGs neither more than 5% of the domain. (Not all of this domain was assigned to an MVG).

- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (77%) and Eucalypt Open Forest (21%), with one other MVG occupying less than 5% of the domain.
- Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (72%) with two other MVGs of which only Eucalypt Open Forest was more than 5% of the domain. Not all of this domain was assigned to an MVG.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced in all zones, but most in the Slopes, and has severely affected Eucalypt Woodlands, formerly the most extensive MVG in the valley, in all zones.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands have been reduced (now 13% of the domain area), with Eucalypt Open Forests now slightly more extensive (13%). About 61% of the Upland Near Riparian domain is cleared or non-native vegetation, with a non-uniform effect on MVGs: Eucalypt Woodlands are reduced from 61% to 13% of the domain.
- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands is still the most extensive vegetation type although reduced (16% of the domain). About 76% is cleared or non-native vegetation, severely affecting two MVGs and completely reducing a third.
- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands is still the most extensive vegetation type although reduced (20% of the domain area). About 56% is cleared or non-native vegetation. Eucalypt Open Forests are reduced from 6% to 3% of the domain.

Unlike the other themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping is 2004, whereas LiDAR was flown in March-May 2010. This means that the Structure Sub-indicator and three mapping metrics (abundance, richness and nativeness) are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Conditon, without considering the number, density or extent of trees. In each the mapping polygon that is being assessed, the trees may be only a remnant clump or scattered isolates. Mapping quality may also affect mapping-based metrics, particularly richness: 12% of pixels in the Lowland zone were not assigned to an MVG.

Most of the metrics are based on vegetation mapping, which is not current and can be of variable quality. About 12%, 3% and 20% of the Upland, Slopes and Lowland zones, respectively, are not assigned to an MVG. The condition of the Near Riparian domain, and hence of the zones and of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation in the Campaspe Valley is in Extremely Poor condition overall. The two indicators, Abundance and Diversity, and Quality and Integrity, are both Very Poor. The scores for these indicators differ slightly because the decision rules on integrating metrics and sub-indicators give slightly more importance to nativeness than to abundance, and slightly more importance to richness than to structure.

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Riverine vegetation in the Upland and the Lowland zones, although rated as Very Poor in both, is in better condition than in the Slopes zone, where it is in Extremely Poor condition, despite having tree heights (Structure) near Reference Conditon, due to low abundance, low nativeness and reduced richness. The Slopes zone, together with the Lowland zone, with stream lengths of 251 km and 264 km out of a valley total of 697 km, has more influence on the valley score than the Upland zone. The MVG lost from the Near Riparian domain in the Slopes and Lowland zones is Other Grasslands, Herblands, Sedgelands and Rushlands.

The riverine vegetation of the Campaspe Valley is notable for the Extremely Poor condition of the Slopes zone, and for the low abundance and nativeness scores for the Near Riparian domain throughout the valley.

Table CMP 7: Campaspe Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	18	22	13	21
Indicator	Abundance and diversity	35	39	29	37
Metric	LF stability				
Sub-ind.	NRLF richness				
Metric	NR richness	0.79	1	0.67	0.75
Metric	LF richness				
Sub-ind.	NRLF abundance				
Metric	NR abundance	0.27	0.30	0.22	0.30
Metric	LF abundance				

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Quality and integrity	36	37	33	38
Sub-ind.	NRLF nativeness				
Metric	NR nativeness	0.27	0.30	0.22	0.30
Metric	LF nativeness				
Sub-ind.	NR structure	78 (73–82)	71 (62–79)	82 (77–87)	78 (68–86)
Sub-ind.	LF fragmentation				

Table CMP 8: The most abundant MVGs in the Near Riparian domain in the Campaspe Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone		
	Upland	Slopes	Lowland
MVG			
3. Eucalypt Open Forests	22	21	6
5. Eucalypt Woodlands	61	77	72

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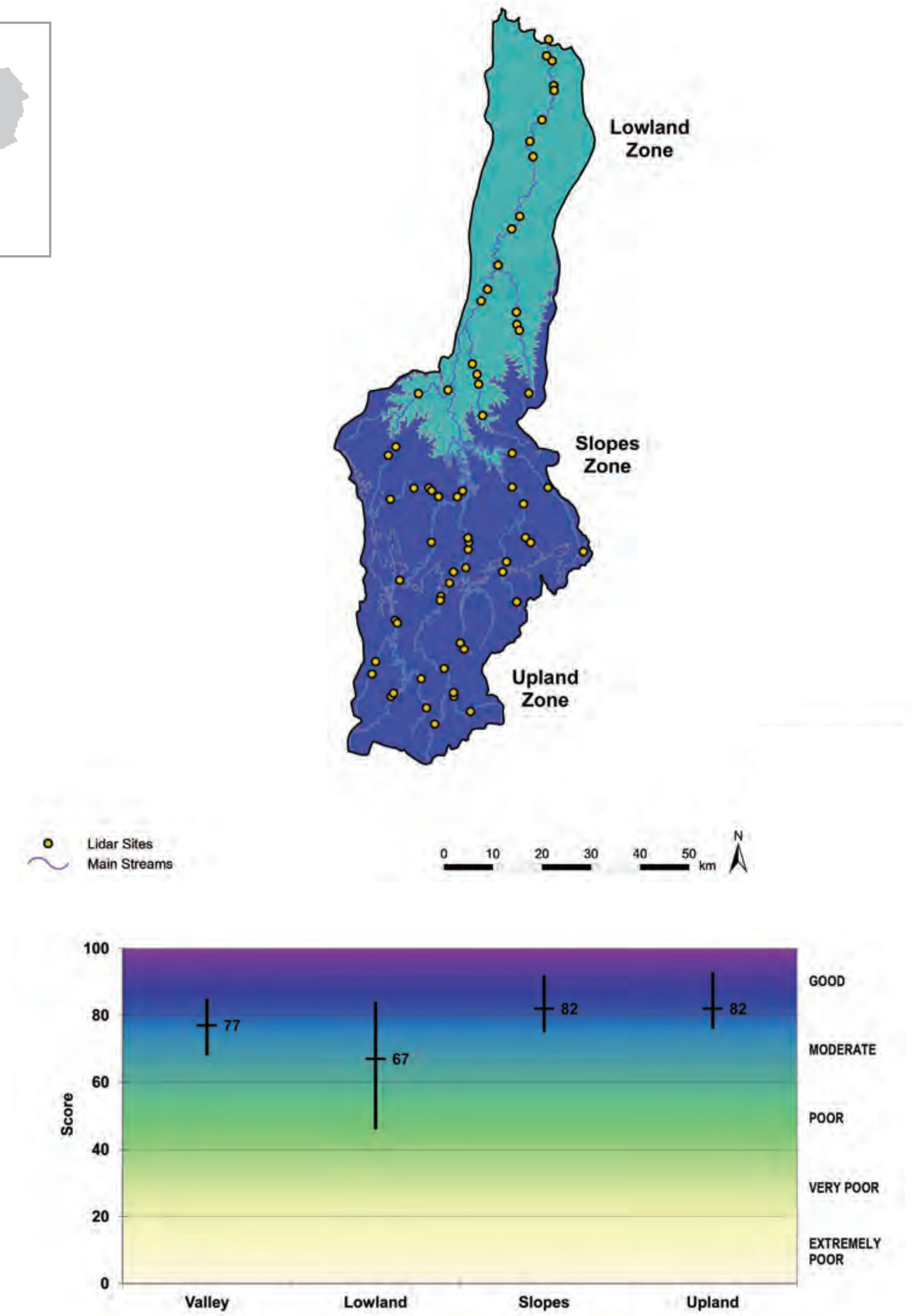

Figure CMP 5: Campaspe Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Campaspe Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 77. The condition of Physical Form in the zones was: Upland and Slopes Good; Lowland Moderate. The valley's river Channel Form was rated as Moderate. Bank Dynamics was rated as Good. Bed Dynamics and Floodplain Dynamics were rated as Moderate. Overall, the valley's physical form was characterised by channel enlargement and simplification. There was also indication of elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain.

The SRA Physical Form assessment considers physical form and processes along 697 km of stream across the valley. It is based on LiDAR data collected at 67 sites along river channels, as well as modelling of all 46 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure CMP.5 shows values of the Physical Form Index (SR–PI) for the Campaspe Valley and Table CMP.9 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Campaspe Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 77 (CL 68–85), indicating Moderate Physical Form condition
- the Channel Form indicator = 75 (CL 68–80), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 60 (CL 53–67), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 98 (CL 97-99), showing near Reference Condition
- the Floodplain indicator = 68 (CL 59–81), showing a moderate difference from Reference Condition.

Upland zone

There were 18 LiDAR survey sites and 14 SedNet river segments in the Upland zone of the Campaspe Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Conditon throughout most of the Upland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases). Channel Depth and Meander Wavelength were modified from reference for approximately half of the Upland zone. At these sites Channel Depth was generally increased (a few sites having large increases) and Meander Wavelength was also generally increased (many sites having large increases). Channel Width Variability, Sinuosity, Bank Variability and Channel Sediment Deposition were modified from Reference Conditon for less than half of the Upland zone. At these sites results show both increases and decreases in Channel Width Variability across the zone, Sinuosity was generally increased (a few sites having large increases), Bank Variability was generally increased indicating enhanced Bank Dynamics and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period. Channel Width was largely unmodified from Reference Conditon in the Upland zone.

Slopes zone

There were 23 LiDAR survey sites and 13 SedNet river segments in the Slopes zone of the Campaspe Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Conditon throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases). Channel Width and Meander Wavelength were modified from Reference Condition in more than half of the Slopes zone. At these sites Channel Width was generally increased and Meander Wavelength was generally increased (many sites having large increases). Channel Depth and Bank Variability were modified from reference for approximately half of the Slopes zone. At these sites Channel Depth was generally increased and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability and Sinuosity were modified from reference for less than half of the Slopes zone. At these sites Channel Width Variability was generally reduced and Sinuosity was generally increased (a few sites having large increases). Channel Sediment Deposition was largely unmodified from reference in the Slopes zone.

Lowland zone

There were 26 LiDAR survey sites and 19 SedNet river segments in the Lowland zone of the Campaspe Valley. Based on these samples, Channel Sediment Ratio was modified from Reference Conditon throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases). Channel Width, Channel Depth and Floodplain Sediment Deposition were modified from Reference Conditon in more than half of the Lowland zone. At these sites Channel Width and Depth were generally increased (many sites having large increases in Channel Depth) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width Variability, Sinuosity, Meander Wavelength, Bank Variability and Channel Sediment Deposition were modified from Reference Conditon for less than half of the Lowland zone. At these sites Channel Width Variability was generally reduced, Sinuosity was generally increased (a few sites having large increases), Meander Wavelength was generally increased (many sites having large increases), results show both increases and decreases in Bank Variability across the zone and there was a large increase in Channel Sediment Deposition across 40% of the zone for the post-European period.

Channel Form

There was minor change from Reference Conditon in Channel Form in the Upland zone. The more serious changes were channel enlargement and channel simplification. An enlarged channel was indicated at 50% of sites as a result of channel widening and bed degradation. These estimates of increased channel depth and width in the Upland zone are supported by field observations of widespread gullying in the catchment (Davis *et al*. 1999). This result is further supported by an analysis of data from North Central CMA (2006) by Gippel *et al*. (2008), indicating that while the majority of stream lengths in the Upper Campaspe were not incised, incision had occurred in streams of the Coliban catchment (Gippel *et al.* 2008).

Channel simplification was indicated at 50% of sites mostly as a result of channel straightening. There was widespread evidence of channel straightening but small deviations from Reference Conditon had little influence on scores when aggregated at the zone scale. Adjustments to Channel Planform in the Upland zone will be constrained by bedrock. Local knowledge is required to interpret any departures from reference planform in bedrock channels. There was minor change from Reference Conditon in Channel Form in the Slopes zone. The more serious impact was channel simplification. Channel simplification was indicated at 80% of sites mostly as a result of channel straightening. There was widespread evidence of channel enlargement and channel straightening but small deviations from reference had little influence on scores when aggregated at the zone scale. Consistent with this result, SKM (2005b) reported that most of the small tributaries that enter the Campaspe River in the Lowland zone are degraded with substantive bank erosion. In contrast, the analysis of data from North Central CMA (2006) by Gippel et al. (2008) indicated that for almost the entire stream length in the Lower Campaspe the level of bank erosion was equivalent to Reference Condition or showed a slight deviation from reference, while no streams were incised (Gippel *et al.* 2008). It is not possible to reconcile this inconsistent result without a more detailed investigation.

There was minor change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 80% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Conditon in Bank Dynamics in the Upland, Slopes and Lowland zones. Bank variability exceeded Reference Conditions at 40% of sites in the Slopes zone. Elevated Bank Variability may indicate accelerated erosion of stream banks, and this is supported by field observations (Rutherfurd pers. comm.). Previous analysis of data from North Central CMA (2006) by Gippel *et al.* (2008) indicated elevated bank instability along some rivers in the Upland zone, including over half the stream length in the Coliban River catchment (a tributary flowing through both the Upland and Slopes zones).

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics. Where possible we compare results of SedNet modelling used for this SRA assessment with field observations.

There was minor change from Reference Condition in Bed Dynamics in the Upland and Slopes zones mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). In addition, approximately 20% of sites in the Upland zone exhibit elevated sediment deposition. This is consistent the analysis of data from North Central CMA (2006) by Gippel *et al.* (2008), which reports evidence of sand slugs along channels of the Upland zone, particularly in the Coliban catchment. Large quantities of sediment were released from the upper catchment in association with (i) extensive gold mining in the upland areas, which was most active in the 1850s, and (ii) the development of extensive gullying associated with clearing for agriculture of upland areas with erodible sodic duplex soils (Ford *et al.* 1993, North Central CMA 2006). Earth Tech (2003) quoted other studies that identified the major tributaries of the Coliban River (which lies in the Upland and Slopes zones) as having an oversupply of coarse sediment. Davis (1996) and Davis *et al.* (1999) found that there was a major phase of gully expansion in the upper Campaspe Valley during the 19th century. These gullies have since stabilised, with the sediment from the gullies now stored in hillslopes. These hillslopes are decoupled from drainage lines and currently exhibit low sediment production.

SedNet results for the Slopes zone suggest that in-channel sedimentation is largely unmodified from Reference Condition. However, this is not consistent with previous field observations that the tributaries above Eppalock Reservoir have experienced elevated coarse sediment deposition from widespread gullying of the granite catchment (Davis *et al.* 1999; Gippel *et al*. 2008).

There was considerable change from Reference Conditon in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (40% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Lowland zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. The analysis of data from North Central CMA (2006) by Gippel *et al.* (2008) did not report any sand slugs in streams of the lower Campaspe. Thus, for the Lowland zone, the field observations (reported in Gippel et al., 2008) are inconsistent with the SedNet predictions of widespread sedimentation; they are also inconsistent with this SRA assessment result indicating widespread incision.

There was minor change from Reference Conditon in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (80% of SedNet river segments). There was considerable change from Reference Conditon in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (70% of SedNet river segments). This is consistent with previous field observations suggesting that there is substantial sedimentation on floodplains throughout the Campaspe Valley (Davis 1996). Davis *et al.* (1999) report that the channel of the Campaspe and its tributaries below Eppalock Reservoir generally exhibit enhanced bank erosion and there is evidence of substantial anthropogenic deposition (up to one metre depth) on the confined floodplains of these streams.

Table CMP 9: Campaspe Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level)

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Physical Form Condition (SR–PI)	77 (68–85)	82 (76–93)	82 (75–92)	67 (46–84)
Indicator	Channel Form (volume and flow events)	75 (68–80)	75 (63–87)	76 (68–86)	73 (62–83)
Sub-ind.	Cross-section Form	80 (73–86)	79 (65–90)	91 (82–96)	70 (57–82)
Metric	Channel Depth (mean)	1.29 (1.16–1.45)	1.13 (0.96–1.35)	1.11 (1.03–1.21)	1.57 (1.26–1.88)
Metric	Channel Width (mean)	1.19 (1.13–1.27)	1.20 (1.05–1.44)	1.17 (1.11–1.23)	1.20 (1.09–1.34)
Sub-ind.	Cross-section Form (variability)	95 (91–98)	96 (84–100)	95 (90–99)	95 (85–100)
Metric	Channel Width (CV)	0.97 (0.94–0.99)	1.00 (0.94–1.05)	0.95 (0.90–0.98)	0.97 (0.91–1.01)
Sub-ind.	Channel Planform	75 (68–83)	75 (62–89)	67 (55–80)	82 (72–92)
Metric	Sinuosity	1.03 (1.02–1.06)	1.02 (1.00–1.04)	1.04 (1.00–1.09)	1.04 (1.01–1.07)
Metric	Meander Wavelength	1.19 (1.11–1.26)	1.12 (1.02–1.22)	1.29 (1.14–1.47)	1.13 (1.04–1.25)
Indicator	Bed Dynamics	60 (53–67)	71 (68–76)	70 (70–70)	42 (25–60)
Metric	Channel Sediment Ratio	195 (127–270)	63 (34–92)	191 (96–310)	289 (169–438)
Metric	Channel Sediment Depth	0.006 (0.001–0.01)	0.0007 (0.0001–0.002)	0 (0–0)	0.01 (0.002–0.04)
Indicator	Bank Dynamics	98 (97–99)	97 (94–99)	99 (98–100)	99 (97–100)
Metric	Bank Variability (longitudinal)	1.06 (1.03–1.11)	1.10 (1.01–1.20)	1.06 (1.02–1.11)	1.03 (0.99–1.09)
Indicator	Floodplain Form	68 (59–81)	79 (69–99)	78 (70–88)	51 (30–78)
Metric	Floodplain Sediment Deposition	2.00 (1.47–3.00)	1.44 (0.45–1.90)	1.58 (1.08–1.93)	4.00 (1.51–6.00)

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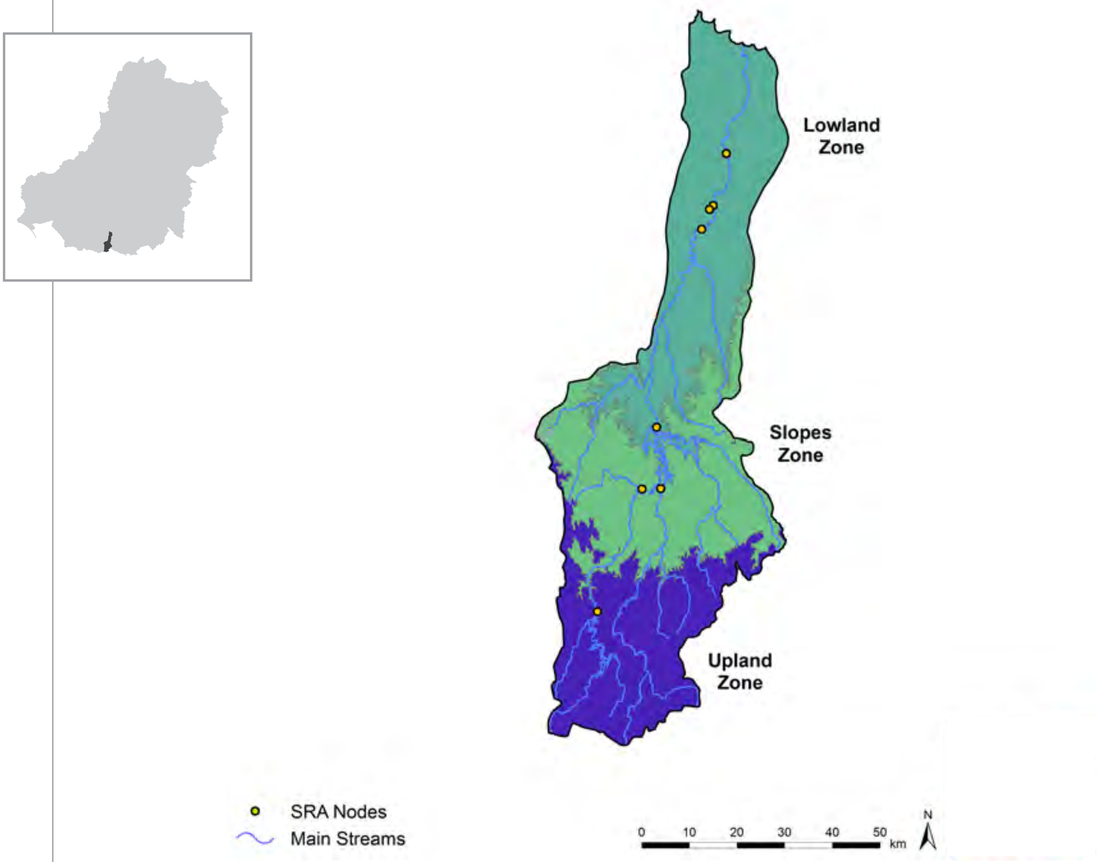

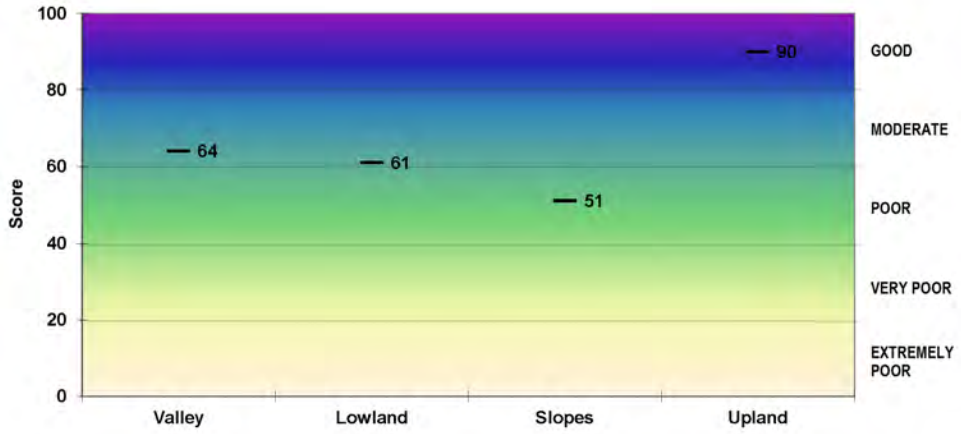

Figure CMP 6: Campaspe Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Campaspe Valley river system was in Moderate condition, with an aggregate Hydrology Index score of 64. The Upland zone was in Good condition. The Lowland zone was in Moderate condition and the Slopes zone was in Poor condition.

The mainstem river system of the Campaspe Valley was rated in Poor condition. The amplitude of seasonal flow variations was reduced throughout most of the mainstem river system with reduced high flows and increased low flows relative to Reference Condition. The timing of seasonal flow variations was also altered through much of the mainstem river length.

The headwater streams of the Campaspe Valley were rated in Good condition. In contrast to the mainstem river, the amplitude of seasonal flow variations was increased throughout much of the headwater streams, with increased high flows and reduced low flows relative to Reference Condition.

The Campaspe River rises in the Great Dividing Range near Woodend and flows north to the Murray at Echuca. The main instream storage is Lake Eppalock (304 GL), near Bendigo and the junction with the Coliban River. There are three storages on the Coliban, namely the Upper Coliban (38 GL), Lauriston (20 GL) and Malmsbury (18 GL). Diversions for irrigation occur at Rochester and downstream toward the Murray. The Coliban provides urban supplies for Bendigo and large towns in the upper catchment, and some irrigation.

In the Campaspe Valley, hydrological condition is assessed using metrics of hydrological alteration available for 919 km of mainstem rivers and headwater streams. There are 181 km of mainstem river extending across the Lowland, Slopes and Upland zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by monthly water resource modelling. It is not possible to calculate the Over Bank Flow metrics, the High Flow Spells metric or the Low Flow Spells using monthly data. Consequently, these metrics have not been included in the analysis for this valley. In the Campaspe Valley there is 738 km of headwater stream (Upland zone: 186 km; Slopes zone: 285 km; Lowland zone: 267 km). In these headwater streams, SRA hydrology metrics represent the effects of farm dams and tree cover change since European settlement.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Campaspe Valley there are 228 km of these mid-size tributaries (48 km in the Upland zone; 68 km in the Slopes zone; 112 km in the Lowland zone) which is 0.2 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs corresponding for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwaters streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures CMP. 6 and CMP.7 show values of the Hydrology Condition Index (SR–HI) for the Campaspe Valley and its river network, and Table CMP.10 and CMP.11 show the Index, sub-index, indicator

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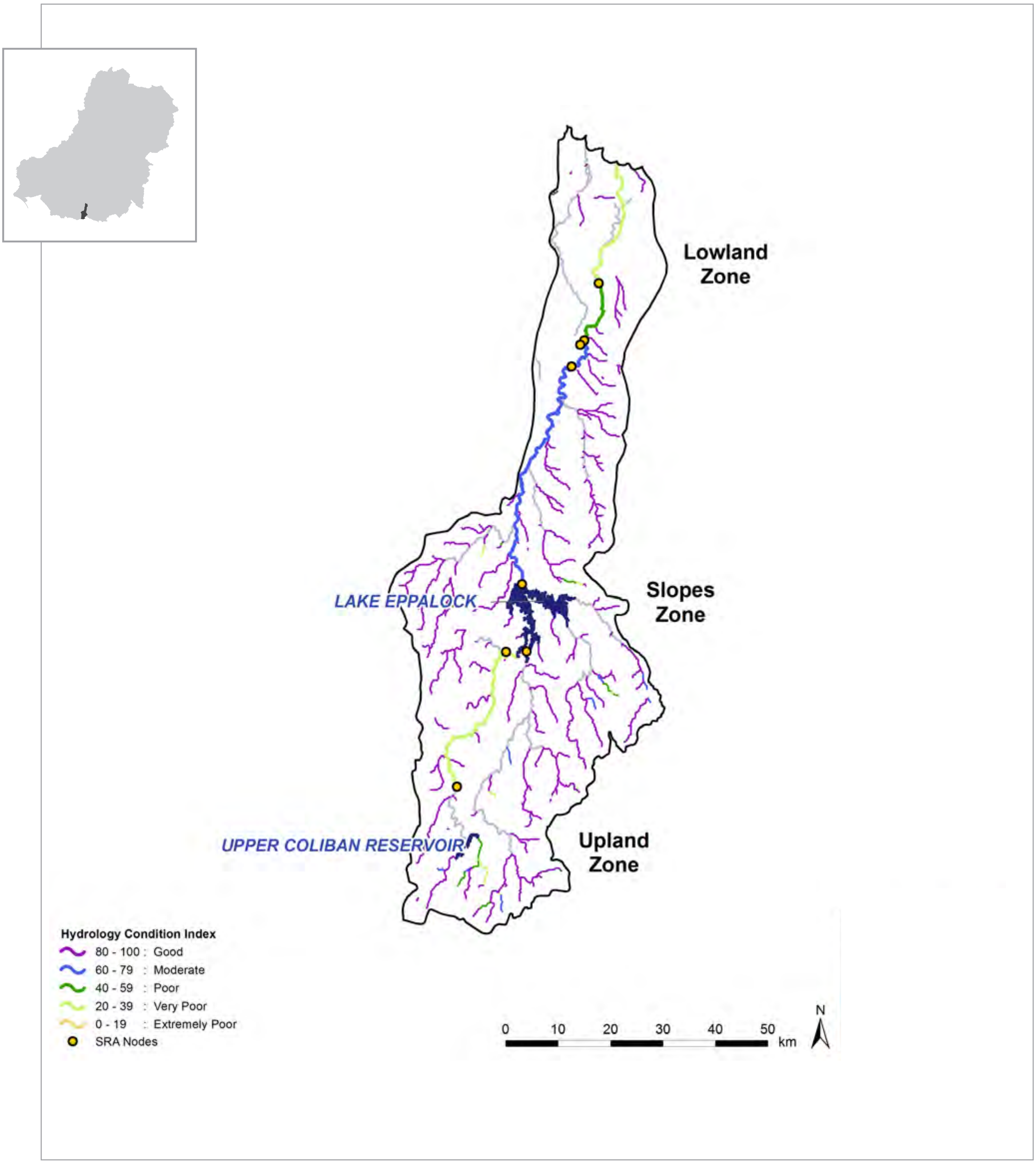

Figure CMP 7: Campaspe Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

and metric values. Analyses showed a moderate difference from Reference Condition for the Campaspe Valley, with:

- The Hydrology Condition Index for the whole valley = 64, indicating Moderate hydrological condition.
- The Hydrology Condition Index for the Upland, Slopes and Lowland zones = 90, 51 and 61 indicating Good, Poor and Moderate hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 96, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 55, indicating Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 55, indicating Poor condition and a large difference from Reference Condition for the flow regime within the channels.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a significant alteration from reference in 5% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and most in the Lowland zone. In addition, results for the Flow Duration metric showed a significant alteration from reference in 39% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to Reference Conditon.

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 5% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Conditon in 85% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. The High Flow Spells metric could not be calculated for this valley.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 10% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 35% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone, some in the Slopes zone and some in the Lowland zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to Reference Condition. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 64% of the mainstem river length (mostly associated with increased flows) and a significant alteration from Reference Condition in 25% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and Lowland zones. Results for the Zero Flows Proportion metric showed a significant alteration from Reference Conditon in 5% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones. The Low Flow Spells metric could not be calculated for this valley.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 7% of the headwater river length (mostly associated with reduced flows) and a significant alteration from reference in 42% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed no significant variations from Reference Condition.

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to Reference Conditon.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a large difference from Reference Condition. Results for the Seasonal Amplitude metric showed a significant alteration from reference in 90% of the mainstem river length (mostly associated with reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 58% of the mainstem river length and a significant alteration from reference in 9% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 12% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 51% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed only small variations from Reference Condition throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed a moderate difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 6% of the mainstem river length (mostly associated with increased variability) and a significant alteration from reference in 25% of the mainstem river length (mostly associated with increased variability). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Slopes zone and most in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 15% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone, a small proportion in both the Slopes and a Lowland zones.

Summary: mainstem rivers

The mainstem river system of the Campaspe Valley was generally characterised by considerable alteration in Flow Seasonality relative to Reference Condition, minor alteration in Flow Variability and Low and Zero Flow Events and little or no alteration in High Flow Events and Flow Gross Volume. The amplitude of seasonal flow variations was reduced throughout most of the mainstem river system with reduced high flows and increased low flows relative to reference. The timing of seasonal flow variations was also altered through much of the mainstem river length.

Summary: headwater streams

The headwater streams of the Campaspe Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events or Flow Gross Volume relative to Reference Condition. In contrast to the mainstem river, the amplitude of seasonal flow variations was increased throughout much of the headwater streams with increased high flows and reduced low flows.

Table CMP 10: Campaspe Valley SRA Hydrology Condition Index at valley and zone scales.
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	64		90	51	61

CAMPASPE VALLEY

Table CMP 11: Campaspe Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.
(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**55 (21–100)**	**96 (28–100)**
Sub-Index	In-Channel Flow Regime	55 (21–100)	96 (28–100)
Indicator	**In-Channel Flow Regime A (volume and flow events)**	**82 (52–100)**	**97 (35–100)**
Sub-ind.	Flow Gross Volume	96 (80–100)	98 (89–100)
Metric.	Mean Annual Flow	0.90 (0.70–1.00)	1.06 (0.81–1.20)
Metric	Flow Duration	1.19 (1.15–1.26)	1.00 (0.86–1.16)
Sub-ind.	High Flow Events	83 (67–100)	92 (32–100)
Metric	High Flow	0.64 (0.47–1.00)	1.18 (0.66–1.90)
Metric	High Flow Spells		
Sub-ind.	Low and Zero Flow Events	73 (42–99)	93 (49–99)
Metric	Zero Flows Proportion	0.97 (0.78–1.02)	0.97 (0.95–1.00)
Metric	Low Flow	1.42 (0.22–1.83)	0.89 (0.19–1.80)
Metric	Low Flow Spells		
Indicator	**In-Channel Flow Regime B (seasonality & variability)**	**50 (25–100)**	**91 (20–100)**
Sub-ind.	Flow Seasonality	49 (33–100)	87 (62–100)
Metric.	Flow Seasonal Amplitude	0.64 (0.53–1.00)	1.27 (0.89–1.72)
Metric	Flow Seasonal Period	0.58 (0.38–0.99)	0.94 (0.83–1.00)
Sub-ind.	Flow Variability	73 (30–100)	81 (12–100)
Metric	Flow Variation	1.13 (0.82–1.78)	0.86 (0.59–1.00)
Sub-Index	Over Bank Flow Regime	Not assessed	
Indicator	Over Bank Floods Low		
Metric	OB Flow Duration (ARI 1)		
Metric	OB Flow Spells (ARI 1)		
Indicator	Over Bank Floods High		
Metric	OB Flow Duration (ARI 8)		
Metric	OB Flow Spells (ARI 8)		

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
	36	**35**	**61**		**90**	**96**
	36	35	61		90	96
	52	**52**	**92**		**98**	**95**
	100	99	95		99	96
	0.99	0.96	0.88		1.04	1.09
	1.17	1.17	1.20		0.98	1.02
	92	90	81		96	86
	0.74	0.72	0.62		1.20	1.32
	42	43	82		88	94
	1.02	1.00	0.96		0.97	0.98
	1.83	1.74	1.32		0.71	1.06
	49	**47**	**51**		**83**	**94**
	37	38	52		88	84
	0.63	0.62	0.64		1.27	1.34
	0.43	0.45	0.62		0.91	0.94
	74	71	74		73	84
	0.82	0.88	1.21		0.83	0.87

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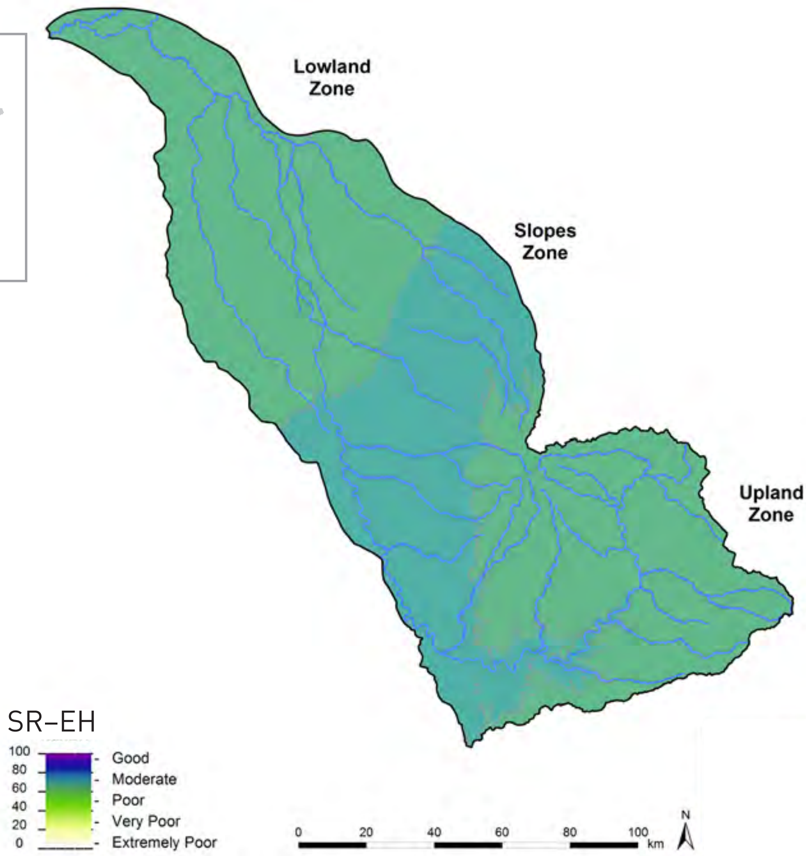

Figure CST 1: Castlereagh Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure CST 1 shows the Ecosystem Health ratings for the Castlereagh Valley and Table CST 1 and CST 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a moderate difference from Reference Condition for the Castlereagh Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Very Poor, Moderate and Good condition respectively, while Hydrology and Physical Form were both in Good condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Castlereagh Valley river system. River Ecosystem Health was rated as Poor (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Castlereagh Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Upland and Lowland Poor, Slopes Moderate. The Fish community was in Very Poor condition. Most expected species absent. Species abundance and biomass were dominated by alien species. Recruitment levels among the remaining native species were high. The Macroinvertebrate community was in Moderate condition, with moderate declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Good condition overall; with some reduction in abundance, structure and nativeness in the Near Riparian domain. The Physical Form of the river system was in Good condition with channel form and bank dynamics in Good condition and bed dynamics in Moderate condition. There were moderate to high levels of floodplain sediment deposition. The river system's Hydrology was in Good condition; with little or no alteration to the magnitudes of annual flow volumes and low and zero flows, variability, seasonality and high flows relative to Reference Condition.

Ecosystem Health

The Castlereagh Valley river system is ranked third amongst the 23 Basin valleys for River Ecosystem Health (see Table 5.2) and is in the upper 50% for all five SRA condition Indices. It is equal highest with the Paroo and Warrego valleys in terms of the condition of Hydrology (SR–HI = 100) and fifth highest for Vegetation condition.

Although the condition of the fish community is considered to be Very Poor (SR–FI = 38), the Condamine showed the greatest improvement in Fish condition between SRA1 and SRA2 (see Figure 6.2). Sampling for fish and macroinvertebrates took place in the first part of 2010, following rains in 2008–09. Prior to that there had been an extended drought with either limited or no surface flow between isolated water holes and weir pools. It is likely that the observed improvements in Fish and Macroinvertebrate condition, especially the widespread successful fish recruitment, are responses to restored longitudinal connectivity and general improvement in hydrological habitat, which is supported or enabled by the relatively Good condition of other aspects of the riverine ecosystem.

Fish Theme

The Fish Condition Index SR–FI = 38, indicating Very Poor condition (Lowland zone: Very Poor; Slopes zone: Poor; Upland zone: Very Poor). The Expectedness indicator = 27, indicating Very Poor condition, and a very large difference from Reference Condition. The Nativeness indicator = 54, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 88, indicating Good condition, and a minor difference from Reference Condition.

In general, the fish community of the Castlereagh had reduced numbers of expected native species, though most showing signs of recruitment. Carp comprised half of the fish biomass in the valley. Larger native species were particularly lacking.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 78, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate; Upland zone: Good). The simOE metric = 51, indicating moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in moderate or Good condition was high (31 of 35 rated sites, 89%) across all zones. 16 of these sites were in Good condition. No site was in Poor or Extremely Poor condition.

Family richness generally was moderate and reduced compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 97, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good). The Vegetation Abundance and Diversity indicator = 91, indicating Good condition and a minor difference from Reference Condition for the abundance and stability of vegetation groups within Near Riparian and Lowland Floodplain areas. The Vegetation Quality and Integrity indicator = 82, indicating Good condition and a minor difference from Reference Condition for the structure, nativeness and fragmentation of vegetation communities and groups within Near Riparian and Lowland Floodplain areas.

The Lowland Floodplain domain is little affected by clearing, with the abundance and degree of fragmentation of major vegetation groups being near Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 87, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good). The Channel Form indicator = 90 and the Bank Dynamics indicator = 99; both indicating Good condition and showing near Reference Condition. The Bed Dynamics indicator = 68 and the Floodplain Form indicator = 61; both indicating Moderate condition and showing a minor difference from Reference Condition.

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation in the Slopes and Lowland zones. There were also indications of bed aggradation and channel narrowing in the Lowland zone.

Hydrology Theme

The Hydrology Condition Index SR–HI = 100, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good). The In-Channel Flow Regime indicator = 100, indicating Good condition and near Reference Condition for the flow regime within the channels. The Over Bank Flow Regime sub-index = 100, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

Both the mainstem river and headwater streams were characterised by little or no alteration in High Over Bank Floods, Low Over Bank Floods, Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume relative to Reference Condition.

Table CST 1: Castlereagh Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	UPLAND	SLOPES	LOWLAND
		Poor	Poor	Moderate	Poor

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	38 (30–41) Very Poor	28 (17–41) Very Poor	53 (34–58) Poor	28 (20–32) Very Poor
Macro-invertebrates	SCORE RATING	78 (74–81) Moderate	81 (72–88) Good	78 (72–85) Moderate	74 (68–79) Moderate
Vegetation	SCORE RATING	97 Good	96 Good	97 Good	99 Good

Table CST 2: Castlereagh Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	87 (80–90) Good	89 (86–91) Good	81 (76–86) Good	91 (74–98) Good
Hydrology	SCORE RATING	100 Good	100 Good	100 Good	100 Good

CASTLEREAGH VALLEY

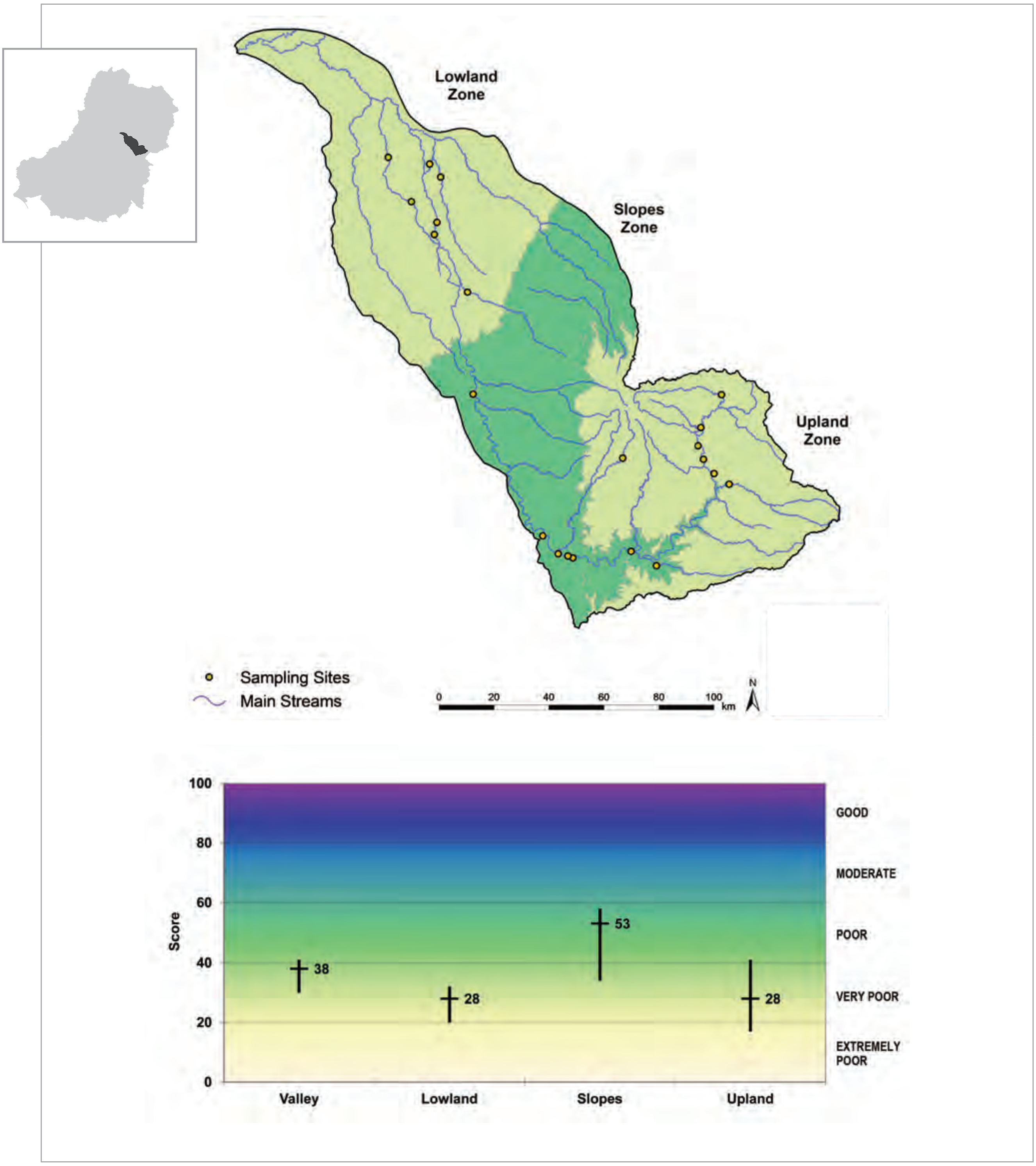

Figure CST 2: Castlereagh Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Castlereagh Valley river system was in Very Poor condition, with an aggregate Fish Index score (SR–FI) of 38. The condition of the fish community in the zones was as follows: Upland Very Poor: Slopes Poor; Lowland Very Poor. The fish community was characterised by a Very Poor score for expected native fish species, a Poor score for nativeness and a Good score for native fish recruitment. The Lowland zone in particular had few fish and lacked almost 75% of the predicted native species. The valley had lost much of its native species richness. Alien species contributed 53% of the biomass in samples. Native fish recruitment was Very Poor, Good and Good in the Upland, Slopes and Lowland zones respectively.

Twenty-one sites were surveyed across the Castlereagh Valley in March–April 2010, yielding 2,455 fish. Analyses showed a very large difference from Reference Condition for the Castlereagh Valley, with:

- SRA Fish Index (SR–FI) = 38 (CL 30–41), indicating Very Poor condition of the fish community.
- The Expectedness indicator = 27 (CL 23–31), indicating Very Poor condition, and a very large difference from Reference Condition. Only 43% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 54 (CL 46–60), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 88 (CL 62–90), indicating Good condition, and a minor difference from Reference Condition. Evidence of recruitment was observed for four of the six native species observed in the valley.

Figure CST 2 shows sampling sites, zones and corresponding SR–FI values, and Table CST 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Castlereagh Valley was tenth highest amongst the 23 valleys, and close to that for the Ovens valley. The Slopes zone community was in much better condition (SR–FI = 53) than that in either the Upland zone or the Lowland zone (SR–FI = 28 in both cases). The Lowland zone scored less than the Upland and Slopes zones in terms of Expectedness (16 versus 42 and 38 respectively) whereas the Upland zone scored only 28 for Recruitment against 97 and 92 for the Slopes and Lowland zones.

The Castlereagh had the ninth highest number of fish caught per site, but the lowest fish biomass per site (1.27 kg/site) of the 23 valleys surveyed. Of this biomass, 53% was contributed by alien species, with 49% by common carp.

All of the native species still present in the Slopes and Lowland zones showed some evidence of recruitment. In the Upland zone only two of the five native species captured, gudgeon and Australian smelt, were considered to exhibit evidence of recruitment. The three alien species were observed to be recruiting in all three zones.

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Table CST 4 shows native species abundances in the Castlereagh Valley compared with Reference Condition.

Eight of the fourteen native species expected to be present in the Castlereagh Valley did not appear in any sample. These included the medium- and large-bodied species, Murray cod, silver perch, and river blackfish. The endangered species, southern purple-spotted gudgeon, was expected in all three zones but was not captured. The native fish community was numerically dominated by gudgeon in the higher altitudes, spangled perch, a common fish in northern Australian rivers, in the Slopes zone, and bony herring in the Lowland zone.

In general, the fish community of the Castlereagh had reduced numbers of expected native species. Larger native species were particularly lacking.

Table CST 3: Castlereagh Valley SRA Fish Condition Index, indicators, metrics and derived variables.

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	38 (30–41)	28 (17–41)	53 (34–58)	28 (20–32)
Indicator	Expectedness	27 (23–31)	42 (20–59)	38 (29–45)	16 (15–19)
Metric	O/E	0.47 (0.41–0.52)	0.54 (0.25–0.87)	0.58 (0.47–0.69)	0.36 (0.34–0.41)
Metric	O/P (Zone level)	0.29 (0.29–0.29)	0.38 (0.38–0.38)	0.31 (0.31–0.31)	0.25 (0.25–0.25)
Indicator	Nativeness	54 (46–60)	66(46–87)	62 (57–70)	45 (29–55)
Metric	Proportion biomass native	0.45 (0.36–0.55)	0.59 (0.29–0.86)	0.57 (0.45–0.67)	0.33 (0.19–0.48)
Metric	Proportion abundance native	0.49 (0.37–0.61)	0.66 (0.41–0.88)	0.58 (0.47–0.71)	0.38 (0.16–0.62)
Metric	Proportion species native	0.56 (0.52–0.59)	0.51 (0.31–0.68)	0.59 (0.54–0.64)	0.54 (0.50–0.59)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Recruitment	88 (62–90)	28 (23–42)	97 (44–98)	92 (61–97)
Metric	Proportion of sites with native recruits	0.79 (0.61–0.87)	0.40 (0.32–0.40)	0.86 (0.50–0.99)	0.80 (0.60–0.94)
Metric	Proportion of native taxa with recruits	0.94 (0.82–1.00)	0.40 (0.40–1.00)	1.00 (0.67–1.00)	1.00 (1.00–1.00)
Metric	Proportion of abundance as recruits	0.70 (0.58–0.73)	0.40 (0.40–1.00)	0.74 (0.63–0.75)	0.72 (0.49–0.74)
Variables					
	Number of sites sampled	21	7	7	7
	Total number of species	9	8	7	6
	Number of native species	6	5	4	3
	Number of predicted species	14	13	13	12
	Number of alien species	3	3	3	3
	Mean number of fish per site	117	55	180	116
	Biomass/site all species (g)	1271	1342	593	1877
	Mean native biomass/fish (g)	10	15	4	18
	Mean alien biomass/fish (g)	12	61	3	15

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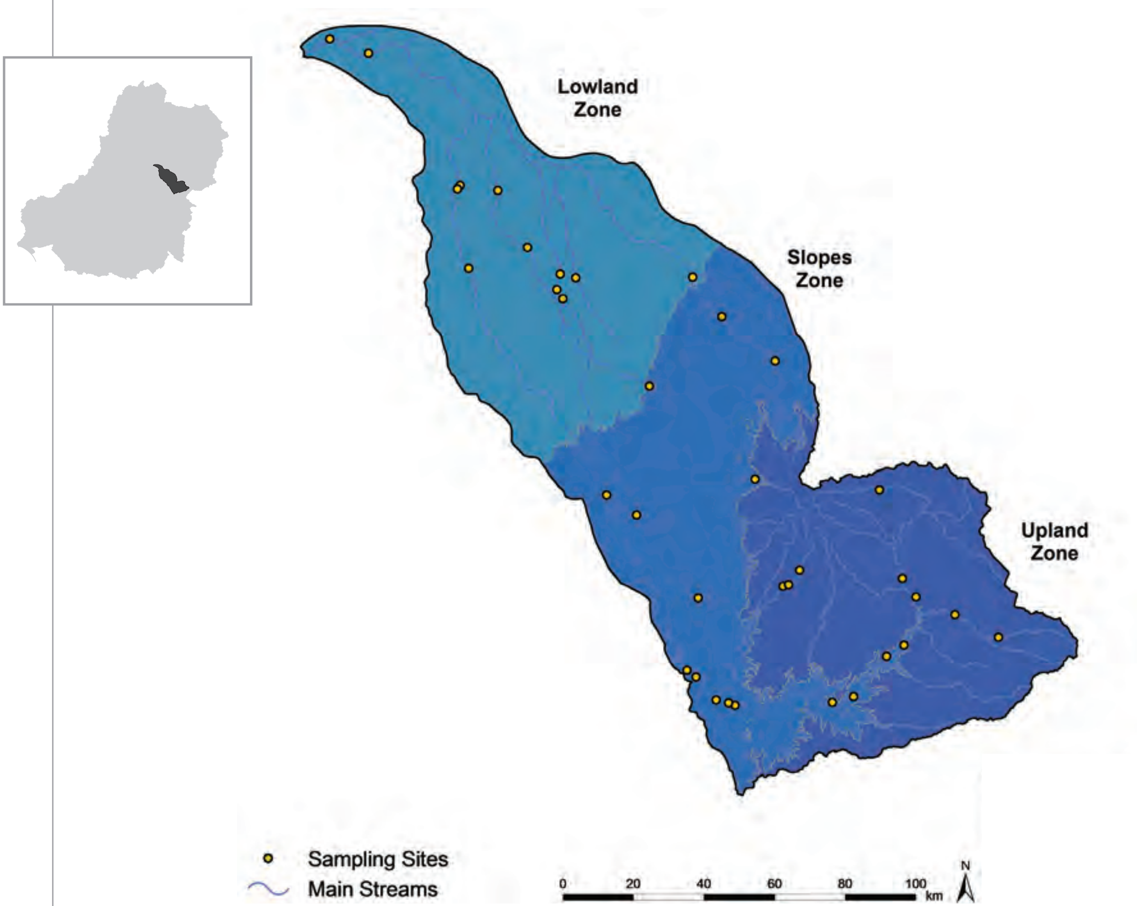
Table CST 4: Castlereagh Valley number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone		
		Upland	Slopes	Lowland
Sites sampled	21	7	7	7
Native species				
Australian smelt	43	37	6	0
Bony herring	296	6	60	230
Freshwater catfish	1	1	0	0
Golden perch	2	2	0	0
Gudgeon	466	254	197	15
Mountain galaxias	0	0		
Murray cod	0	0	0	0
Murray–Darling rainbowfish	0	0	0	0
Olive perchlet	0		0	0
River blackfish	0	0	0	
Silver perch	0	0	0	0
Southern purple-spotted gudgeon	0	0	0	0
Spangled perch	427	0	326	101
Unspecked hardyhead	0	0	0	0
Alien species				
Common carp	350	24	68	258
Gambusia	834	57	587	190
Goldfish	36	1	18	17

CASTLEREAGH VALLEY



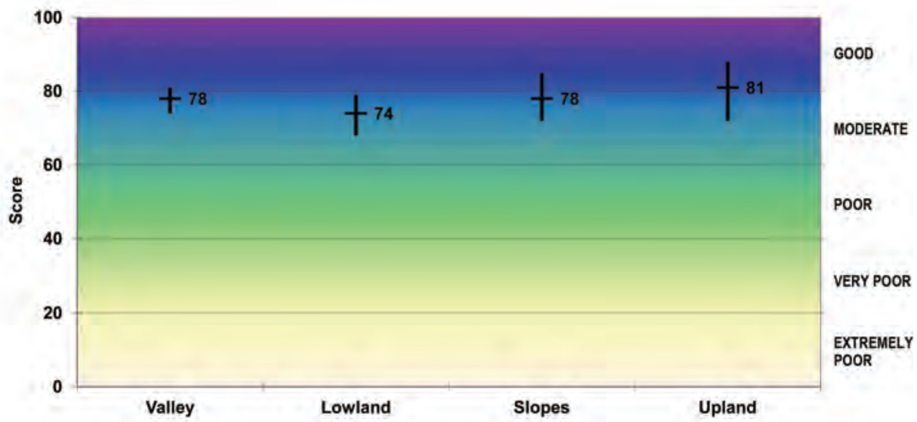


Figure CST 3: Castlereagh Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Castlereagh Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 78. The condition of the Macroinvertebrate community in the zones was as follows: Upland Good; Slopes Moderate; Lowland Moderate. The proportion of sites in Good condition was high (14 of 35 rated sites, 40%), across all zones. No site was in Poor to Extremely Poor condition. Family richness generally was moderate, and was reduced compared to Reference Condition.

Thirty-six sites were surveyed across the Castlereagh Valley in March–April 2010 yielding 4,741 macroinvertebrates in 46 families (49% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 78 (CL 74–81), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 51 (CL 49–53) indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate or Good condition was high (31 of 35 rated sites, 89%), across all zones. 14 of these sites were in Good condition. No site was in Poor to Extremely Poor condition.
- The number of families found was lowest in the Upland zone (34 families) and highest in the Lowland zone (43 families), while the Slopes zone had the highest average number of families per site (22).

Figure CST 3 shows sampling sites, zones and SR–MI values, and Table CST 5 shows Index and metric values. The SR–MI score for the Castlereagh Valley indicated Moderate condition of macroinvertebrate communities, rating 8 out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the Slopes and Lowland zones both showed moderate differences from Reference Condition (SR–MI = 78 and 74, respectively), while those of the Upland zone showed only minor differences from Reference Condition (SR–MI = 81). Similar confidence intervals (ranges of points) were observed across all three zones. Expectedness (simOE) was moderate and varied only moderately (by up to seven points) across the zones.

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Table CST 6 shows that most sites in both zones had moderate to high SR–MI values, with 14 sites rated in Good condition. Only one site had a low simOE score (<40 points), and only four sites were rated (SR–MI) in Poor condition. Many sites had close to the expected diversities of macroinvertebrates, though coupled with a reduction in frequency of occurrence of the families present.

Family richness generally was reduced compared to Reference Condition. Diversity was moderate (average 21 families per site), with the Slopes zone being most diverse at site scale (average 22 families per site). The valley contained 49% of the families found across the Basin (Table CST 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (72 – 83%) of the fauna of the valley was found in each of the zones.

Table CST 5: Castlereagh Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower – upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	78 (74–81)	81 (72–88)	78 (72–85)	74 (68–79)
Metric	SimOE	51 (49–53)	53 (49–56)	52 (49–56)	49 (47–52)

Table CST 6: Castlereagh Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone		
		Upland	Slopes	Lowland
Sites				
Number of sites sampled	36	8	15	13
Number of sites with index values*	35	8	14	13
N sites by SR–MI condition band				
Good (80–100)	14	5	5	4
Moderate (60–80)	17	2	8	7
Poor (40–60)	4	1	1	2
Very or Extremely Poor (0–40)				
Families				
Number of families sampled	46	34	38	43
No. families/site (min–max)	21 (9–33)	21 (9–33)	22 (12–32)	19 (12–26)
Percent of families in Basin	49	36	40	35
Percent of families in valley	100	74	83	93

*simOE values could occasionally not be derived for every sample site.

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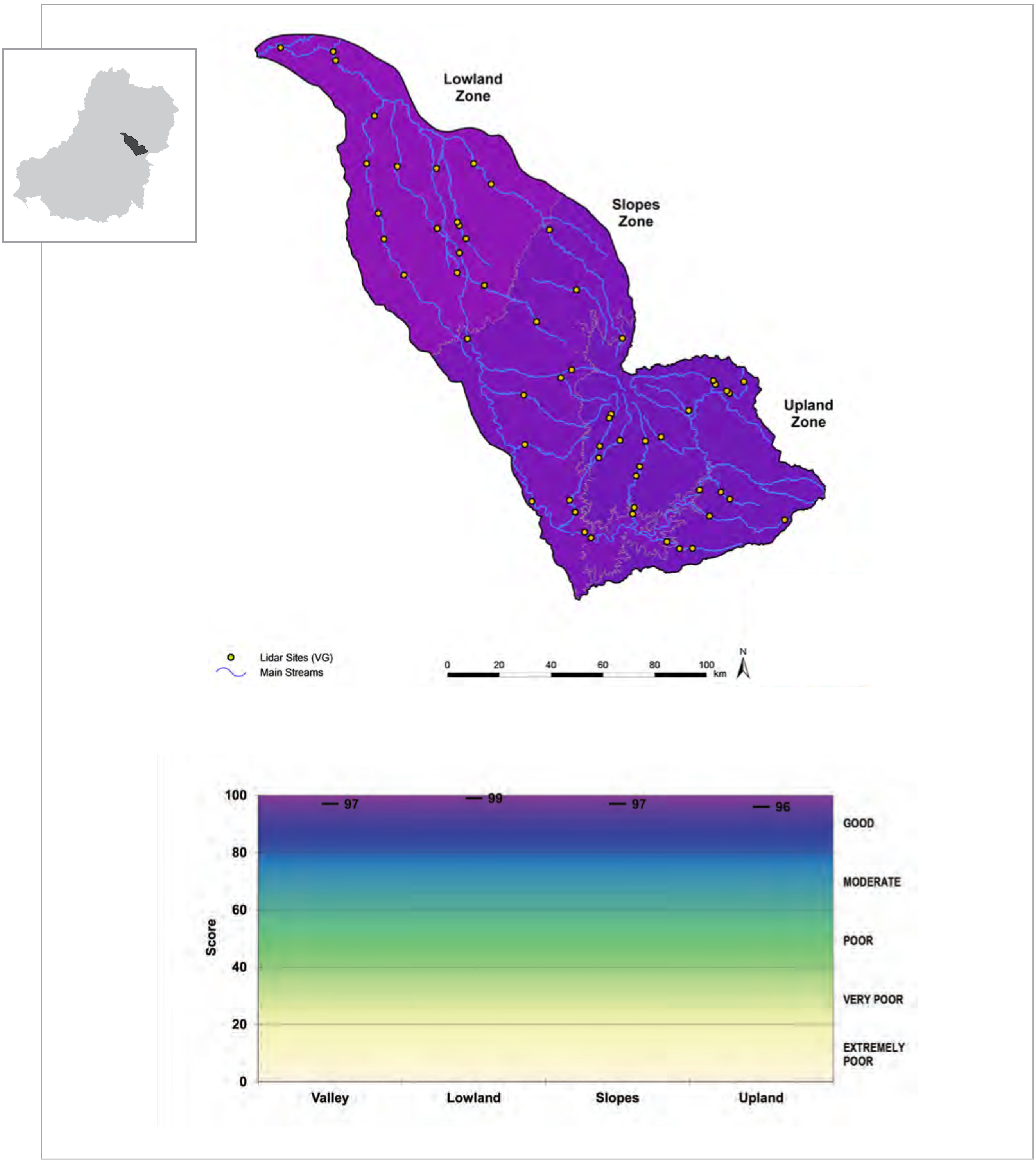

Figure CST 4: Castlereagh Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Castlereagh Valley river system was in Good condition, with an aggregate Vegetation Index score (SR–VI) of 97. Overall condition was Good for all three zones in this valley (Upland, Slopes, Lowland).

The Abundance and Diversity indicator score was 91 for the valley, indicating a Good rating overall; and it was rated Good in all three zones.

The Quality and Integrity indicator score was 82 for the valley, indicating a Good rating overall; and it was rated Good in all three zones.

The SRA Vegetation assessment for the Castlereagh Valley considers riverine vegetation in two spatial domains: Near Riparian, along 2,170 km of stream across the valley, and Lowland Floodplain, for 163 km^2 of flooding land which is part of the floodplain in the Lowland zone. The length of stream assessed is fairly evenly distributed amongst the zones, as follows: Upland, 685 km; Slopes, 759 km; and Lowland, 726 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVG) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 58 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream network amongst the three zones as follows: Upland, 20 sites; Slopes, 19 sites; and Lowland, 19 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups (MVGs).

Figure CST 4 shows values of the Vegetation Index (SR–VI) for the Castlereagh Valley and Table CST 7 shows the Index, indicator and sub-indicator values. Tables CST 8 and CST 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a near Reference Condition for the Castlereagh Valley with:

- SRA Vegetation Index (SR–VI) = 97, indicating Good condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 91, indicating near Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 82, indicating near Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

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The Abundance and Diversity of valley riverine vegetation is in Good condition overall, with MVGs in near Reference Condition in the Upland, Slopes and Lowland zones. The Good rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wide abundance in both the Near Riparian and Lowland Floodplain domains is in near Reference Condition. MVG richness is maintained near Reference Condition in both the Near Riparian and Lowland Floodplain domains, as no MVG has been completely cleared. Vegetation in the Lowland Floodplain domain has 96% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Good condition overall, and in near Reference Condition in Upland, Slopes and Lowland zones. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table CAS.6 as well as other native but non-specific MVGs. Valley-wide Nativeness in the Near Riparian domain shows a moderate difference from reference, and in the Lowland Floodplain domain it is near Reference Condition. The degree of MVG fragmentation in the Lowland Floodplain domain is also near reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain, is in Good condition overall, and the metrics show no loss of any MVG from the Near Riparian domain in any of the zones, and no loss of any MVG from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show that the domains differ. Abundance in the Near Riparian domain shows a moderate difference from Reference Condition for the Upland, Slopes and Lowland zones; and is near reference in the Lowland Floodplain domain.

Stability

- Floodplain areas within the Lowland Floodplain domain are in near Reference Condition, with little evidence of turnover or change, when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show that the domains differ. Nativeness in the Near Riparian domain shows a moderate difference from Reference Condition in the Upland, Slopes and Lowland zones; and is near reference in the Lowland Floodplain domain.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with quite big differences between zones. Structure is near Reference Condition in the Upland zone, shows a moderate difference from Reference Condition in the Slopes zone, and a large difference from reference in the Lowland zone. This sub-indicator refers only to height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of these MVGs is in near Reference Condition. Most of them have a number of patches and mean patch area that is near reference, the exception being Eucalypt Open Woodlands where the evidence of fragmentation is slight.

Under Reference Conditions, the riverine vegetation in the Castlereagh Valley was characterised as follows:

- Upland zone: The Near Riparian domain was dominated by Eucalypt Woodlands (47% of domain) and by Eucalypt Open Forests (27%) with five other MVGs of which two were greater than 5% of the domain.

- Slopes zone: The Near Riparian domain was dominated by Eucalypt Open Forests (26% of the domain), Eucalypt Woodlands (21%) and Tussock Grasslands (21%), with five other MVGs, of which only one covered more than 5% of the domain.

- Lowland zone: The Near Riparian domain was dominated by Eucalypt Open Woodlands (34% of the domain) and Eucalypt Woodlands (32%) and seven other MVGs of which two covered more than 5% of the domain.

- Lowland zone: The Lowland Floodplain domain was dominated by Eucalypt Woodlands (50%) with six other MVGs, of which four covered more than 5% of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced, particularly in the higher zones, and the proportional effect on MVGs is quite variable:

- Upland zone: Eucalypt Woodlands is reduced but still dominates the Near Riparian domain (37% of the domain area). About 36% of the domain is cleared or non-native vegetation. The most disproportionate reduction is Eucalypt Open Forests, reduced from 27% of the Near Riparian under Reference Conditions to 2%.

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- Slopes zone: Eucalypt Woodlands are so reduced that they no longer dominate the Near Riparian domain (now 9% of the domain area) and instead Tussock Grasslands (21%) and Eucalypt Open Forests (17%) are the most extensive MVGs. About 33% of the domain is now cleared. Proportionately, the most affected MVG is Callitris Forests and Woodlands, reduced from 6 to 1% of the area, while Eucalypt Woodlands are reduced by 12% in area.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are much reduced but they are still the most extensive MVG along with Eucalypt Open Woodlands (at 21% of the area). About 21% of the domain is cleared. Proportionately, the most affected MVG is Callitris Forests and Woodlands, reduced in area from 0.15% of the domain under Reference Conditions to 0.02%, while Eucalypt Open Woodlands are reduced by 14% in area.

- Lowland zone: In the Lowland Floodplain domain, although a little reduced, Eucalypt Woodlands are still the most extensive MVG in the domain (50% of area). About 4% of the domain is cleared or non-native vegetation. Proportionately, the most affected MVG is Eucalypt Open Woodlands, reduced from 14% of the domain under Reference Conditions to 10%.

Unlike the other Themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, the on-ground date for the current NVIS 3.0 mapping may range from 1997 to 2004, whereas the LiDAR was flown in November–December 2009. This means that the Structure sub-indicator for the Near Riparian domain and three metrics (abundance, richness and nativeness) are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees present. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

The riverine vegetation of the Castlereagh Valley is notable for being in near Reference Condition in all three zones, and in the Lowland Floodplain where there is little evidence of clearing, turnover or fragmentation of MVGs. Most of the metrics are based on vegetation mapping which is not current and can be variable in quality: about 1–3% of the Near Riparian area is not assigned to an MVG. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled.

In all three zones, the condition of the riverine vegetation is near Reference Condition. The score for the Lowland zone is slightly higher than for the other zones, due to higher scores for abundance and nativeness in the Near Riparian domain, and to having near reference scores for all metrics in the Lowland Floodplain domain. Unusually amongst valleys in the Murray–Darling Basin, stream lengths in the three zones are similar, and hence no one zone has a dominating influence on the Index score for the valley.

In the Lowland zone, the Lowland Floodplain domain is in better condition than the Near Riparian domain, which has metrics ranging from Very Poor to Reference Condition. These two domains assess differing but slightly overlapping parts of the landscape: the Lowland Floodplain is two patches of land that flood around the major channels, whereas the Near Riparian domain is a continuous strip centred on all stream types in the zone and covers a greater area.

Table CST 7: Castlereagh Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	97	96	97	99
Indicator	Abundance and diversity	91	85	88	100
Metric	LF stability	0.96			0.96
Sub-ind.	NRLF richness	100			100
Metric	NR richness	1	1	1	1
Metric	LF richness	1			1
Sub-ind.	NRLF abundance	97			97
Metric	NR abundance	0.70	0.64	0.67	0.79
Metric	LF abundance	0.96			0.96
Indicator	Quality and integrity	82	81	81	84
Sub-ind.	NRLF nativeness	97			97
Metric	NR nativeness	0.70	0.64	0.67	0.79
Metric	LF nativeness	0.97			0.96
Sub-ind.	NR structure	68 (61–74)	80 (69–88)	75 (62–85)	49 (36–60)
Sub-ind.	LF fragmentation	97			97

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Table CST 8: The most abundant MVGs in the Near Riparian domain in the Castlereagh Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone		
	Upland	Slopes	Lowland
MVG			
3. Eucalypt Open Forests	27	26	
5. Eucalypt Woodlands	47	21	32
6. Acacia Forests and Woodlands			15
8. Casuarina Forests and Woodlands	10	4	
11. Eucalypt Open Woodlands		11	34
19. Tussock Grasslands	8	21	
17. Chenopod Shrublands, Samphire Shrublands and Forblands			10

Table CST 9: Most abundant MVGs in the Lowland Floodplain domain in the Castlereagh Valley.
Showing percentage of domain area under Reference Condition and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
3. Eucalypt Open Forests	6	1	1
5. Eucalypt Woodlands	50	1	1
6. Acacia Forests and Woodlands	6	1	1
11. Eucalypt Open Woodlands	14	1	0.8
21. Other Grasslands, Herblands, Sedgelands and Rushlands	5	1	1
22. Chenopod Shrublands, Samphire Shrublands and Forbland	15	1	1

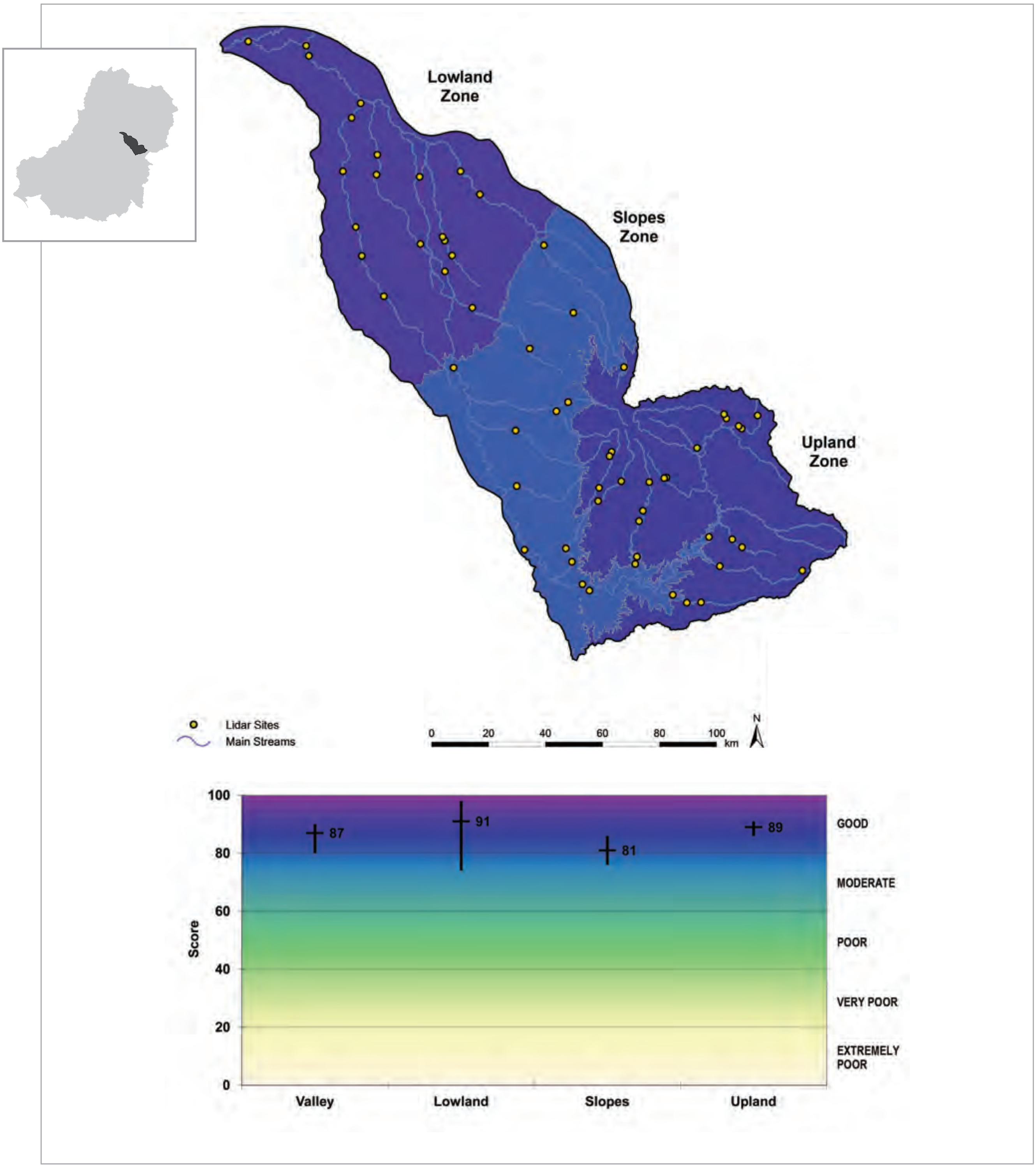

Figure CST 5: Castlereagh Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR-PI) scores.

Graph shows mean SR-PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Castlereagh Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 87. The condition of Physical Form in the zones was: Upland, Slopes and Lowland Good. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics and Floodplain Dynamics were rated as Moderate. Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation in the Slopes and Lowland zones. There were also indications of bed aggradation and channel narrowing in the Lowland zone.

The SRA Physical Form assessment considers physical form and processes along 2,170 km of stream across the valley. It is based on LiDAR data collected at 60 sites along river channels, as well as modelling of all 152 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure CST 4 shows values of the Physical Form Index (SR–PI) for the Castlereagh Valley and Table CST 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a near Reference Condition for the Castlereagh Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 87 (CL 80–90), indicating Good Physical Form condition
- the Channel Form indicator = 90 (CL 84–95), showing near Reference Condition
- the Bed Dynamics indicator = 68 (CL 64–71), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 99 (CL 98–99), showing near Reference Condition
- the Floodplain indicator = 61 (CL 51–69), showing a moderate difference from Reference Condition.

Upland zone

There were 21 LiDAR survey sites and 26 SedNet river segments in the Upland zone of the Castlereagh Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period. Channel Depth was modified from Reference Condition for approximately half of the Upland zone. At these sites results show both increases and decreases in Channel

Depth across the zone. Sinuosity, Meander Wavelength and Bank Variability were modified from Reference Condition for less than half of the Upland zone. At these sites Sinuosity was generally reduced, Meander Wavelength was generally increased (a few sites having large increases) and results show both increases and decreases in Bank Variability across the zone. Channel Width, Channel Width Variability and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

Slopes zone

There were 19 LiDAR survey sites and 62 SedNet river segments in the Slopes zone of the Castlereagh Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period. Channel Width, Sinuosity, Meander Wavelength and Bank Variability were modified from Reference Condition for approximately half of the Slopes zone. At these sites Channel Width was generally increased, results show both increases and decreases in Sinuosity across the zone, Meander Wavelength was generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Depth, Channel Width Variability and Channel Sediment Deposition were modified from reference for less than half of the Slopes zone. At these sites Channel Depth was generally reduced, Channel Width Variability was generally increased and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period.

Lowland zone

There were 20 LiDAR survey sites and 64 SedNet river segments in the Lowland zone of the Castlereagh Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Depth was modified from Reference Condition in more than half of the Lowland zone. At these sites Channel Depth was generally reduced. Channel Width and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites Channel Width was generally reduced (with a large reduction at over half of these sites) and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Channel Width Variability and Meander Wavelength were modified from reference for less than half of the Lowland zone. At these sites Channel Width Variability was generally increased and Meander Wavelength was generally increased (a few sites having large increases). Sinuosity and Bank Variability were largely unmodified from reference in the Lowland zone.

Channel Form

There was little change from Reference Condition in Channel Form in the Upland zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale. Adjustments to Channel Planform in the Upland zone will be constrained by bedrock. Local knowledge is required to interpret any departures from reference planform in bedrock channels.

There was little change from Reference Condition in Channel Form in the Slopes zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was channel contraction. Channel contraction was indicated at 70% of sites as a result of channel narrowing and bed aggradation.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Upland zone. There was little change from Reference Condition in Bank Dynamics in the Slopes zone. Bank variability exceeded Reference Conditions at 40% of sites. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result. There was little change from Reference Condition in Bank Dynamics in the Lowland zone.

There was minor change from Reference Condition in Bed Dynamics in the Upland zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was considerable change from reference in Bed Dynamics in the Slopes zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was minor change from Reference Condition in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (40% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments).

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was minor change from Reference Condition in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (100% of SedNet river segments). There was minor change from Reference Condition in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

Table CST 10: Castlereagh Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Physical Form Condition (SR–PI)	87 (80–90)	89 (86–91)	81 (76–86)	91 (74–98)
Indicator	Channel Form (volume and flow events)	90 (84–95)	93 (86–99)	94 (87–98)	84 (72–93)
Sub-ind.	Cross-section Form	86 (80–90)	95 (91–98)	90 (82–96)	72 (58–83)
Metric	Channel Depth (mean)	0.95 (8.89–1.00)	1.01 (0.96–1.07)	0.95 (0.86–1.03)	0.88 (0.74–1.00)
Metric	Channel Width (mean)	0.99 (0.93–1.07)	0.99 (0.96–1.00)	1.03 (0.94–1.12)	0.96 (0.80–1.15)
Sub-ind.	Cross-section Form (variability)	98 (97–100)	97 (92–100)	99 (98–100)	99 (98–100)
Metric	Channel Width (CV)	1.05 (1.01–1.09)	1.01 (0.95–1.09)	1.07 (1.00–1.15)	1.07 (1.01–1.14)
Sub-ind.	Channel Planform	89 (84–93)	89 (79–95)	86 (78–93)	92 (84–97)
Metric	Sinuosity	1.02 (0.99–1.06)	1.03 (0.99–1.09)	1.03 (0.98–1.10)	1.01 (1.00–1.05)
Metric	Meander Wavelength	1.03 (1.00–1.08)	1.05 (0.99–1.13)	1.03 (0.96–1.09)	1.02 (0.96–1.08)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Bed Dynamics	68 (64–71)	68 (63–70)	59 (52–65)	78 (70–84)
Metric	Channel Sediment Ratio	67 (58–77)	89 (72–104)	91 (74–113)	23 (14–31)
Metric	Channel Sediment Depth	0.002 (0.001–0.003)	0.001 (0–0.004)	0.003 (0.002–0.005)	0.001 (0.001–0.002)
Indicator	Bank Dynamics	99 (98–99)	99 (98–100)	98 (96–99)	100 (99–100)
Metric	Bank Variability (longitudinal)	1.05 (1.02–1.09)	1.01 (0.98–1.05)	1.09 (1.02–1.17)	1.05 (1.01–1.09)
Indicator	Floodplain	61 (51–69)	53 (35–72)	60 (47–73)	70 (56–83)
Metric	Floodplain sediment deposition	3.00 (2.00–4.00)	3.00 (2.00–4.00)	3.00 (2.00–5.00)	2.00 (1.24–4.00)

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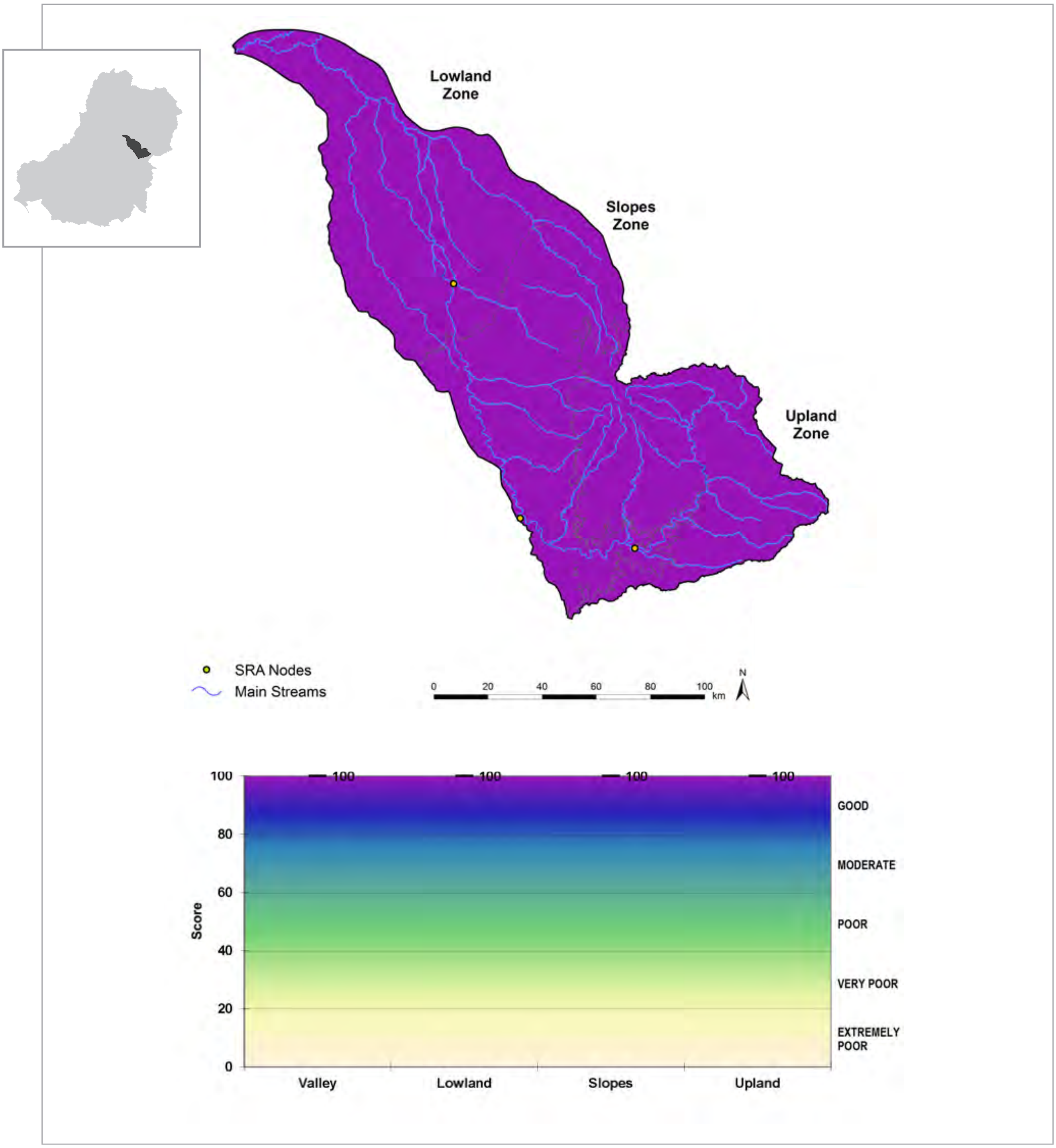

Figure CST 6: Castlereagh Valley map with zones coloured by SRA Hydrology Index (SR-HI) scores.
Graph shows SR-HI scores as horizontal bars.

The Hydrology of the Castlereagh Valley river system was in Good condition, with an aggregate Hydrology Index score (SR–HI) of 100. The Lowland, Slopes and Upland zones were all in Good condition.

The mainstem river system and headwater streams of the Castlereagh Valley were rated in Good condition. Throughout some of the headwater streams the magnitude of low flows was reduced relative to Reference Condition.

The Castlereagh River rises in the Great Dividing Range south-west of Coonabarabran and flows north-west to the Barwon and lower Macquarie rivers via a network of channels. The Castlereagh has several foothill tributaries, and there are also tributaries running parallel to the channel in the Lowland zone, some joining the river within 50 km of the valley terminus. There are no major instream storages or irrigation developments.

In the Castlereagh Valley, hydrological condition is assessed using metrics of hydrological alteration available for 2,706 km of mainstem rivers and headwater streams. There are 383 km of mainstem river extending across the Lowland and Slopes zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily water resource modelling. In the Castlereagh Valley there is 2,323 km of headwater stream (Upland zone: 984 km; Slopes zone: 1,121 km; Lowland zone: 217 km). In these headwater streams, SRA hydrology metrics represent the effects of farm dams and tree cover change since European settlement.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Castlereagh Valley there is 1,338 km of these mid-size tributaries (233 km in the Upland zone; 491 km in the Slopes zone; 615 km in the Lowland zone) which is 0.5 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwaters streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures CST 6 and CST 7 show values of the Hydrology Condition Index (SR–HI) for the Castlereagh Valley and its river network, and Table CST 11 and CST 12 show the Index, sub-index, indicator and metric values. Analyses showed near Reference Condition for the Castlereagh Valley, with:

- The Hydrology Condition Index for the whole valley = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for the Upland, Slopes and Lowland zones = 100, 100 and 100, all indicating Good condition.
- The Hydrology Condition Index for headwater streams (valley-wide) = 100, indicating Good hydrological condition.

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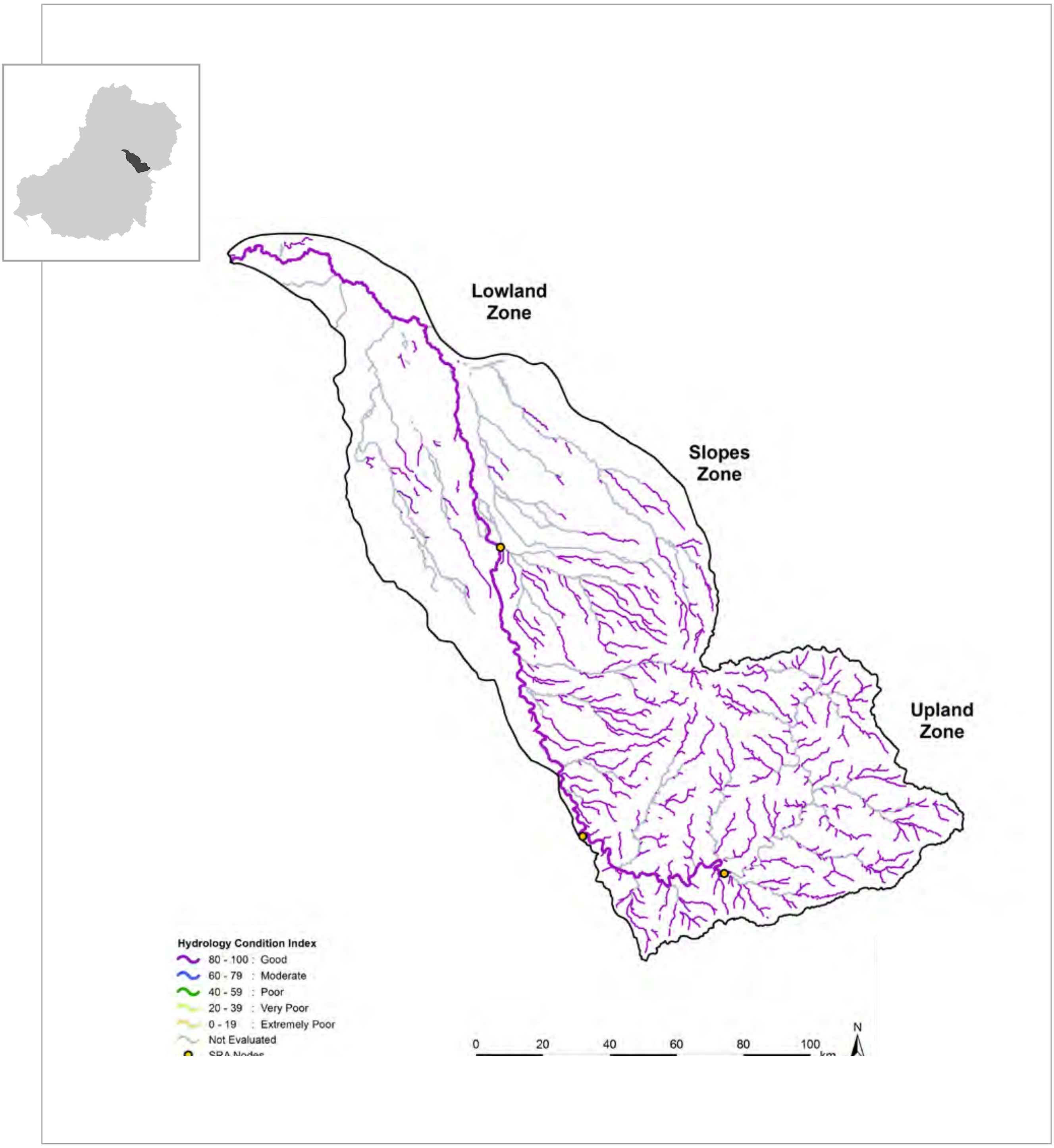

Figure CST 7: Castlereagh Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

- The Hydrology Condition Index for mainstem rivers (valley-wide) = 100, indicating Good hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 100, indicating Good condition and near Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 100, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows). In addition, results for the Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to reference.

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed only small variations from Reference Condition throughout the mainstem river length (mostly associated with increased flows). Results for the High Flow Spells metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a significant alteration from Reference Condition in 2% of the headwater river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

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In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed only small variations from Reference Condition throughout the mainstem river length (mostly associated with increased flows). Results for the Zero Flows Proportion metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows). Results for the Low Flow Spells metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a significant alteration from reference in 40% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed only small variations from reference throughout the mainstem river length (mostly associated with an increased amplitude). Results for the Seasonal Period metric showed only small variations from reference throughout the mainstem river length.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a significant alteration from reference in 2% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone and most in the Slopes zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased variability).

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed only small variations from reference throughout the headwater river length (mostly associated with reduced variability).

Low Over Bank Floods

The Low Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 1-year flood in the reference regime. It is calculated from a combination of the Low Over Bank Flood Duration metric and the Low Over Bank Flood Spells metric. The Low Over Bank Flood Duration metric quantifies change in the duration of flooding of low-level floodplain areas relative to Reference Condition. The Low Over Bank Flood Spells metric quantifies change in the duration of time between low-level floodplain inundation events relative to reference. The Low Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly timestep.

In the mainstem rivers, the Low Over Bank Floods indicator showed near Reference Condition. Results for the Low Over Bank Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows). Results for the Low Over Bank Flow Spells metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

High Over Bank Floods

The High Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 8-year flood in the reference regime. It is calculated from a combination of the High Over Bank Flood Duration metric and the High Over Bank Flood Spells metric. The High Over Bank Flood Duration metric quantifies change in the duration of flooding of high-level floodplain areas relative to Reference Condition. The High Over Bank Flood Spells metric quantifies change in the duration of time between high-level floodplain inundation events relative to reference. The High Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly timestep.

In the mainstem rivers, the High Over Bank Floods indicator showed near Reference Condition. Results for the High Over Bank Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows). Results for the High Over Bank Flow Spells metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

Summary: mainstem rivers

The mainstem river system of the Castlereagh Valley was generally characterised by little or no alteration in High Over Bank Floods, Low Over Bank Floods, Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events or Flow Gross Volume, relative to Reference Condition.

Summary: headwater streams

The headwater streams of the Castlereagh Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events or Flow Gross Volume, relative to Reference Condition. Throughout some of the headwater streams the magnitude of low flows was reduced.

Table CST 11: Castlereagh Valley SRA Hydrology Condition Index at valley and zone scales.
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	100		100	100	100

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Table CST 12: Castlereagh Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**100 (100–100)**	**100 (100–100)**
Sub-Index	In-Channel Flow Regime	100 (100–100)	100 (100–100)
Indicator	**In-Channel Flow Regime A (volume and flow events)**	**100 (100–100)**	**100 (98–100)**
Sub-ind.	Flow Gross Volume	100 (100–100)	100 (93–100)
Metric	Mean Annual Flow	1.00 (1.00–1.00)	1.01 (1.00–1.17)
Metric	Flow Duration	1.00 (1.00–1.00)	0.98 (0.94–1.18)
Sub-ind.	High Flow Events	99 (99–99)	99 (79–100)
Metric	High Flow	1.00 (1.00–1.00)	0.97 (0.76–1.54)
Metric	High Flow Spells	1.00 (1.00–1.00)	
Sub-ind.	Low and Zero Flow Events	98 (98–98)	96 (84–99)
Metric	Zero Flows Proportion	1.00 (1.00–1.00)	0.99 (0.96–1.00)
Metric	Low Flow	1.00 (1.00–1.00)	0.84 (0.54–1.12)
Metric	Low Flow Spells	1.00 (1.00–1.00)	
Indicator	**In-Channel Flow Regime B (seasonality & variability)**	**100 (100–100)**	**100 (93–100)**
Sub-ind.	Flow Seasonality	100 (100–100)	98 (68–100)
Metric	Flow Seasonal Amplitude	1.00 (1.00–1.00)	1.02 (0.89–1.62)
Metric	Flow Seasonal Period	1.00 (1.00–1.00)	0.97 (0.93–1.00)
Sub-ind.	Flow Variability	100 (100–100)	95 (78–100)
Metric	Flow Variation	1.00 (1.00–1.00)	0.94 (0.84–1.00)
Sub-Index	Over Bank Flow Regime	100 (100–100)	
Indicator	**Over Bank Floods Low**	**99 (99–99)**	
Metric	OB Flow Duration (ARI 1)	1.00 (1.00–1.00)	
Metric	OB Flow Spells (ARI 1)	1.00 (1.00–1.00)	
Indicator	**Over Bank Floods High**	**98 (98–98)**	
Metric	OB Flow Duration (ARI 8)	1.00 (1.00–1.00)	
Metric	OB Flow Spells (ARI 8)	1.00 (1.00–1.00)	

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
		100	**100**		**100**	**100**
		100	100		100	100
		100	**100**		**100**	**100**
		100	100		100	100
		1.00	1.00		1.02	1.01
		1.00	1.00		1.00	0.98
		99	99		100	99
		1.00	1.00		1.00	0.95
		1.00	1.00			
		98	98		97	96
		1.00	1.00		0.99	1.00
		1.00	1.00		0.88	0.83
		1.00	1.00			
		100	**100**		**100**	**100**
		100	100		98	98
		1.00	1.00		1.04	1.01
		1.00	1.00		0.97	0.97
		100	100		96	94
		1.00	1.00		0.95	0.93
		100	100			
		99	**99**			
		1.00	1.00			
		1.00	1.00			
		98	**98**			
			1.00			
			1.00			

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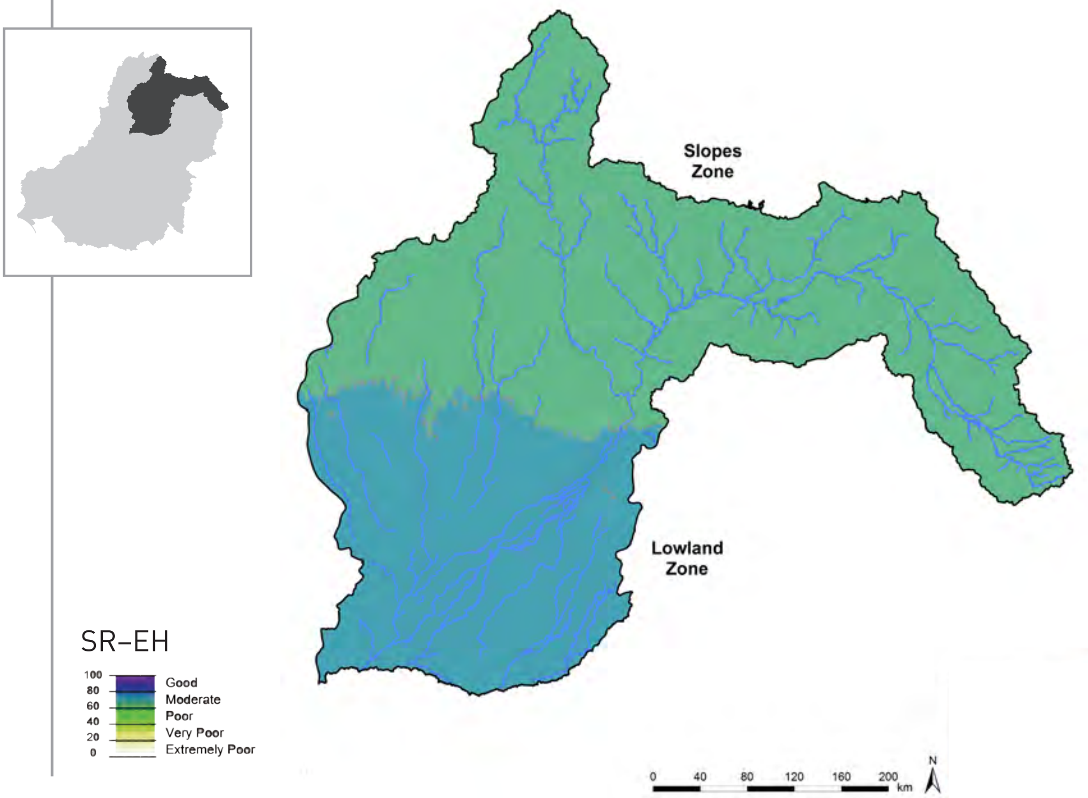

Figure CON 1: Condamine Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure CON 1 shows the Ecosystem Health ratings for the Condamine Valley and Tables CON 1 and CON 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Condamine Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Moderate, Moderate and Good condition respectively, while Hydrology and Physical Form were both in Moderate condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Condamine Valley river system. River Ecosystem Health was rated as Poor (Lowland zone: Moderate; Slopes zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

Ecosystem Health

The Condamine Valley ranked fourth amongst the 23 SRA valleys in terms of River Ecosystem Health (see Table 5.2) and among the top three valleys rates as being in Poor health. It was in the upper 50% for all Theme condition indices except Physical Form for which it ranked equal 19th with the Gwydir and Avoca valleys.

The Condamine Valley river ecosystem was in Poor Health. River Ecosystem Health for the zones was as follows: Slopes Poor; Lowland Moderate. The Fish community was in Moderate condition. Several expected species were absent. Species counts, abundance and biomass were dominated by native species; but native species recruitment was limited. The Macroinvertebrate community was in Moderate condition, with declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Good condition overall; with moderate reductions in abundance, stability and nativeness in the Near Riparian and Lowland Floodplain areas; and moderate fragmentation in the Lowland Floodplain. The Physical Form of the river system was in Moderate condition with bank dynamics in Good condition and channel form and bed dynamics in Moderate condition. There were moderate levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition. There was a significant alteration from Reference Condition for the mean annual flow metric for mainstem rivers, and moderate alteration for all other indicators except flow duration and low over-bank flows. The headwater streams of the Condamine Valley were generally characterised by near Reference Condition or minor alteration for all indicators.

The Condamine system consists of a number of streams several of which contain in-stream storages and weirs. There is a large capacity for off-stream storage as well, indicating a potential for water management to influence ecosystem health, though the Hydrology Index indicates only minor change from Reference.

The Condamine and Castlereagh valleys have experienced broadly similar climatic conditions during the period 2001–10 with drought prevailing until 2008, when major rainfall occurred, particularly in the lowlands. Further rain fell in 2009 followed by the Basin-wide wet conditions of 2010–11. The two ecosystems were assessed as being in similar health in this SRA2 reporting period (ranked fourth and third respectively). These are the only two valleys in which fish sampling occurred more than a year after the onset of wetter conditions and both appeared to have an increase in Fish Condition between SRA1 and SRA2 (though this was not statistically significant for the Condamine) and both showed some increase in Macroinvertebrate Condition in the last sampling round. Further studies will be needed to determine if this represents a response amongst fish and macroinvertebrates to the drought breaking and, if so (and if repeated in other valleys) the extent the response is modified by other (non-hydrological) components of the ecosystem.

Fish Theme

The Fish Condition Index SR–FI = 65, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Moderate). The Expectedness indicator = 57, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 81, indicating Good condition, and near Reference Condition. The Recruitment indicator = 70, indicating Moderate condition, and a moderate difference from Reference Condition. Recruitment amongst native species was limited to golden perch, bony herring and short-lived species.

The fish community of the Condamine Valley had reduced numbers of expected native species, though native fish outnumbered alien fish by more than 3:1 and accounted for 57% of total biomass.

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Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 77, indicating Moderate condition (Lowland zone: Good; Slopes zone: Moderate). The simOE metric = 51 indicating a moderate to large difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Good condition was high (22 sites, 63%) across all zones, and only six of the 35 rated sites (17%) were in Poor or Very Poor condition.

Family richness was low (average 19 families per site), with the Slopes zone being most diverse.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 83, indicating Good condition (Lowland zone: Good; Slopes zone: Moderate). The Vegetation Abundance and Diversity indicator = 79, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and stability of major vegetation groups within Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 82, indicating Good condition and a minor difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is moderately affected by clearing, with the abundance and degree of fragmentation of major vegetation groups in the sampled area being moderately different from Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 71, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate). The Channel Form indicator = 69 and the Bed Dynamics indicator = 70; both indicating Moderate condition and showing a minor difference from Reference Condition. The Bank Dynamics indicator = 84 and the Floodplain Form indicator = 80; both indicating Good condition and showing near Reference Condition.

Overall, the valley's riverine physical form was characterised by enlarged channels with evidence of channel widening and bed degradation. There was also indication of elevated sediment loads since European settlement.

Hydrology Theme

The Hydrology Condition Index SR–HI = 74, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Moderate). The In-Channel Flow Regime indicator = 64, indicating Moderate condition and a minor difference from Reference Condition for the flow regime within the channels. The Over Bank Flow Regime sub-index = 80, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

The mainstem river reaches were generally characterised by minor alteration relative to Reference Condition in High Over Bank Floods, Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume and little or no alteration in Low Over Bank Floods. The headwater streams were generally characterised by little or no alteration in these indicators.

Table CON 1: Condamine Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	SLOPES	LOWLAND
		Poor	Poor	Moderate

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Fish	SCORE RATING	65 (48–72) Moderate	69 (46–81) Moderate	58 (42–70) Poor
Macro–invertebrates	SCORE RATING	77 (71–82) Moderate	74 (66–81) Moderate	80 (72–86) Good
Vegetation	SCORE RATING	83 Good	71 Moderate	100 Good

Table CON 2: Condamine Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Physical Form	SCORE RATING	71 (59–81) Moderate	73 (59–82) Moderate	69 (46–86) Moderate
Hydrology	SCORE RATING	74 Moderate	78 Moderate	56 Poor

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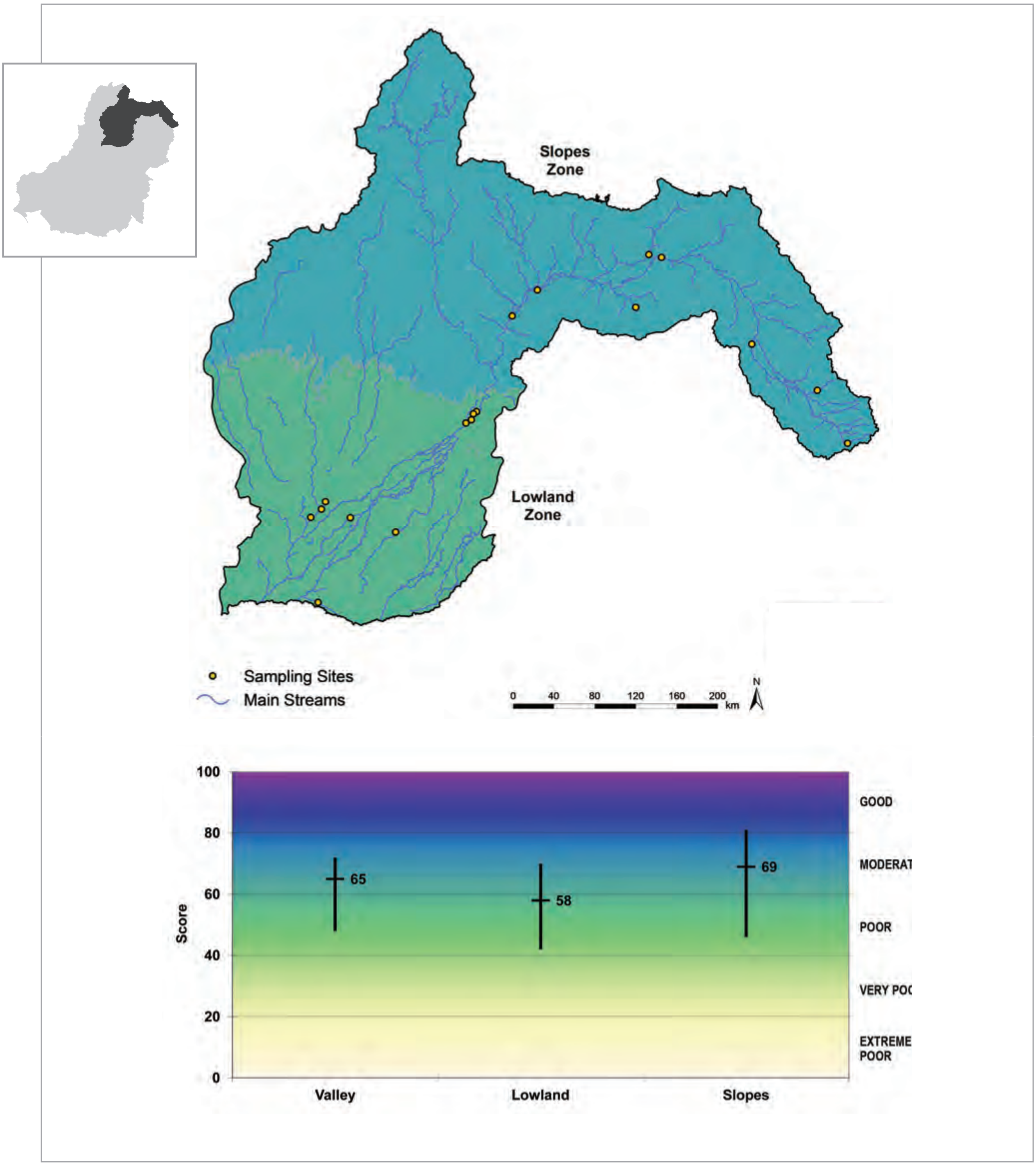

Figure CON 2: Condamine Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Condamine Valley river system was in Moderate condition, with an aggregate Fish Index score (SR–FI) of 65. The condition of the fish community in the zones was as follows: Slopes Moderate, and Lowland Poor. The fish community was characterised by a poor score for expected native fish species, a good score for nativeness and a moderate score for native fish recruitment. The Slopes zone in particular lacked 50% of the predicted native species. The valley had reduced native species richness. Alien species contributed 43% of the biomass in samples. Native fish recruitment was moderate in both the Slopes and Lowland zones and in the valley overall.

Eighteen sites were surveyed across the Condamine Valley in February–June 2010, yielding 8,198 fish. Analyses showed a moderate difference from Reference Condition for the Condamine Valley, with:

- SRA Fish Index (SR–FI) = 65 (CL 48–72), indicating Moderate condition of the fish community.
- The Expectedness indicator = 57 (CL 49–65), indicating Poor condition, and a large difference from Reference Condition. Only 67% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 81 (CL 72–87), indicating Good condition, and a minor difference from Reference Condition.
- The Recruitment indicator = 70 (CL 47–76), indicating Moderate condition, and a moderate difference from Reference Condition. Evidence of recruitment was observed for 9 of the 12 native species observed in the valley.

Figure CON 2 shows sampling sites, zones and corresponding SR–FI values, and Table CON 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Condamine Valley was second highest for all valleys, and close to that for Border Rivers Valley. The Lowland zone community was in poorer condition (SR–FI = 58) than that in the Slopes zone (SR–FI = 69).

Nativeness and Expectedness varied between zones. Expectedness was higher in the Lowland zone (a score of 67) than in the Slopes zone (50). The Nativeness score was 94 for the Slopes zone, reflecting the fact that native fish had higher species richness, total biomass, and numbers of individuals compared to alien fish. The Lowland zone scored 63 for the Nativeness indicator.

Throughout the valley, 76% of the fish caught belonged to native species. In the Slopes zone, although only half of the expected species were caught, 96% of the catch consisted of native fish.. With the exception of golden perch there were few large-bodied native fish caught and, on average, individual alien fish were more than twice as heavy as native fish.

Table CON 4 shows native species abundances in the Condamine Valley compared with Reference Condition. Bony herring were numerous throughout the valley as were gudgeons—the latter particularly in the Slopes zone. Spangled perch were also numerous, mainly in the Lowland zone. Rendahl's tandan and the endangered Southern purple-spotted gudgeon were expected to occur in both zones (under Reference Condition) but did not appear in samples. Very few specimens of the larger native species, including Murray cod and silver perch, were captured. The exception was golden perch, of which 96 specimens were captured in total at 15 of the 18 sites sampled. Evidence of golden perch recruitment was observed in both zones, at a total of seven sites.

Evidence of recruitment amongst native species was limited to golden perch, bony herring and short-lived species. All three alien species showed evidence of recruitment throughout the valley.

In general, the fish community of the Condamine had reduced numbers of expected native species, though the native fish outnumbered alien fish by more than 3:1 and accounted for 57% of total biomass.

Table CON 3: Condamine Valley SRA Fish Condition Index, indicators, metrics and derived variables.

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Fish Condition (SR–FI)	65 (48–72)	69 (46–81)	58 (42–70)
Indicator	Expectedness	57 (49–65)	50 (39–61)	67 (56–78)
Metric	O/E	0.52 (0.41–0.63)	0.50 (0.34–0.65)	0.55 (0.40–0.70)
Metric	O/P (Zone level)	0.56 (0.56–0.56)	0.50 (0.50–0.50)	0.64 (0.64–0.64)
Indicator	Nativeness	81 (72–87)	94 (79–98)	63 (54–77)
Metric	Proportion biomass native	0.68 (0.56–0.80)	0.80 (0.64–0.94)	0.51 (0.33–0.70)
Metric	Proportion abundance native	0.77 (0.65–0.88)	0.87 (0.69–0.98)	0.64 (0.47–0.79)
Metric	Proportion species native	0.64 (0.58–0.69)	0.65 (0.57–0.73)	0.61 (0.54–0.68)

Continued/...,

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Indicator	Recruitment	70 (47–76)	78 (47–88)	60 (36–71)
Metric	Proportion of sites with native recruits	0.64 (0.47–0.68)	0.66 (0.46–0.76)	0.60 (0.39–0.65)
Metric	Proportion of native taxa with recruits	0.84 (0.77–0.95)	0.89 (0.75–1.00)	0.78 (0.71–1.00)
Metric	Proportion of abundance as recruits	0.67 (0.56–0.71)	0.71 (0.58–0.78)	0.61 (0.45–0.68)
Variables				
	Number of sites sampled	18	8	10
	Total number of species	15	12	12
	Number of native species	12	9	9
	Number of predicted species	18	18	14
	Number of alien species	3	3	3
	Mean number of fish per site	455	568	366
	Biomass/site all species (g)	8244	6659	9511
	Mean native biomassfish (g)	13	11	19
	Mean alien biomass/fish (g)	33	32	33

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Table CON 4: Condamine Valley number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone	
		Slopes	Lowland
Sites sampled	18	8	10
Native species			
Australian smelt	31	17	14
Bony herring	2828	1962	866
Dwarf flathead gudgeon	0	0	
Flathead gudgeon	0	0	
Freshwater catfish	2	2	0
Golden perch	96	34	62
Gudgeon	2270	2257	13
Hyrtl's tandan	2	0	2
Mountain galaxias	0	0	
Murray cod	1	0	1
Murray–Darling rainbowfish	42	36	6
Olive perchlet	3	3	0
Rendahl's tandan	0	0	0
River blackfish	0	0	
Silver perch	2	0	2

Fish species	Valley	Zone	
		Slopes	Lowland
Southern purple-spotted gudgeon	0	0	0
Spangled perch	977	56	921
Unspecked hardyhead	8	8	0
Alien species			
Common carp	1611	4	1607
Gambusia	300	144	156
Goldfish	25	18	7

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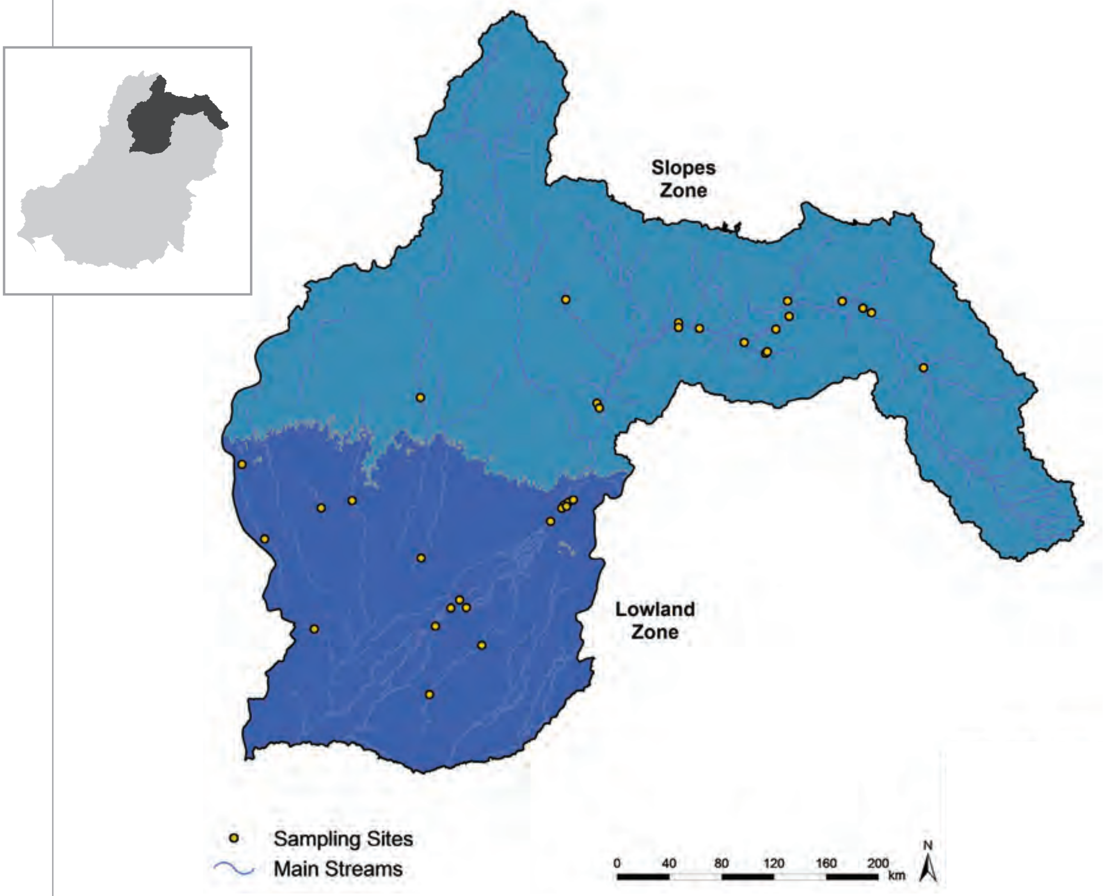

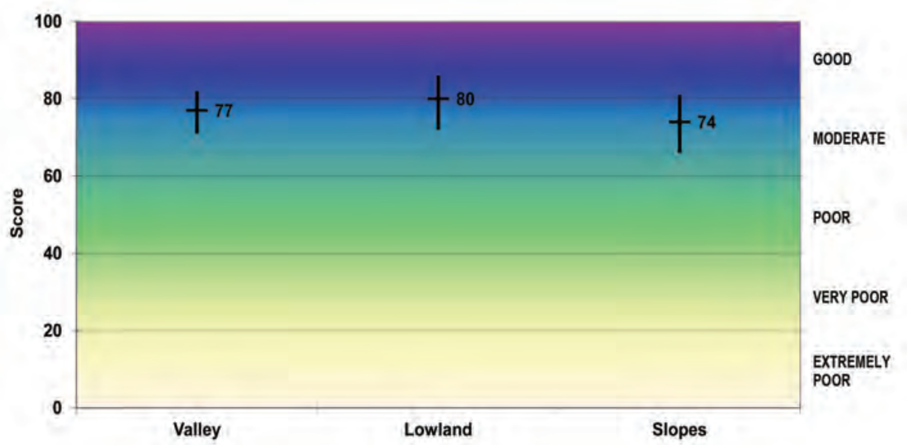

Figure CON 3: Condamine Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Condamine Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 77. The condition of the Macroinvertebrate community in the zones was as follows: Slopes Moderate; Lowland Good. The proportion of sites in Good condition was high across all zones (21 of 35 rated sites, 60%); only 6 (17%) were in Poor or Very Poor condition. Family richness generally was low, and was reduced compared to Reference Condition.

Thirty-five sites were surveyed across the Condamine Valley in April–June 2009 yielding 5,473 macroinvertebrates in 44 families (47% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 77 (CL 71–82), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 51 (CL 49–53) indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Good condition was high (21 sites, 60%) across all zones, and only six of the 35 rated sites (17%) were in Poor or Very Poor condition.
- The number of families found was lowest in the Lowland zone (37 families) and highest in the Slopes zone (43 families), which also had the highest average number of families per site (21).

Figure CON 3 shows sampling sites, zones and SR–MI values, and Table CON 5 shows Index and metric values. The SR–MI score for the Condamine Valley indicated Moderate condition of macroinvertebrate communities, rating 9th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The Lowland zone showed a minor difference, whereas the Upland zone showed a moderate difference from Reference Condition (SR–MI = 80 and 74). Only two sites showed a very large or extremely large difference from Reference Condition. Expectedness (simOE) was Moderate and varied only moderately (by up to seven points) across both zones.

Table CON 6 shows that most sites (29) in both zones had moderate to high SR–MI values indicative of Moderate to Good condition, 21 of which were rated in Good condition. Each zone had only one site with a low simOE score (<40 points). Most sites had close to the expected diversities of macroinvertebrates, though coupled with a reduction in frequency of occurrence of the families present.

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Family richness generally was reduced compared to Reference Condition. Diversity was low (average 19 families per site), with the Slopes zone being most diverse (average 21 families per site). The valley contained 47% of the families found across the Basin (Table CON 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (>84%) of the fauna of the valley was found in each of the zones.

Table CON 5: Condamine Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower – upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	77 (71–82)	74 (66–81)	80 (72–86)
Metric	SimOE	51 (49–53)	50 (46–53)	53 (49–55)

Table CON 6: Condamine Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone	
		Slopes	Lowland
Sites			
Number of sites sampled	35	17	18
Number of sites with index values*	35	17	18
N sites by SR–MI condition band			
Good (80–100)	21	8	13
Moderate (60–80)	8	5	3
Poor (40–60)	4	3	1
Very or Extremely Poor (0–40)	2	1	1
Families			
Number of families sampled	44	43	37
No. families/site (min–max)	19 (7–26)	21 (9–26)	17 (7–22)
Percent of families in Basin	47	46	39
Percent of families in valley	100	98	84

*simOE values could occasionally not be derived for every sample site.

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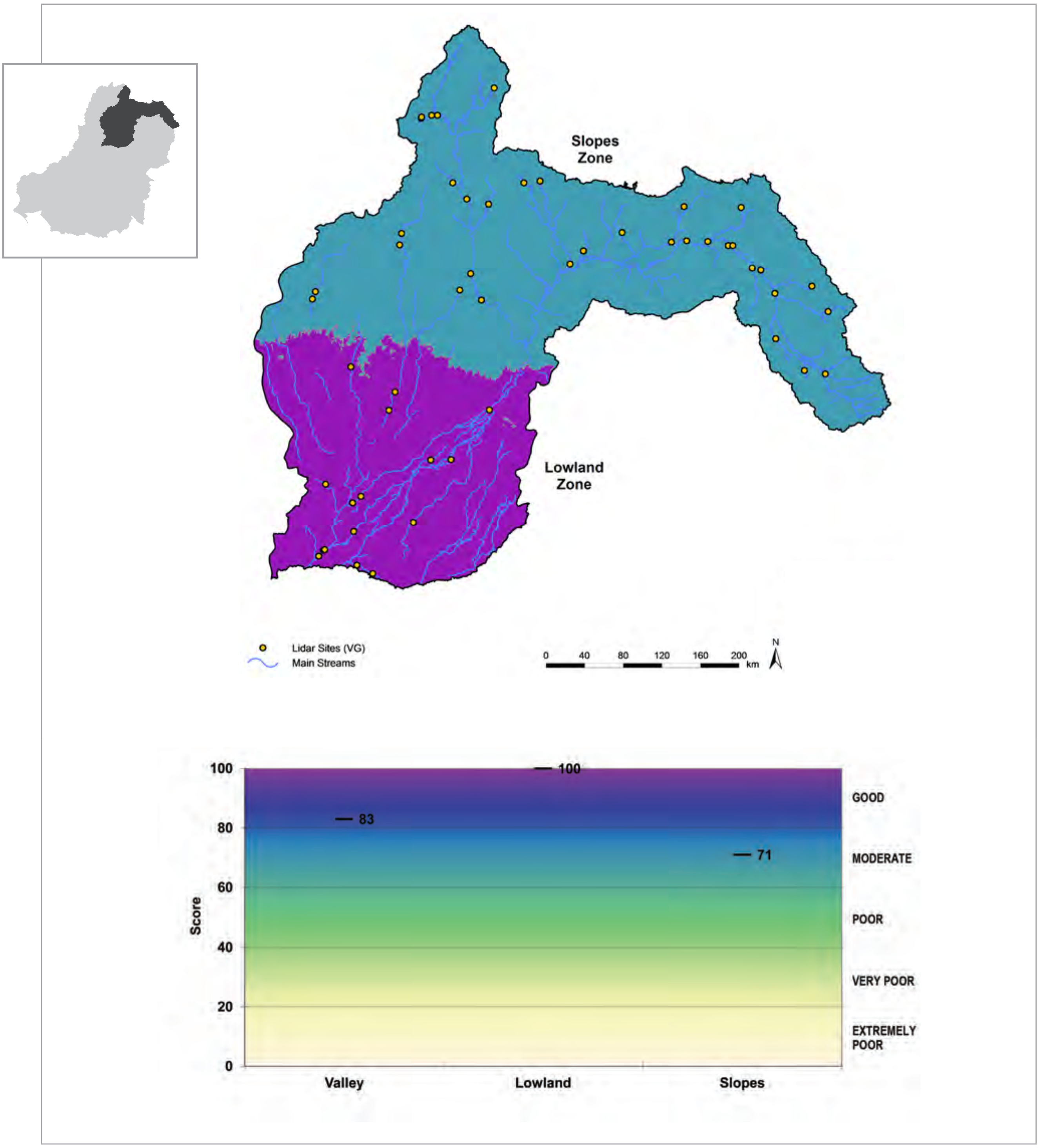

Figure CON 4: Condamine Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Condamine Valley river system was in Good condition, with an aggregate Vegetation Index score (SR–VI) of 83. Overall condition for the two zones in this valley was: Slopes Moderate; Lowland Good.

The Abundance and Diversity indicator score was 79 for the valley, indicating a Moderate rating overall. In the two zones it was: Slopes Moderate; Lowland Good.

The Quality and Integrity indicator score was 82 for the valley, indicating a Good rating overall. In the two zones it was: Slopes Moderate; Lowland Good.

The SRA Vegetation assessment for the Condamine Valley considers riverine vegetation in two spatial domains: Near Riparian, along 8,886 km of stream, and Lowland Floodplain, for 8,046 km^2 of flooding land in the Lowland zone, which is part of the actual floodplain. Slightly more (58%) of the stream length is in the Slopes zone, and the length of stream assessed per zone is as follows: Slopes, 5,133 km; and Lowland, 3,752 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVG) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 51 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the network in each zone, as follows: Slopes, 35 sites; and Lowland, 16 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups (MVGs).

Figure CON 4 shows values of the Vegetation Index (SR–VI) for the Condamine Valley and Table CON 7 shows the Index, indicator and sub-indicator values. Tables CON 8 and CON 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a near Reference Condition for the Condamine Valley with:

- SRA Vegetation Index (SR–VI) = 83, indicating Good condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 79, indicating a moderate difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 82, indicating a near Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is moderately affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is moderately different from Reference Condition.

CONDAMINE VALLEY

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with a moderate difference from Reference Condition in the Slopes zone and near reference in the Lowland zone. The Moderate rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wide abundance in the Near Riparian and Lowland Floodplain domains both show a moderate difference from reference. MVG richness is maintained near reference overall, and in both domains. Vegetation in the Lowland Floodplain domain has 69% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Good condition overall, showing a moderate difference from Reference Condition in the Slopes zone and is near reference in the Lowlands zone. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table CON 8 as well as other native but non-specific MVGs. Valley-wide Nativeness shows a moderate difference from reference in both the Near Riparian and Lowland Floodplain domains. The degree of MVG fragmentation shows a moderate difference from Reference Condition.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall. The metrics show differences between zones and domains, with the loss of one MVG out of ten originally present in the Slopes zone, and no loss of any MVG from the Near Riparian and Lowland Floodplain domains in the Lowland zone, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, with the metrics showing differences between zones and domains. Abundance in the Near Riparian domain shows a large difference from Reference Condition in the Slopes zone and near reference in the Lowland zone; and in the Lowland Floodplain domain, it shows a moderate difference from reference.

Stability

- Floodplain areas within the Lowland Floodplain domain are in Moderate condition, with evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show differences between zones and domains. Nativeness in the Near Riparian domain shows a large difference from Reference Condition in the Slopes zone and is near reference in the Lowland zone; and in the Lowland Floodplain domain, nativeness shows a moderate difference from reference.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Good condition overall. Structure is near Reference Condition in the Slopes and Lowland zones, with no differences as shown by the confidence limits. This sub-indicator refers only to the height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. Eucalypt Woodlands, which was the most extensive MVG under Reference Condition, has an increased number of patches and a decrease in mean patch area, indicating both dissection and clearing.

Under Reference Conditions, the riverine vegetation in the Condamine Valley was characterised as follows:

- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (60%) with seven other MVGs of which four covered more than 5% of the domain.

- Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (62%) with eleven other MVGs of which three covered more than 5% of the domain.

- Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (40%) and Tussock Grasslands (25%), with nine other MVGs.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced in all domains, but most in the Slopes:

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG although reduced (now 22% of the domain area). About 45% of the domain is cleared or non-native vegetation.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG although reduced (now 52% of domain area). About 16% of the domain is cleared or non-native vegetation. Proportionately, Casuarina Forests and Woodlands are the most depleted MVG, though small in area.

- Lowland zone: In the Lowland Floodplain domain, although reduced, Eucalypt Woodlands are still the most extensive MVG in the domain (22% of domain area) along with Tussock Grasslands (21%). About 26% of the domain is cleared or non-native vegetation. Proportionately, the most reduced MVGs are Casuarina Forests and Woodlands, and Acacia Open Woodlands.

CONDAMINE VALLEY

Unlike the other Themes, the Vegetation Theme relies substantially on data that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain. For example the on-ground date for the current NVIS 3.0 mapping in this valley ranges from 1997 to 2004 depending on source, whereas the LiDAR was flown in July–August 2010. This means that the Structure sub-indicator and three metrics (abundance, richness and nativeness) for the Near Riparian domain are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

The riverine vegetation of the Condamine Valley is notable for being in near Reference Condition, notably in the Lowland zone. Most of the metrics are based on vegetation mapping which is not current and can be variable in quality. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled.

Within the Lowland zone, the abundance and nativeness are noticeably higher in the Near Riparian domain than in the Lowland Floodplain. These two domains assess differing but slightly overlapping parts of the landscape: the Lowland Floodplain is land that floods around and between the main river channels, whereas the Near Riparian domain is a continuous strip centred on all types of channels and considerably smaller in area.

Riverine vegetation is in better condition in the Lowland zone than in the Slopes zone, and is rated near Reference Condition overall, as are the two indicators, Abundance and Diversity and Quality and Integrity. In contrast the Slopes zone is in Moderate condition, as are the two indicators, with lower abundance and nativeness and the loss of one MVG. The Slopes zone has more than half stream length in the valley, so has more influence on the riverine Vegetation Index for the valley.

Table CON 7: Condamine Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Vegetation Condition (SR–VI)	83	71	100
Indicator	Abundance and diversity	79	65	99
Metric	LF stability	0.69		0.69
Sub-ind.	NRLF richness	100		100
Metric	NR richness	0.94	0.90	1
Metric	LF richness	1		1
Sub-ind.	NRLF abundance	90		90
Metric	NR abundance	0.63	0.50	0.81
Metric	LF abundance	0.70		0.70
Indicator	Quality and integrity	82	72	96
Sub-ind.	NRLF nativeness	94		94
Metric	NR nativeness	0.67	0.55	0.84
Metric	LF nativeness	0.74		0.74
Sub-ind.	NR structure	85 (80–89)	85 (77–90)	85 (77–91)
Sub-ind.	LF fragmentation	74		74

Table CON 8: The most abundant MVGs in the Near Riparian domain in the Condamine Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone	
	Slopes	Lowland
MVG		
3. Eucalypt Open Forests	12	
5. Eucalypt Woodlands	60	62
6. Acacia Forests and Woodlands		5
7. Callitris Forests and Woodlands	6	
11. Eucalypt Open Woodlands	11	14
19. Tussock Grasslands	8	6

Table CON 9: Most abundant MVGs in the Lowland Floodplain domain in the Condamine Valley.
Showing percentage of domain area under Reference Condition and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
5. Eucalypt Woodlands	40	1.44	0.39
6. Acacia Forests and Woodlands	6	0.96	0.74
11. Eucalypt Open Woodlands	12	0.84	0.55
17. Other Shrublands	9	1	1
19. Tussock Grasslands	25	0.95	0.91

CONDAMINE VALLEY

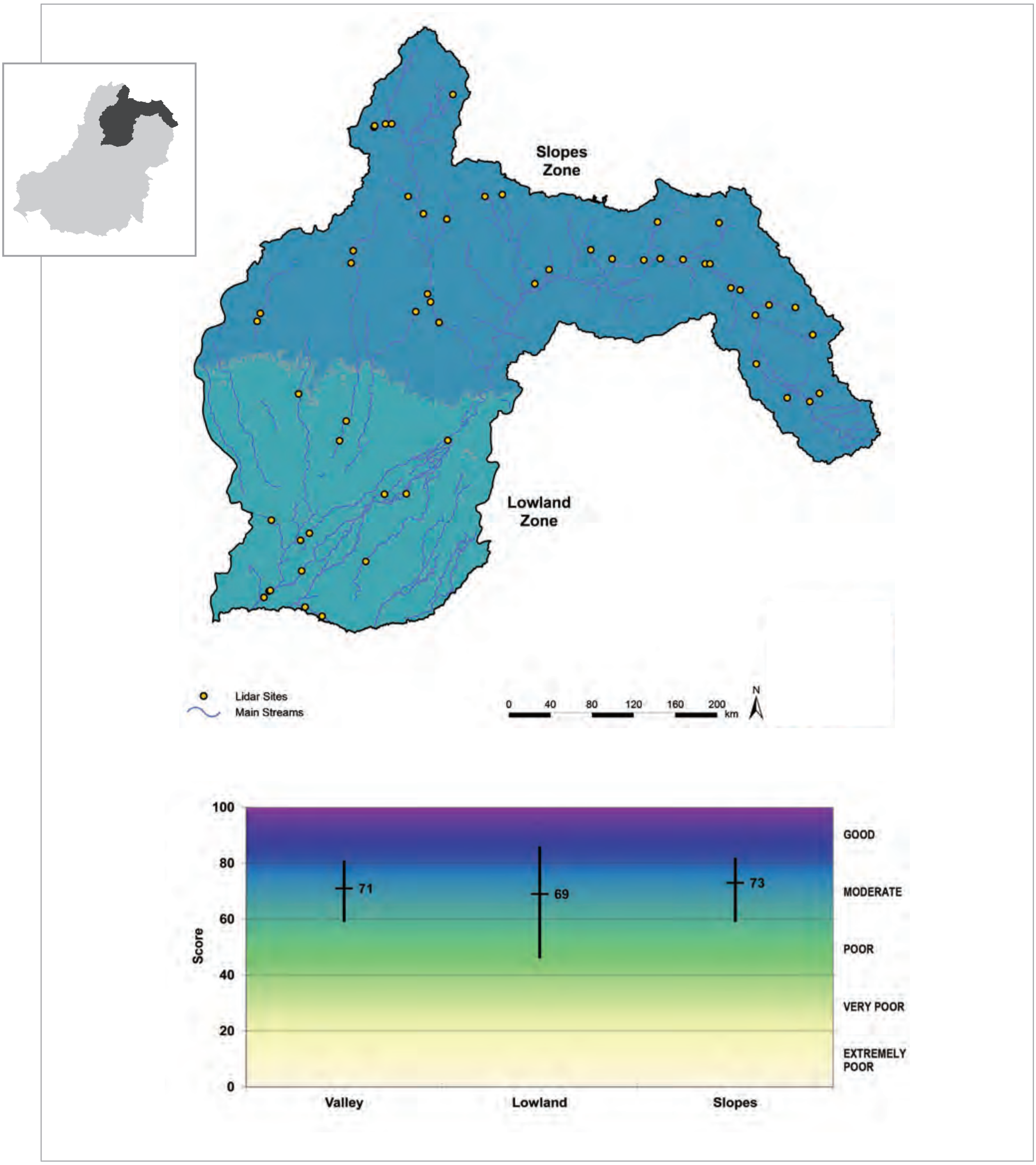

Figure CON 5: Condamine Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Condamine Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 71. The condition of Physical Form in the zones was: Slopes and Lowland Moderate. The valley's river Channel Form was rated as Moderate. Bank Dynamics was rated as Good. Bed Dynamics was rated as Moderate. Floodplain Dynamics was rated as Good. Overall, the valley's riverine physical form was characterised by enlarged channels with evidence of channel widening and bed degradation. There was also indication of elevated sediment loads since European settlement.

The SRA Physical Form assessment considers physical form and processes along 8,886 km of stream across the valley. It is based on LiDAR data collected at 55 sites along river channels, as well as modelling of all 856 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure CON 5 shows values of the Physical Form Index (SR–PI) for the Condamine Valley and Table CON 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Condamine Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 71 (CL 59–81), indicating Moderate Physical Form condition
- the Channel Form indicator = 69 (CL 62–76), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 70 (CL 68–71), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 84 (CL 76–89), showing near Reference Condition
- the Floodplain indicator = 80 (CL 77–83), showing near Reference Condition.

Slopes zone:

There were 39 LiDAR survey sites and 645 SedNet river segments in the Slopes zone of the Condamine Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width Variability and Bank Variability were modified from reference in more than half of the Slopes zone. At these sites Channel Width Variability and Bank Variability was generally reduced. Channel Width and Channel Depth were modified from Reference Condition for approximately half of the Slopes zone. At these sites results show both increases and decreases in Channel Width across the zone and Channel Depth was generally increased (many sites having large increases). Sinuosity, Meander Wavelength and Channel Sediment Deposition were modified from Reference Condition for less than half of the Slopes zone. At these sites results show both increases and decreases in Sinuosity across the zone, results show both increases and decreases in Meander Wavelength across the zone and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period.

Lowland zone

There were 16 LiDAR survey sites and 211 SedNet river segments in the Lowland zone of the Condamine Valley. Based on these samples, Channel Depth, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Depth and Channel Sediment Ratio were generally increased (many sites having large increases). Channel Width Variability and Bank Variability were modified from Reference Condition in more than half of the Lowland zone. At these sites Channel Width Variability was generally reduced (with a large reduction at over half of these sites) and Bank Variability was generally reduced indicating enhanced bank stability. Channel Sediment Deposition was modified from reference for approximately half of the Lowland zone. At these sites there was a moderate increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Sinuosity and Meander Wavelength were modified from reference for less than half of the Lowland zone. At these sites Sinuosity was generally reduced and Meander Wavelength was generally increased (a few sites having large increases). Channel Width was largely unmodified from reference in the Lowland zone.

Channel Form

There was minor change from Reference Condition in Channel Form in the Slopes zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 60% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was considerable change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 80% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Slopes zone. At 60% of sites across the zone, Bank Variability was less than Reference Conditions indicating altered Bank Dynamics. There was little change from Reference Condition in Bank Dynamics in the Lowland zone. At 60% of sites across the zone, Bank Variability was less than Reference Conditions indicating altered Bank Dynamics.

There was minor change from Reference Condition in Bed Dynamics in the Slopes zone as a result of widespread sedimentation (40% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Slopes zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Local knowledge is required to resolve these conflicting results. There was little change from Reference Condition in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (50% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Lowland zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Local knowledge is required to resolve these conflicting results.

There was minor change from Reference Condition in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (100% of SedNet river segments). There was little change from reference in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

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Table CON 10: Condamine Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

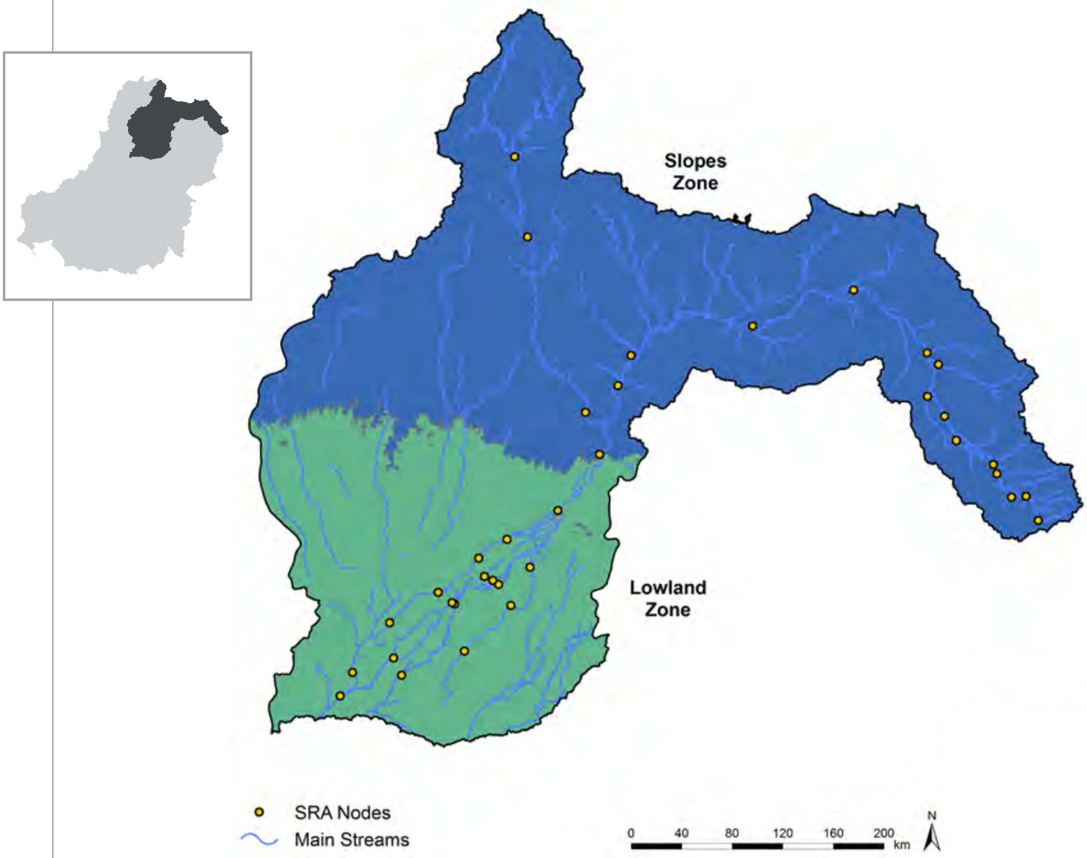
(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Physical Form Condition (SR–PI)	71 (59–81)	73 (59–82)	69 (46–86)
Indicator	Channel Form (volume and flow events)	69 (62–76)	77 (68–84)	58 (45–70)
Sub-ind.	Cross-section Form	67 (60–74)	78 (70–86)	52 (40–66)
Metric	Channel Depth (mean)	1.54 (1.33–1.71)	1.39 (1.17–1.62)	1.75 (1.42–2.00)
Metric	Channel Width (mean)	1.03 (0.99–1.08)	1.05 (0.99–1.12)	1.01 (0.96–1.06)
Sub-ind.	Cross-section Form (variability)	74 (63–83)	76 (67–85)	72 (51–87)
Metric	Channel Width (CV)	0.83 (0.77–0.87)	0.84 (0.79–0.89)	0.81 (0.72–0.90)
Sub-ind.	Channel Planform	93 (88–97)	93 (87–97)	92 (83–98)
Metric	Sinuosity	1.00 (0.99–1.02)	1.00 (0.99–1.02)	1.00 (0.98–1.04)
Metric	Meander Wavelength	1.00 (0.97–1.03)	1.00 (0.97–1.04)	1.00 (0.96–1.05)

Continued/,,,

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Indicator	Bed Dynamics	70 (68–71)	62 (60–63)	80 (77–83)
Metric	Channel Sediment Ratio	54 (52–57)	80 (76–85)	18 (15–22)
Metric	Channel Sediment Depth	0.001 (0.001–0.001)	0.002 (0.001–0.002)	0.0004 (0.0002–0.0007)
Indicator	Bank Dynamics	84 (76–89)	85 (77–92)	82 (69–92)
Metric	Bank Variability (longitudinal)	0.89 (0.84–0.94)	0.89 (0.84–0.94)	0.88 (0.79–0.95)
Indicator	Floodplain	80 (77–83)	71 (67–74)	92(88–96)
Metric	Floodplain Sediment Deposition	2.00 (1.78–3.00)	3.00 (2.00–3.00)	1.24 (0.56–2.00)

CONDAMINE VALLEY



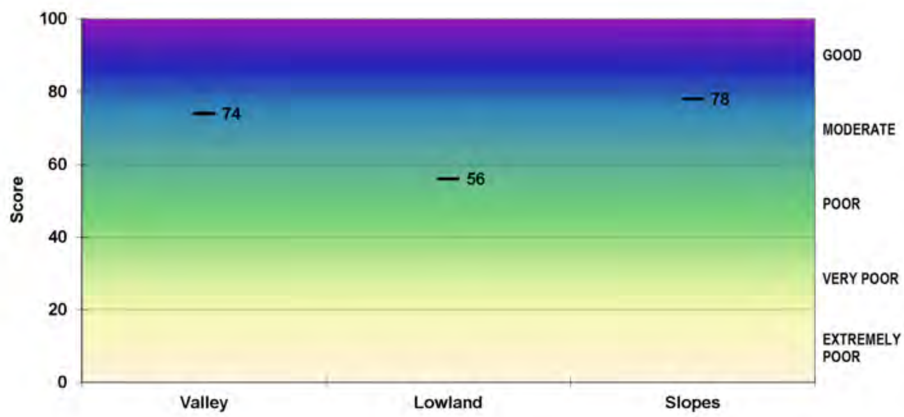


Figure CON 6: Condamine Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Condamine Valley river system was in Moderate condition, with an aggregate Hydrology Index (SR–HI) score of 74. The Slopes zone was in Moderate condition. The Lowland zone was in Poor condition.

The mainstem river system of the Condamine Valley was rated in Moderate condition. Throughout most of the mainstem river system the magnitude, duration and frequency of high flows spells were reduced relative to Reference Condition. The amplitude of seasonal flow variations was reduced through much of the mainstem river length with increased frequency and duration of low flow and cease-to-flow spells. Reduced flooding relative to Reference Condition was also widespread through much of the mainstem river length with reduced flood durations and increased inter-flood periods.

The headwater streams of the Condamine Valley were rated in Good condition.

The Condamine Valley is mostly in southern Queensland, and discharges either to the Barwon via the Culgoa and Bokhara rivers, or to terminal lakes at Narran via braided streams on the Lower Balonne Floodplain. The river changes name along its course. The Condamine rises on the western flank of the Great Dividing Range in the north-eastern Basin, flows north-west then west to Surat, where it becomes the Balonne River and flows south-westerly, breaking into distributary channels, the largest of these becoming the Culgoa River. More than 20 unregulated tributaries feed the Condamine–Balonne system upstream of St George. Flows in the system are regulated by instream storages on the Condamine (Leslie Dam, 106 GL; Chinchilla Weir, 10 GL) and Beardmore Dam on the Balonne (including Buckinbah, Moolabah and Jack Taylor Weirs, total 93.5 GL). The capacities of private offstream storages, however, greatly exceed those of the instream storages. Only the Leslie Dam has a capacity higher than its average annual inflow (106 v. 30 GL).

In the Condamine Valley, hydrological condition is assessed using metrics of hydrological alteration available for 12,193 km of mainstem rivers and headwater streams. There are 2,477 km of mainstem river extending across the Lowland and Slopes zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily water resource modelling. In the Condamine Valley there are 9,716 km of headwater stream (Slopes zone: 9,085 km; Lowland zone: 630 km). In these headwater streams, SRA hydrology metrics represent the effects of farm dams and tree cover change since European settlement.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Condamine Valley there are 12,923 km of these mid-size tributaries (7,997 km in the Slopes zone; 4,926 km in the Lowland zone) which is 1.1 times the stream length for which SRA metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for a period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures CON 6 and CON 7 show values of the Hydrology Condition Index (SR–HI) for the Condamine Valley and its river network, and Tables CON 11 and CON 12 show the Index, sub-index, indicator

CONDAMINE VALLEY

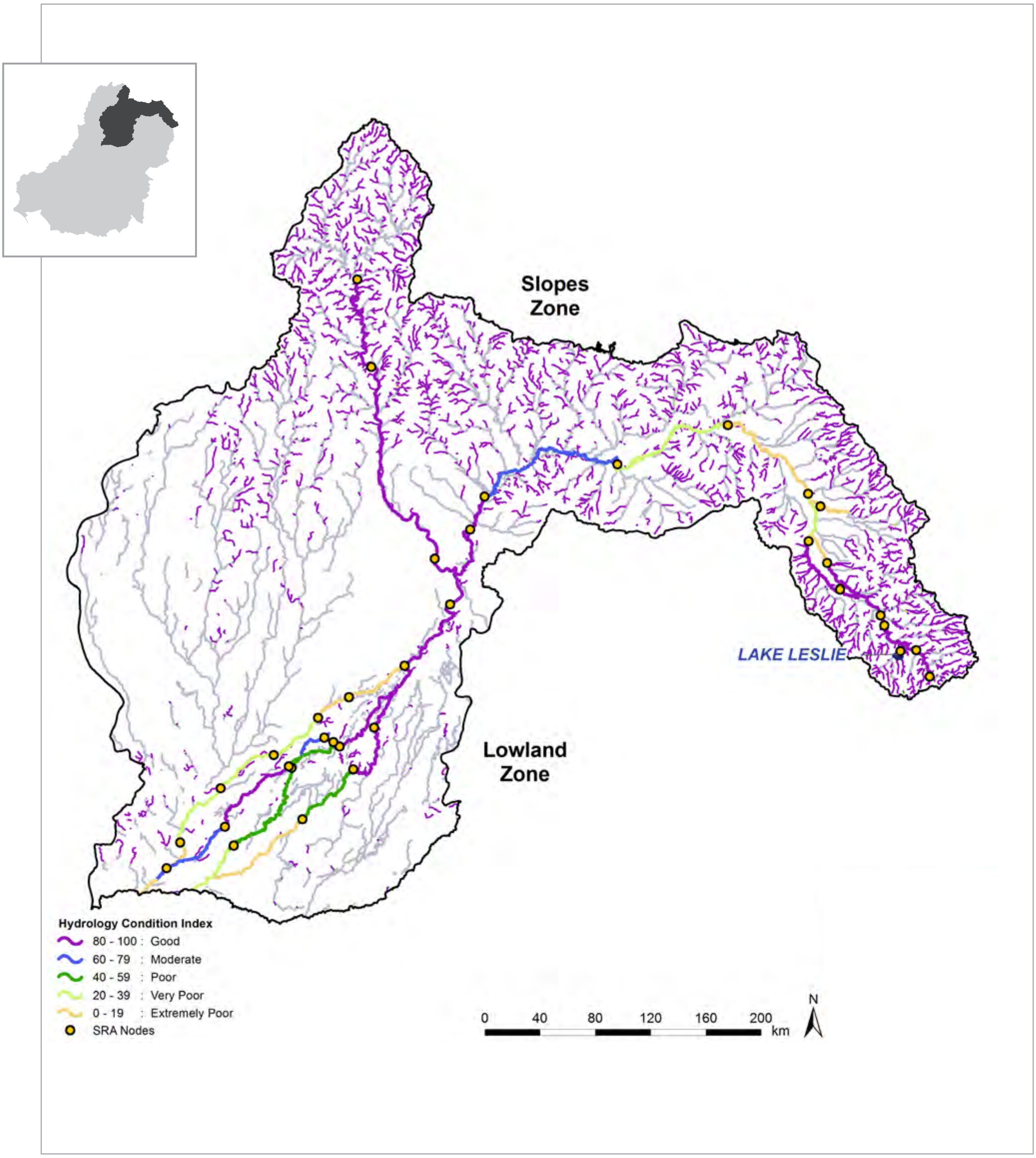


Figure CON 7: Condamine Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

and metric values. Analyses showed a moderate difference from Reference Condition for the Condamine Valley, with:

- The Hydrology Condition Index for the whole valley = 74, indicating Moderate hydrological condition.
- The Hydrology Condition Index for the Slopes and Lowland zones = 78 and 56 indicating Moderate and Poor hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 63, indicating Moderate hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 64, indicating Moderate condition and a moderate difference from Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 80, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed a moderate difference from Reference Condition. Results for the Mean Annual Flow metric showed a very significant alteration from Reference Condition in 27% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 47% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. In addition, results for the Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with reduced flows).

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to Reference Condition.

In the mainstem rivers, the High Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 44% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 32% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 43% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 37% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a significant alteration from reference in 12% of the headwater river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone and a small proportion in the Lowland zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to Reference Condition. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 10% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 4% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone and a small proportion in the Lowland zone. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 39% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 29% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 30% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 43% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a significant alteration from reference in 25% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone and a small proportion in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a moderate difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 21% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 36% of the mainstem river length (mostly associated with a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed a significant alteration from reference in 9% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a significant alteration from reference in 18% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed a moderate difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 15% of the mainstem river length (mostly associated with increased variability) and a significant alteration from reference in 30% of the mainstem river length (mostly associated with increased variability). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 1% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone.

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Low Over Bank Floods

The Low Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 1-year flood in the reference regime. It is calculated from a combination of the Low Over Bank Flood Duration metric and the Low Over Bank Flood Spells metric. The Low Over Bank Flood Duration metric quantifies change in the duration of flooding of low-level floodplain areas relative to reference. The Low Over Bank Flood Spells metric quantifies change in the duration of time between low-level floodplain inundation events relative to reference. The Low Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly timestep.

In the mainstem rivers, the Low Over Bank Floods indicator showed near Reference Condition. Results for the Low Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 31% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 36% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 14% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 28% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and most in the Lowland zone.

High Over Bank Floods

The High Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 8-year flood in the reference regime. It is calculated from a combination of the High Over Bank Flood Duration metric and the High Over Bank Flood Spells metric. The High Over Bank Flood Duration metric quantifies change in the duration of flooding of high-level floodplain areas relative to reference. The High Over Bank Flood Spells metric quantifies change in the duration of time between high-level floodplain inundation events relative to reference. The High Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly timestep.

In the mainstem rivers, the High Over Bank Floods indicator showed a moderate difference from Reference Condition. Results for the High Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 36% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 32% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone. Results for the High Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 16% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 28% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Condamine Valley was generally characterised by moderate alteration in High Over Bank Floods, Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume and little or no alteration in Low Over Bank Floods, relative to Reference Condition. Throughout most of the mainstem river system the magnitude, duration and frequency of high flows spells were reduced relative to Reference Condition. The amplitude of seasonal flow variations was reduced through much of the mainstem river length with increased frequency and duration of low flow and cease-to-flow spells. Reduced flooding relative to Reference Condition was also widespread through much of the mainstem river length with reduced flood durations and increased inter-flood periods.

Summary: headwater streams

The headwater streams of the Condamine Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume, relative to Reference Condition.

Table CON 11: Condamine Valley SRA Hydrology Condition Index at valley and zone scales.

Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	74			78	56

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Table CON 12: Condamine Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**63 (0–100)**	**100 (11–100)**
Sub-Index	In-Channel Flow Regime	64 (0–100)	100 (11–100)
Indicator	In-Channel Flow Regime A (volume and flow events)	**68 (3–100)**	**100 (39–100)**
Sub-ind.	Flow Gross Volume	67 (0–100)	99 (84–100)
Metric	Mean Annual Flow	0.62 (0.01–1.00)	1.03 (0.74–1.24)
Metric	Flow Duration	0.94 (0.80–1.04)	0.99 (0.81–1.13)
Sub-ind.	High Flow Events	67 (0–99)	98 (9–100)
Metric	High Flow	0.59 (0–1.31)	0.98 (0.10–1.58)
Metric	High Flow Spells	0.58 (0.02–0.99)	
Sub-ind.	Low and Zero Flow Events	78 (28–98)	97 (49–99)
Metric	Zero Flows Proportion	0.67 (0–1.23)	0.99 (0.96–1.00)
Metric	Low Flow	0.91 (0.43–1.00)	0.88 (0.21–1.33)
Metric	Low Flow Spells	0.74 (0.34–1.88)	
Indicator	In-Channel Flow Regime B (seasonality & variability)	**69 (10–100)**	**99 (20–100)**
Sub-ind.	Flow Seasonality	76 (23–100)	96 (69–100)
Metric	Flow Seasonal Amplitude	0.70 (0.08–1.00)	1.08 (0.89–1.59)
Metric	Flow Seasonal Period	0.90 (0.42–1.00)	0.98 (0.82–1.00)
Sub-ind.	Flow Variability	68 (30–100)	95 (1–100)
Metric	Flow Variation	1.24 (0.81–2.00)	0.94 (0.53–1.00)
Sub-Index	Over Bank Flow Regime	80 (1–100)	
Indicator	Over Bank Floods Low	**80 (14–99)**	
Metric	OB Flow Duration (ARI 1)	0.66 (0.25–1.00)	
Metric	OB Flow Spells (ARI 1)	0.81 (0.05–1.20)	
Indicator	Over Bank Floods High	**75 (0–98)**	
Metric	OB Flow Duration (ARI 8)	0.40 (0.13–0.83)	
Metric	OB Flow Spells (ARI 8)	0.68 (0–1.07)	

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
		69	**56**			**100**
		65	63			100
		66	**70**			**100**
		77	58			99
		0.71	0.53			1.03
		0.94	0.93			0.99
		69	65			98
		0.55	0.64			0.99
		0.61	0.55			
		71	85			97
		0.56	0.78			0.99
		0.83	0.99			0.88
		0.64	0.85			
		76	**63**			**99**
		86	67			96
		0.83	0.58			1.09
		0.88	0.91			0.98
		72	64			95
		1.22	1.27			0.94
		96	64			
		89	**72**			
		0.79	0.53			
		0.93	0.68			
		91	**59**			
			0.40			
			0.68			

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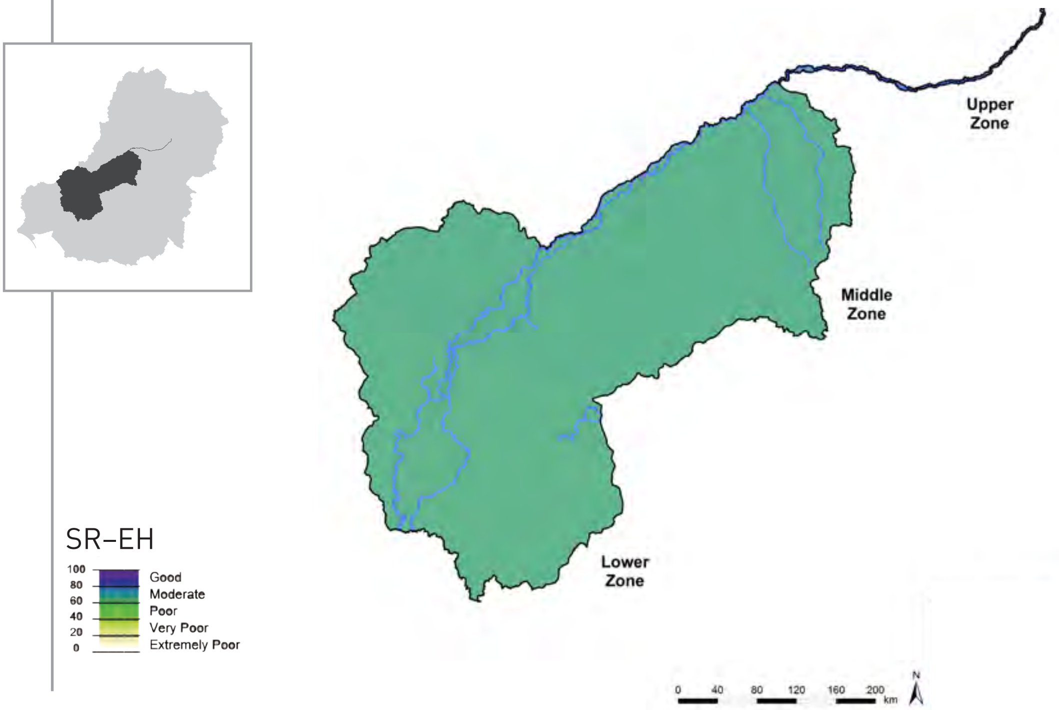

Figure DRL 1: Darling Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure DRL 1 shows the Ecosystem Health ratings for the Darling Valley and Tables DRL 1 and DRL 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Darling Valley as a whole. The river system's Fish, benthic Macroinvertebrate Riverine Vegetation communities were in Poor, Poor and Good condition respectively, while Hydrology and Physical Form were both in Moderate condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Darling Valley river system. River Ecosystem Health was rated as Poor (Lower zone: Poor; Middle zone: Poor; Upper zone: Moderate).

Key features of the condition of biophysical components, represented as Themes, are described below.

Ecosystem Health

The Darling was the fifth highest among the 23 SRA valleys in terms of River Ecosystem Health (see Table 5.2). It was ranked equal first, with the Central Murray, Paroo and Warrego valleys, for Vegetation condition and fourth in terms of Fish condition. Conversely it received the lowest score for Physical Form and Macroinvertebrate condition and a middle ranking (12th) for Hydrological condition.

The Darling Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Upper Moderate; Middle and Lower Poor. The Fish community was in Poor condition. Some expected species were absent. Species counts and abundance were dominated by native species but biomass was dominated by aliens; and recruitment levels among the remaining native species were low. The Macroinvertebrate community was in Poor condition, with substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Good condition overall, with only structure in the Near Riparian domain showing significant alteration from Reference Condition. The Physical Form of the river system was in Moderate condition with bank dynamics in Good condition and channel form and bed dynamics in Moderate condition, but high levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition, with considerable alteration relative to Reference Condition in flow variability and flow gross volume and minor alteration in low over bank floods in mainstem river reaches.

There are no in-stream storages on upper reaches of the Darling in this valley, though its main tributaries contain storages with total capacity of about 3.4 times their mean annual flow. The main Darling channel has a number of low-level weirs used to ensure stock and domestic supply when surface flows cease. A large weir at the junction of the Middle and Lower zones diverts water to the Menindee Lakes system for human use and to support flow regulation downstream. During the dry period that has spanned the SRA program extremely low or zero flow conditions would have prevailed for extended periods in the Darling, with deep holes and weir pools forming most of the aquatic habitat in the main channel. It is possible that fish and macroinvertebrate communities have responded differently to these conditions.

Hydrological analysis indicates that gross flow volume and flow variability are the characteristics which appear to have changed most, whereas over bank flows – events of importance to the canopy condition and recruitment of riverine vegetation – are similar to Reference Condition. It might be hypothesized that a reduction in flow variability, in combination with unfavourable changes to channel form and bed dynamics, could result in the loss of macroinvertebrate families and that this might be exacerbated when the aquatic habitat is reduced mostly to standing water. This could be formally evaluated if a larger variety of macroinvertebrate habitats become available following the cessation of drought.

Fish Theme

The Fish Condition Index SR–FI = 52, indicating Poor condition (Lower zone: Poor; Middle zone: Poor; Upper zone: Moderate). The Expectedness indicator = 46, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 81, indicating Good condition, and near Reference Condition. The Recruitment indicator = 59, indicating Poor condition, and a large difference from Reference Condition.

The Fish community of the Darling had reduced numbers of expected native species overall, but comparatively large numbers and biomass of native fish including Murray cod and golden perch.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 53, indicating Poor condition (Lower zone: Poor; Middle zone: Poor; Upper zone: Poor). The simOE metric = 41 indicating a large difference from

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Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Poor to Extremely Poor condition was high across all zones (66% overall), and only two of the 35 rated sites (6%) were in Good condition.

Family richness generally was very low, and was also low compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 100, indicating Good condition (Lower zone: Good; Middle zone: Good; Upper zone: Good). The Vegetation Abundance and Diversity indicator = 100, indicating Good condition and a minor difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 95, indicating Good condition and a minor difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is little affected by clearing, with the abundance and degree of fragmentation of major vegetation groups being in near Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 60, indicating Moderate condition (Lower zone: Moderate; Middle zone: Moderate; Upper zone: Poor). The Channel Form indicator = 60 and the Bed Dynamics indicator = 67; indicating Moderate condition and showing a minor difference from Reference Condition. The Bank Dynamics indicator = 87 and the Floodplain Form indicator = 78; indicating Good condition and near Reference Condition.

Overall, the valley's Physical Form was characterised by accelerated floodplain sediment deposition in the Upper zone since European settlement and evidence of enlarged channels in the Lower zone.

Hydrology Theme

The Hydrology Condition Index SR–HI = 75, indicating Moderate condition (Lower zone: Moderate; Middle zone: Moderate; Upper zone: Moderate). The In-Channel Flow Regime indicator = 49, indicating Poor condition and a moderate difference from Reference Condition for the flow regime within the channels. The Over Bank Flow Regime sub-index = 93, indicating Good condition and is near Reference Condition for the wetting regime in riparian and floodplain areas.

In the mainstem river reaches High Flows and the duration and frequency of High Flow Spells were reduced along with mean flows and the amplitude of Seasonal Flow Variation; in addition, monthly flow variation and inter-flood durations for Low and High Over Bank Flows were increased. There was also widespread change in the frequency of Low Flow Spells and reduced duration of Low Over Bank Flows. There was little or no change in these indicators in minor tributary streams within the Darling Valley.

Table DRL 1: Darling Valley Ecosystem Health and condition assessments.

Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	UPPER	MIDDLE	LOWER
		Poor	Moderate	Poor	Poor

THEME		VALLEY	ZONE		
			UPPER	MIDDLE	LOWER
Fish	SCORE RATING	52 (39–57) Poor	63 (48–73) Moderate	48 (26–58) Poor	47 (40–58) Poor
Macro-invertebrates	SCORE RATING	53 (47–59) Poor	56 (47–64) Poor	52 (45–60) Poor	52 (39–65) Poor
Vegetation	SCORE RATING	100 Good	100 Good	100 Good	100 Good

Table DRL 2: Darling Valley Physical Form and Hydrology condition assessments.

Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE		
			UPPER	MIDDLE	LOWER
Physical Form	SCORE RATING	60 (48–69) Moderate	48 (37–65) Poor	64 (46–78) Moderate	60 (45–79) Moderate
Hydrology	SCORE RATING	75 Moderate	68 Moderate	67 Moderate	60 Moderate

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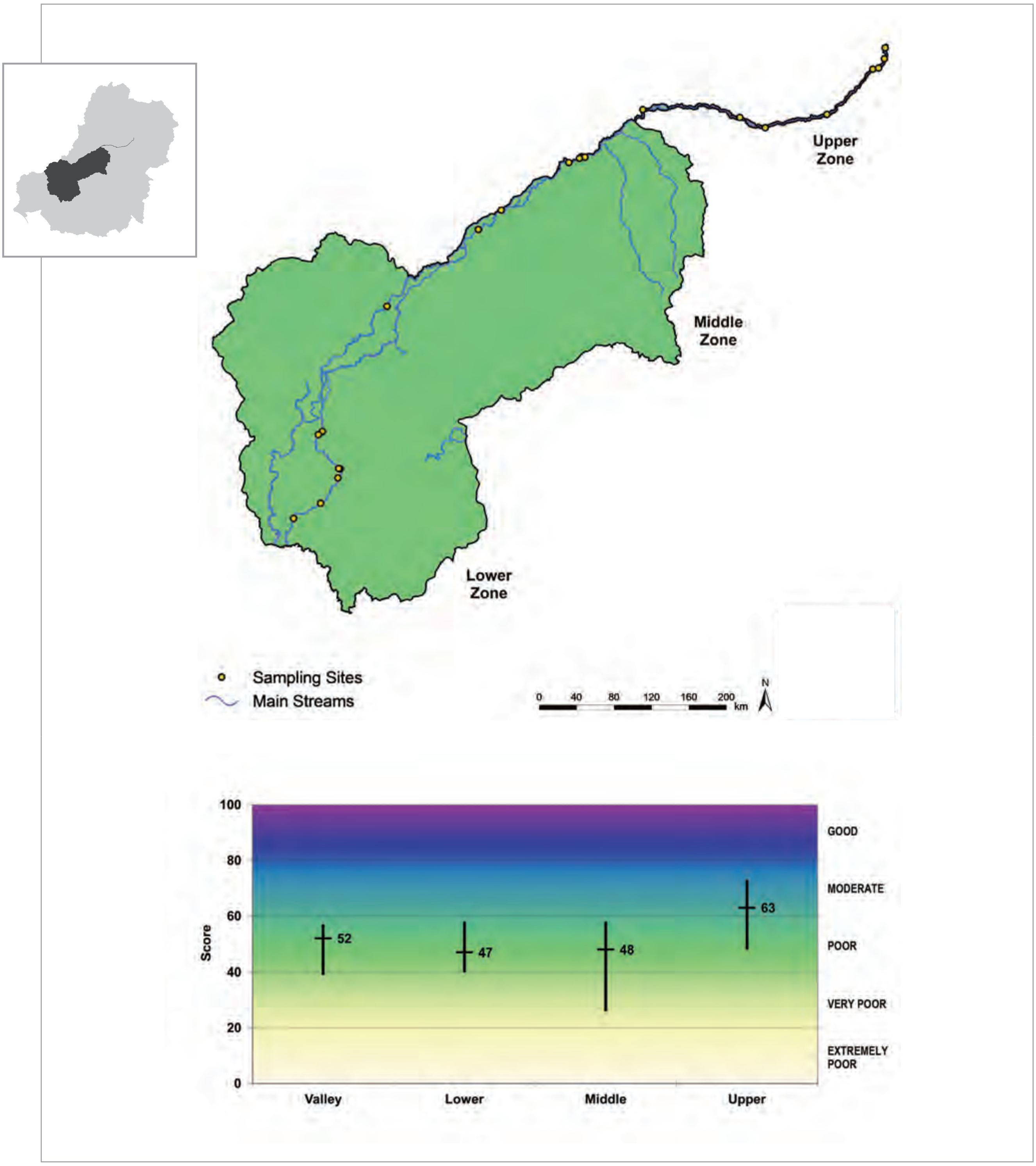

Figure DRL 2: Darling Valley map with sampling sites and zones coloured by SRA Fish Index (SR-FI) scores.

Graph shows mean SR-FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Darling Valley river system was in Poor condition, with an aggregate Fish Index score (SR–FI) of 52. The condition of the fish community in the zones was as follows: Upper zone Moderate; Middle zone Poor, and Lower zone Poor. The fish community was characterised by a Poor score for expected native fish species, a Good score for nativeness and a Poor score for native fish recruitment. The fish communities were similar in all three zones, each with 7 of the 15 predicted native species represented in the samples and each with a similar proportion of native individuals in the total fish community (Upper zone: 89%, Middle zone: 82%, and Lower zone: 87%). The valley had lost half of its native species richness, but alien species contributed 35% of the biomass in samples. Native fish recruitment was Moderate, Poor and Poor in the Upper, Middle and Lower zones respectively.

Twenty-one sites were surveyed across the Darling Valley in March–April 2008, yielding 2,602 fish. Analyses showed a large difference from Reference Condition for the Darling Valley, with:

- SRA Fish Index (SR–FI) = 52 (CL 39–57), indicating Poor condition of the fish community.
- the Expectedness indicator = 46 (CL 43–50), indicating Poor condition, and a large difference from Reference Condition. Only 50% of fish species expected under Reference Condition were recorded.
- the Nativeness indicator = 81 (CL 76–85), indicating Good condition, and a minor difference from Reference Condition.
- the Recruitment indicator = 59 (CL 39–69), indicating Poor condition, and a large difference from Reference Condition. Evidence of recruitment was observed for eight of the nine native species observed in the valley.

Figure DRL 2 shows sampling sites, zones and corresponding SR–FI values, and Table DRL 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Darling Valley was above the average for all valleys, and close to that for the Gwydir Valley. The Fish community of the Upper zone was rated as Moderate (SR–FI = 63). Both the remaining zones had a rating of Poor for fish condition (SR–FI = 48 and 47 respectively for the Middle and Lower zones), reflecting a lower Expectedness score in the Middle zone and a lower Recruitment score in the Lower zone.

Expectedness was rated as Poor in all three zones reflecting the fact that more than half the species expected to be present under Reference Condition (RC–F) did not appear in any samples. Differences among zones reflect within-zone variability (among sites).

Despite the substantial shortfall in the number of native species captured, Nativeness was scored as Good, Good, and Moderate in the Upper, Middle, and Lower zones respectively; a reflection of the relatively low numbers (and biomass) of alien fish.

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With almost 16 kg of fish per site, the Darling Valley had the third largest fish biomass amongst the 23 Valleys. This includes 4.4 kg of bony herring, 3.4 kg of Murray cod, and 2.4 kg of golden perch in the 10.3 kg of native fish on average, per site. On average 5.2 kg of common carp was caught per site.

Table DRL 4 shows native species abundances in the Darling Valley compared with Reference Condition. Bony herring—a native species favouring slow flowing and lentic conditions—was the most numerous fish species, either native or alien, and was found at all 21 sites sampled across the valley. Two large-bodied native species, Murray cod and golden perch, were well represented in samples throughout the valley. A total of 56 Murray cod were caught at 13 sites and golden perch totalling 138 fish were found at 19 of the 21 sites sampled. Freshwater catfish and silver perch were expected in all three zones under Reference Condition but only one silver perch and no freshwater catfish were caught. Three alien species, common carp, gambusia, and goldfish, were found in each of the three zones.

Recruitment varied amongst and within zones resulting in a Recruitment rating of Poor for the valley, and Moderate, Poor, and Poor for the Upper, Middle, and Lower zones respectively. In all, eight of the nine native species observed showed evidence of recruitment in at least one site in the valley— the exception being silver perch with only one (non-recruit) individual caught. Recruitment was wide-spread in the Murray cod population with evidence of recruitment at eight of the 13 sites at which the species was observed. Golden perch showed signs of recruitment at only three of 19 sites, none of which was in the Lower zone. All three alien species had recruits: common carp and gambusia in all three zones; and goldfish in the Middle and Lower zones.

In general, the fish community of the Darling had reduced numbers of expected native species but comparatively large numbers and biomass of native fish including Murray cod and golden perch.

Table DRL 3: Darling Valley SRA Fish Condition Index, indicators, metrics and derived variables.

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upper	Middle	Lower
Index	Fish Condition (SR–FI)	52 (39–57)	63 (48–73)	48 (26–58)	47 (40–58)
Indicator	Expectedness	46 (43–50)	51 (45–57)	42 (35–48)	51 (45–58)
Metric	O/E	0.49 (0.44–0.54)	0.55 (0.47–0.64)	0.42 (0.33–0.51)	0.56 (0.47–0.66)
Metric	O/P (Zone level)	0.47 (0.47–0.47)	0.47 (0.47–0.47)	0.47 (0.47–0.47)	0.47 (0.47–0.47)

Continued/,,,

Indexes Indicators Metrics	Description	Valley	Zone		
			Upper	Middle	Lower
Indicator	Nativeness	81 (76–85)	86 (78–93)	80 (72–87)	75 (68–84)
Metric	Proportion biomass native	0.63 (0.55–0.70)	0.64 (0.49–0.77)	0.63 (0.50–0.75)	0.61 (0.54–0.68)
Metric	Proportion abundance native	0.80 (0.76–0.85)	0.86 (0.80–0.92)	0.80 (0.74–0.87)	0.72 (0.62–0.83)
Metric	Proportion species native	0.66 (0.62–0.70)	0.72 (0.67–0.77)	0.61 (0.55–0.68)	0.71 (0.65–0.77)
Indicator	Recruitment	59 (39–69)	68 (47–81)	59 (24–78)	48 (37–65)
Metric	Proportion of sites with native recruits	0.60 (0.43–0.68)	0.64 (0.49–0.78)	0.60 (0.30–0.75)	0.55 (0.43–0.66)
Metric	Proportion of native taxa with recruits	0.94 (0.76–0.96)	1.00 (0.83–1.00)	1.00 (0.67–1.00)	0.71 (0.67–0.83)
Metric	Proportion of abundance as recruits	0.51 (0.37–0.57)	0.57 (0.42–0.60)	0.48 (0.24–0.60)	0.51 (0.41–0.60)
Variables					
	Number of sites sampled	21	7	7	7
	Total number of species	12	10	10	10
	Number of native species	9	7	7	7
	Number of predicted species	18	15	15	15
	Number of alien species	3	3	3	3
	Mean number of fish per site	124	113	89	170
	Biomass/site all species (g)	15809	13392	10180	23853
	Mean native biomass/fish (g)	96	87	100	100
	Mean alien biomass/fish (g)	328	382	178	406

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Table DRL 4: Darling Valley number of fish by zone.

Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone		
		Upper	Middle	Lower
Sites sampled	21	7	7	7
Native species				
Australian smelt	33	3	2	28
Bony herring	1922	543	445	934
Desert rainbowfish	0	0		
Flathead gudgeon	0		0	0
Freshwater catfish	0	0	0	0
Golden perch	138	75	47	16
Gudgeon	31	5	0	26
Hyrtl's tandan	2	0	2	
Murray cod	56	21	7	28
Murray hardyhead	0			0
Murray–Darling rainbowfish	36	33	1	2
Olive perchlet	0	0	0	0
Rendahl's tandan	0	0		
Shortheaded lamprey	0		0	0
Silver perch	1	0	0	1
Southern purple-spotted gudgeon	0	0	0	0
Spangled perch	27	24	3	0
Unspecked hardyhead	0	0	0	0

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Fish species	Valley	Zone		
		Upper	Middle	Lower
Alien species				
Common carp	244	53	67	124
Gambusia	9	6	2	1
Goldfish	103	26	45	32

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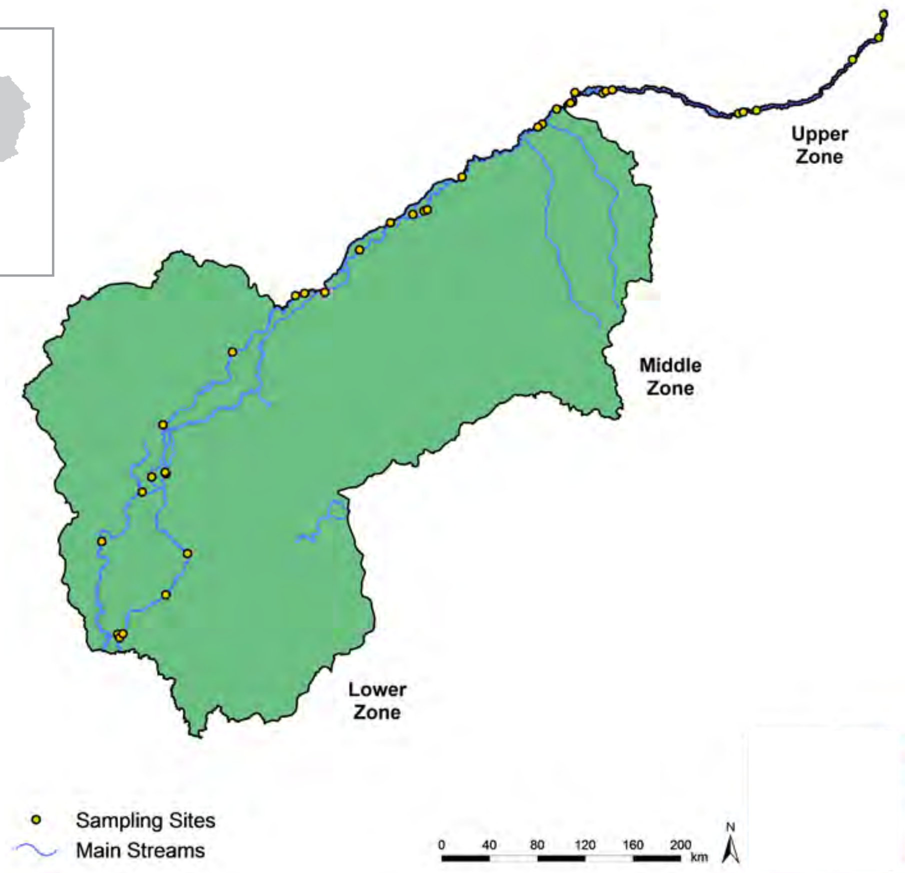

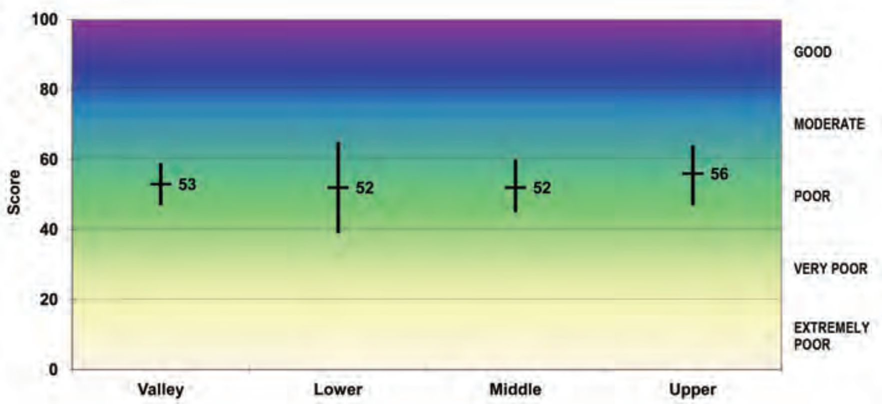

Figure DRL 3: Darling Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Darling Valley river system was in Poor condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 53. The condition of the Macroinvertebrate community in the zones was as follows: Upper zone Poor; Middle zone Poor; Lower zone Poor. The proportion of sites in Poor to Extremely Poor condition was high across all zones (66%). Family richness generally was very low, and was also low compared to Reference Condition.

Thirty-five sites were surveyed across the Darling Valley in March–April 2009 yielding 3,158 macroinvertebrates in 41 families (44% of Basin families). Analyses showed a large difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 53 (CL 47–59), indicating Poor condition of benthic macroinvertebrate communities.
- The simOE metric = 41 (CL 39–43) indicating a large difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Poor to Extremely Poor condition was high across all zones (66% overall), and only two of the 35 rated sites (6%) were in Good condition.
- The number of families found was lowest in the Lower zone (26 families) and highest in the Upper zone (33 families), with the Upper zone having the highest average number of families per site (18).

Figure DRL 3 shows sampling sites, zones and SR–MI values, and Table DRL 5 shows Index and metric values. The SR–MI score for the Darling Valley indicated Poor condition of macroinvertebrate communities, rating the lowest out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of all zones showed large differences from Reference Condition (SR–MI = 52–56). A wide confidence interval (26 points) for the Lower zone SR–MI value indicates more variability there, though most sites showed either a moderate to large difference from Reference Condition. Expectedness (simOE) was low to moderate and varied by up to seven points among sites.

Table DRL 6 shows that most sites across all zones had Moderate to Poor SR–MI values, though only two sites were rated in Good condition. Each zone contained several of the total of 15 sites with low simOE scores (<40 points). Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

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Family richness generally was low compared to Reference Condition. Diversity was very low (average 13 families per site), with the Upper zone being most diverse at site scale (average 18 families per site). The valley contained 44% of the families found across the Basin (Table DRL 6), with the Lower zone having the lowest representation of Basin-wide fauna. Most (89 – 100%) of the fauna of the valley was found in each of the zones.

Table DRL 5: Darling Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower – upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone		
			Upper	Middle	Lower
Index	Macroinvertebrate Condition (SR–MI)	53 (47–59)	56 (47–64)	52 (45–60)	52 (39–65)
Metric	SimOE	41 (39–43)	42 (39–45)	41 (38–44)	41 (36–46)

Table DRL 6: Darling Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone		
		Upper	Middle	Lower
Sites				
Number of sites sampled	35	7	18	10
Number of sites with index values*	35	7	18	10
N sites by SR-MI condition band				
Good (80–100)	2		1	1
Moderate (60–80)	10	2	5	3
Poor (40–60)	14	4	7	3
Very or Extremely Poor (0–40)	9	1	5	3
Families				
Number of families sampled	41	33	30	26
No. families/site (min–max)	13 (7–24)	18 (13–23)	13 (7–24)	12 (8–14)
Percent of families in Basin	44	35	32	28
Percent of families in valley	100	80	73	63

*simOE values could occasionally not be derived for every sample site.

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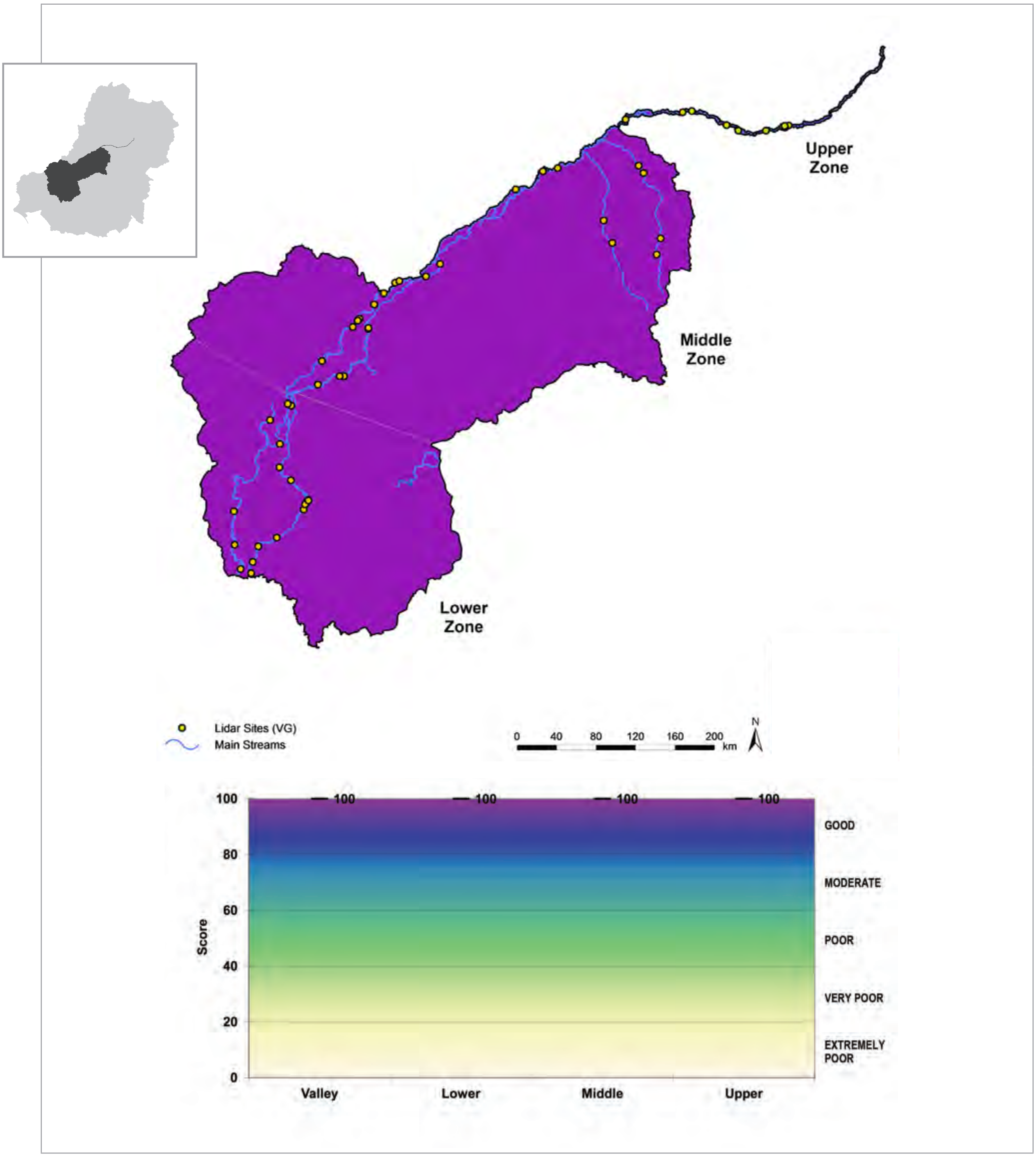

Figure DRL 4: Darling Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Darling Valley river system was in Good condition, with an aggregate Vegetation Index score (SR–VI) of 100. Overall condition for the three zones in this valley (Upper, Middle and Lower) was Good.

The Abundance and Diversity indicator score was 100 for the valley, a Good rating overall. It was rated Good in all three zones.

The Quality and Integrity indicator score was 95 for the valley, a Good rating overall. It was rated Good in all the three zones.

The SRA Vegetation assessment for the Darling Valley considers riverine vegetation in two spatial domains: Near Riparian, along 3,905 km of stream, and Lowland Floodplain, for a total of 5,258 km^2 of flooding land which is part of the floodplain in each of the three zones in this valley (Upper, Middle, Lower). All three zones are Lowland zones. Most (55%) of the stream length is in the Middle zone, and the length of stream assessed per zone is as follows: Upper, 601 km; Middle, 2,161 km; and Lower, 1,143 km. Similarly, most (73%) of the Lowland Floodplain area in the valley is in the Middle zone; the Upper zone has only 5% of the total and the Lower zone has 23%. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 52 sites set back 50 m from top of the bank. LiDAR sites are distributed along the stream network in each of the three zones as follows: Upper, nine sites; Middle, 25 sites; Lower, 18 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure DRL 4 shows values of the Vegetation Index (SR–VI) for the Darling Valley and Table DRL 7 shows the Index, indicator and sub-indicator values. Tables DRL 8 and DRL 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a near Reference Condition for the Darling Valley with:

- SRA Vegetation Index (SR–VI) = 100, indicating Good condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 100, indicating near Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 95, indicating near Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

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The Abundance and Diversity of valley riverine vegetation is in Good condition overall, with MVGs in near Reference Condition in the Upper, Middle and Lower zones. The Good rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of major vegetation groups as given in NVIS 3.0. Valley-wide abundance in the Near Riparian domain and the Lowland Floodplain domain is near reference. MVG richness is maintained near reference in both Near Riparian and Lowland Floodplain domains, as no MVG has been completely reduced. Vegetation in the Lowland Floodplain has 91%, 100% and 97% stability in the Upper, Middle and Lower zones.

In addition, the Quality and Integrity of valley riverine vegetation is in Good condition overall, and is near reference in the Upper, Middle and Lower zones. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table DRL 8 as well as other native but non-specific MVGs. Valley-wide Nativeness is near reference in both domains, and in all three zones. The degree of MVG fragmentation in the Lowland Floodplain domain is near reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain, is in Good condition overall, and the metrics show no loss of any MVG in any of the three zones from the Near Riparian domain, and no loss of any MVG in any of the three zones from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall. The metrics show no difference between zones or domains, and Abundance is consistently near reference.

Stability

- Floodplain areas within the Lowland Floodplain are in Good condition, with little evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall. The metrics show no difference between zones and domains, and nativeness is consistently near reference.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with quite big differences between zones. Structure is near reference in the Upper zone, is moderately different from reference in the Middle zone, and shows a large difference from reference in the Lower zone. This sub-indicator refers only to height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of MVGs is in Good condition. The two most affected MVGs are Eucalypt Open Woodland in the Upper zone, which shows a substantial reduction in number of patches and a considerable reduction in mean patch area relative to reference, indicating dissection and clearing; and Eucalypt Woodlands in the Lower zone which shows a moderate reduction in patch number and an increase in mean patch area, indicating loss of small patches. Most of the MVGs in these three zones have patch numbers and mean patch areas that are close to reference.

Under Reference Conditions, the riverine vegetation in the Darling Valley was characterised as follows:

- Upper zone: The Near Riparian domain was mostly (59%) Eucalypt Woodlands. Four of the other five MVGs present covered at least 5% of the domain.
- Middle zone: The Near Riparian domain was mostly (83%) Eucalypt Woodlands. Only one of the seven other MVGs present covered at least 5% of the domain.
- Lower zone: The Near Riparian domain was mostly Eucalypt Open Forests (48%) and Eucalypt Woodlands (29%). Only one of the seven other MVGs present covered at least 5% of the domain.
- Upper zone: The Lowland Floodplain domain was mostly (60%) covered by Eucalypt Woodlands. Four of the five other MVGs present covered 5% or more of the domain.
- Middle zone: The Lowland Floodplain domain was mostly (73%) covered by Eucalypt Woodlands. Two of the seven other MVGs present covered 5% or more of the domain.
- Lower zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (46%) and Eucalypt Open Forests (42%). Only one of the seven other MVGs present covered 5% or more of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the vegetation in the valley is little reduced, and the dominant MVGs are virtually unchanged.

- Upper zone: In the Near Riparian domain, Eucalypt Woodlands is still the most extensive MVG (59% of domain area). Only about 7% is cleared or non-native vegetation. The most severely reduced MVG is Eucalypt Open Woodlands, which has been reduced from 11% under Reference Conditions to 3%.

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- Middle zone: In the Near Riparian domain, Eucalypt Woodlands is still the most extensive MVG (83% of domain area). Less than 1% is cleared or non-native vegetation. None of the MVGs show signs of being seriously reduced.
- Lower zone: In the Near Riparian domain, the most extensive MVGs are still Eucalypt Open Forests (48% of domain area) and Eucalypt Woodlands (29%). Only about 4% of the domain is cleared or non-native vegetation. The most severely affected MVG is Eucalypt Open Woodlands, reduced from 2% of the domain to 0%.
- Upper zone: In the Lowland Floodplain domain, Eucalypt Woodlands is still the most extensive MVG (60% of domain area). About 8% is cleared or non-native vegetation. The most affected MVG is Eucalypt Open Woodlands, reduced from 11% of the domain under reference to 2%.
- Middle zone: In the Lowland Floodplain domain, Eucalypt Woodlands is still the most extensive MVG (73%). Less than 1% of the domain is cleared or non-native vegetation. None of the MVGs shows signs of being reduced in area relative to reference.
- Lower zone. In the Lowland Floodplain domain, Eucalypt Woodlands (44% of domain area) and Eucalypt Open Forests (42%) are still the most extensive MVGs. About 3% of the domain is cleared or non-native vegetation. The most severely affected MVGs are Eucalypt Open Woodlands, reduced from 0.3% to 0.03%, and Other Shrublands, reduced from 2% to 0%.

Unlike the other Themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up-to-date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping may range from 1997-2004, whereas the LiDAR was flown in 2009–2010. This means that the Structure Sub-indicator and three metrics (abundance, richness and nativeness) are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees present. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

The riverine vegetation of the Darling Valley is notable for being in near Reference Condition in all three zones, with little evidence of clearing, loss, turnover or fragmentation of the MVGs, however the Structure sub-indicator implies modifications close to the main river channels. Most of the metrics are based on vegetation mapping which is not up-to-date and can be of variable quality. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation in the Darling Valley is in near Reference Condition, overall, and in each of the three zones. The two indicators, Abundance and Diversity, and Quality and Integrity, are also both rated near reference. All the metrics for the Lowland Floodplain domain are near Reference Condition with the exception of Structure sub-indictor which is moderate and poor (and quite variable) in the Middle and Lower zones. The Lowland Floodplain and Near Riparian domains assess differing but slightly overlapping parts of the landscape: the Lowland Floodplain is, in broad terms, the grey clay areas of the riverine corridor on both sides of the main river channels and along the anabranches, whereas the Near Riparian domain is a narrow continuous strip centred on all channels and set within the Lowland Floodplain, and much smaller in area.

Table DRL 7: Darling Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone		
			Upper	Middle	Lower
Index	Vegetation Condition (SR–VI)	100	100	100	100
Indicator	Abundance and diversity	100	100	100	100
Metric	LF stability	0.98	0.91	1	0.97
Sub-ind.	NRLF richness	100	100	100	100
Metric	NR richness	1	1	1	1
Metric	LF richness	1	1	1	1
Sub-ind.	NRLF abundance	100	100	100	100
Metric	NR abundance	0.98	0.92	1	0.96
Metric	LF abundance	0.98	0.92	1	0.97
Indicator	Quality and integrity	95	100	96	91
Sub-ind.	NRLF nativeness	100	100	100	100
Metric	NR nativeness	0.98	0.92	1	0.96
Metric	LF nativeness	0.98	0.92	1	0.97
Sub-ind.	NR structure	68 (60–76)	84 (73–93)	69 (56–80)	59 (47–71)
Sub-ind.	LF fragmentation	95	92	98	89

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Table DRL 8: The most abundant MVGs in the Near Riparian domain in the Darling Valley.

Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone		
	Upper	Middle	Lower
MVG			
2. Eucalypt Tall Open Forests	14		
3. Eucalypt Open Forests	8		48
5. Eucalypt Woodlands	59	83	29
11. Eucalypt Open Woodlands	11		
19. Tussock Grasslands	6		
22. Chenopod Shrublands, Samphire Shrublands and Forblands		6	19

Table DRL 9: Most abundant MVGs in the Lowland Floodplain domain in the Darling Valley.

Showing percentage of domain area under Reference Condition in each of the three zones, and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
Darling Valley (Upper)			
2. Eucalypt Tall Open Forests	10	1.04	0.96
3. Eucalypt Open Forests	8	0.99	1.02
5. Eucalypt Woodlands	60	0.99	1.01
11. Eucalypt Open Woodlands	11	0.35	0.54
19. Tussock Grasslands	9	1.00	1.00
Darling Valley (Middle)			
5. Eucalypt Woodlands	75	1.00	1.00
19. Tussock Grasslands	8	0.83	1.19
22. Chenopod Shrublands, Samphire Shrublands and Forblands	12	1.00	1.00
Darling Valley (Lower)			
3. Eucalypt Open Forests	42	1.00	1.00
5. Eucalypt Woodlands	46	0.62	1.54
22. Chenopod Shrublands, Samphire Shrublands and Forblands	8	0.90	1.06

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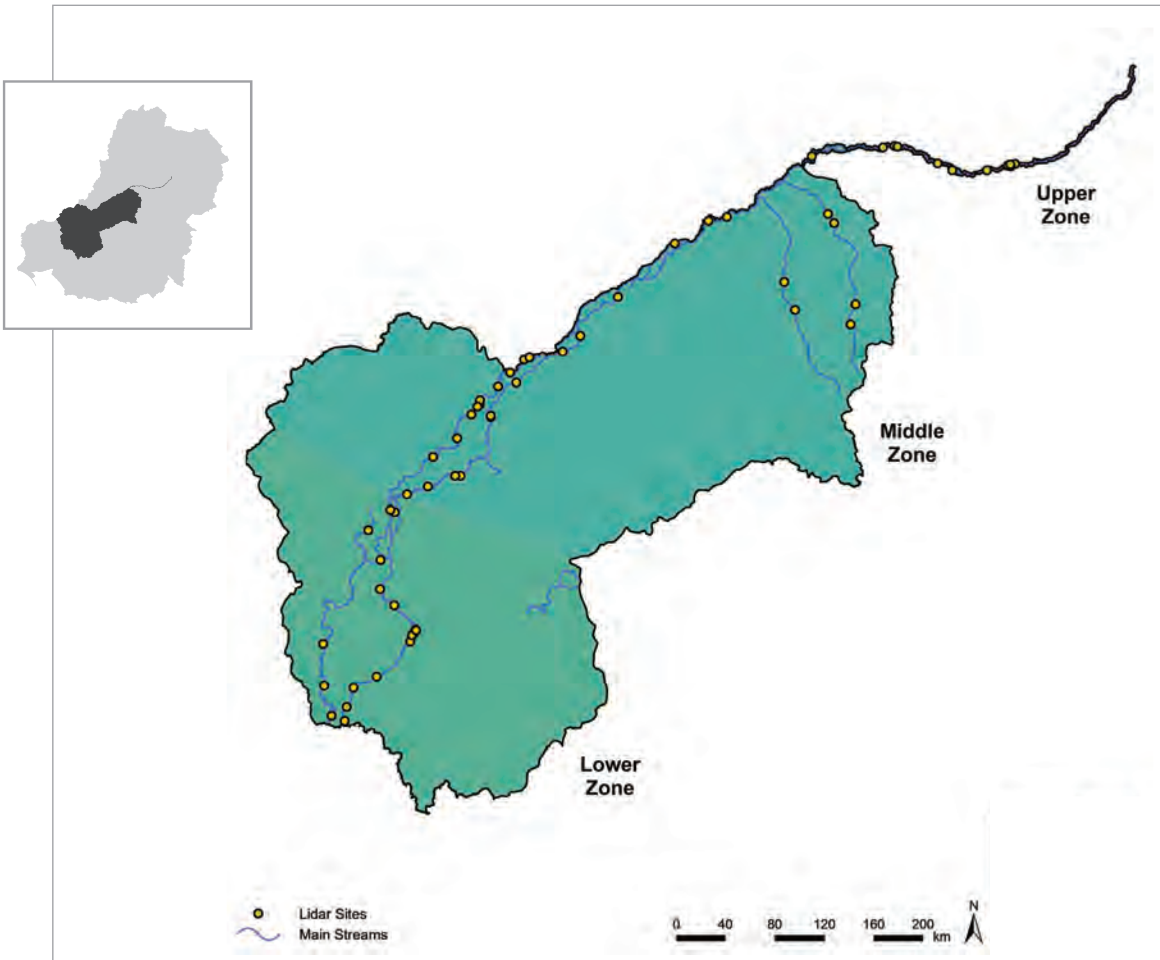

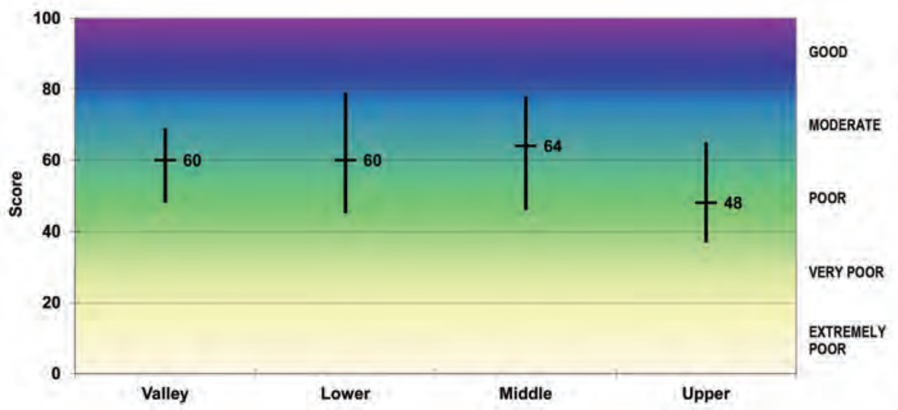

Figure DRL 5: Darling Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Darling Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 60. The condition of Physical Form in the zones was: Upper Poor; Middle and Lower Moderate. The valley's river Channel Form was rated as Moderate. Bank Dynamics was rated as Good. Bed Dynamics and Floodplain Dynamics were rated as Moderate. Overall, the valley's physical form was characterised by accelerated floodplain sediment deposition in the Upper zone since European settlement and evidence of enlarged channels in the Lower zone.

The SRA Physical Form assessment considers physical form and processes along 3,905 km of stream across the valley. It is based on LiDAR data collected at 58 sites along river channels, as well as modelling of all 628 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure DRL 5 shows values of the Physical Form Index (SR–PI) for the Darling Valley and Table DRL 10 shows the Index, sub-index, indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Darling Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 60 (CL 48–69), indicating Moderate Physical Form condition
- the Channel Form indicator = 60 (CL 52–66), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 67 (CL 64–71), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 87 (CL 80–92), showing near Reference Condition
- the Floodplain indicator = 78 (CL 74–82), showing a moderate difference from Reference Condition.

Upper zone

There were 10 LiDAR survey sites and 44 SedNet river segments in the Upper zone of the Darling Valley. Based on these samples, Channel Width, Channel Depth, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upper zone. At these sites Channel Width and Depth were generally increased, Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 60% of the zone for the post-European period.

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Channel Width Variability was modified from reference in more than half of the Upper zone. At these sites Channel Width Variability was generally reduced. Meander Wavelength was modified from Reference Condition for approximately half of the Upper zone. At these sites Meander Wavelength was generally increased (many sites having large increases). Sinuosity was modified from reference for less than half of the Upper zone. At these sites Sinuosity was generally reduced. Bank Variability and Channel Sediment Deposition were largely unmodified from reference in the Upper zone.

Middle zone

There were 30 LiDAR survey sites and 376 SedNet river segments in the Middle zone of the Darling Valley. Based on these samples, Channel Depth, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Middle zone. At these sites results show both increases and decreases in Channel Depth across the zone, Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width and Channel Sediment Deposition were modified from Reference Condition in more than half of the Middle zone. At these sites Channel Width was generally increased and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period. Channel Width Variability and Bank Variability were modified from reference for approximately half of the Middle zone. At these sites Channel Width Variability was generally reduced (with a large reduction at over half of these sites) and Bank Variability was generally reduced indicating enhanced bank stability. Meander Wavelength was modified from reference for less than half of the Middle zone. At these sites Meander Wavelength was generally increased (many sites having large increases). Sinuosity was largely unmodified from reference in the Middle zone.

Lower zone

There were 18 LiDAR survey sites and 208 SedNet river segments in the Lower zone of the Darling Valley. Based on these samples, Channel Depth, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lower zone. At these sites Channel Depth and Channel Sediment Ratio were generally increased (many sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width, Channel Width Variability and Bank Variability were modified from Reference Condition in more than half of the Lower zone. At these sites Channel Width was generally increased, Channel Width Variability was generally reduced (with a large reduction at over half of these sites) and Bank Variability was generally reduced indicating enhanced bank stability. Meander Wavelength and Channel Sediment Deposition were modified from Reference Condition for approximately half of the Lower zone. At these sites Meander Wavelength was generally increased (a few sites having large increases) and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period. Sinuosity was largely unmodified from reference in the Lower zone.

Channel Form

There was minor change from Reference Condition in Channel Form in the Upper zone. The more serious impacts were channel straightening and channel simplification. Channel straightening was indicated at 60% of sites as a result of both increased meander wavelength and reduced sinuosity. Channel simplification was indicated at 100% of sites mostly as a result of channel straightening. There was widespread evidence of channel enlargement but small deviations from Reference Condition had little influence on scores when aggregated at the zone scale.

There was minor change from Reference Condition in Channel Form in the Middle zone. The more serious impact was changes in channel size. There was evidence of both channel enlargement and contraction across this zone. An enlarged channel was indicated at 60% of sites as a result of channel widening and bed degradation. Channel contraction was indicated at 30% of sites as a result of channel narrowing and bed aggradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

The SRA result of widespread channel widening is consistent with the findings of previous field studies (Hale *et al.* 2007, Thoms 1996), but these field studies did not support the SRA result of channel narrowing and bed degradation in parts of the Middle zone. There was considerable change from Reference Condition in Channel Form in the Lower zone. The more serious impacts were channel enlargement and channel straightening. An enlarged channel was indicated at 80% of sites as a result of channel widening and bed degradation. Channel straightening was indicated at 40% of sites mostly as a result of increased meander wavelength. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Upper and Lower zones and minor change from reference in Bank Dynamics in the Middle zone. At 50% of sites in the Middle zone Bank Variability was less than under Reference Conditions indicating altered Bank Dynamics.

There was minor change from Reference Condition in Bed Dynamics in the Upper, Middle and Lower zones mostly as a result of widespread elevated sediment load (80-100% of the SedNet river segments) in all three zones and widespread sedimentation (50-70% of the SedNet river segments) in the Middle and Lower zones. In the Middle and Lower zones, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Bed aggradation is expected because of the increased load of sediment to the river from the upstream catchment, both from local bank erosion (Thoms 1996, Hale *et al*. 2007) and from active bank gullies that Hale et al. (2007) observed to be common in the Upper and Middle zones. While considerable lengths of the river are in weir pools, which are conducive to sediment deposition, the reaches downstream of the weirs could be sediment starved, and therefore prone to bed degradation..

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Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was substantial change from reference in Floodplain Sedimentation in the Upper zone as a result of widespread sedimentation (100% of SedNet river segments). There was little change from reference in Floodplain Sedimentation in the Middle and Lower zones as a result of widespread sedimentation (100% of SedNet river segments).

Table DRL 10: Darling Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upper	Middle	Lower
Index	Physical Form Condition (SR-PI)	60 (48–69)	48 (37–65)	64 (46–78)	60 (45–79)
Indicator	Channel Form (volume and flow events)	60 (52–66)	75 (60–92)	60 (48–69)	50 (40–63)
Sub-ind.	Cross-section Form	56 (50–62)	86 (74–93)	54 (46–63)	45 (35–56)
Metric	Channel Depth (mean)	1.83 (1.59–2.00)	1.26 (1.14–1.44)	1.81 (1.41–2.00)	2.00 (1.68–3.00)
Metric	Channel Width (mean)	1.07 (1.02–1.14)	1.20 (1.15–1.25)	1.08 (1.00–1.16)	1.00 (0.88–1.09)
Sub-ind.	Cross-section Form (variability)	75 (66–83)	78 (63–90)	73 (55–85)	78 (63–89)
Metric	Channel Width (CV)	0.85 (0.79–0.90)	0.82 (0.75–0.89)	0.86 (0.74–0.94)	0.86 (0.78–0.95)
Sub-ind.	Channel Planform	82 (76–87)	76 (55–91)	84 (73–90)	81 (67–92)
Metric	Sinuosity	1.04 (1.01–1.08)	1.01 (0.99–1.04)	1.06 (1.00–1.24)	1.03 (1.00–1.07)
Metric	Meander Wavelength	1.09 (1.06–1.13)	1.15 (1.05–1.28)	1.06 (1.02–1.13)	1.11 (1.04–1.20)
Indicator	Bed Dynamics	67 (64–71)	70 (60–78)	64 (59–69)	72 (64–79)
Metric	Channel Sediment Ratio	56 (46–65)	22 (17–26)	88 (71–105)	12 (8–15)
Metric	Channel Sediment Depth	0.002 (0.002–0.003)	0.001 (0–0.003)	0.002 (0.002–0.003)	0.003 (0.002–0.004)
Indicator	Bank Dynamics	87 (80–92)	100 (99–100)	79 (68–87)	95 (92–98)
Metric	Bank Variability (longitudinal)	0.91 (0.88–0.95)	0.99 (0.97–1.00)	0.87 (0.80–0.94)	0.95 (0.90–1.00)
Indicator	Floodplain	78 (74–82)	24 (10–42)	86 (80–90)	91 (84–96)
Metric	Floodplain Sediment Deposition	5.00 (3.00–6.00)	23.00 (15.00–29.00)	1.77 (1.12–2.00)	1.38 (0.52–3.00)

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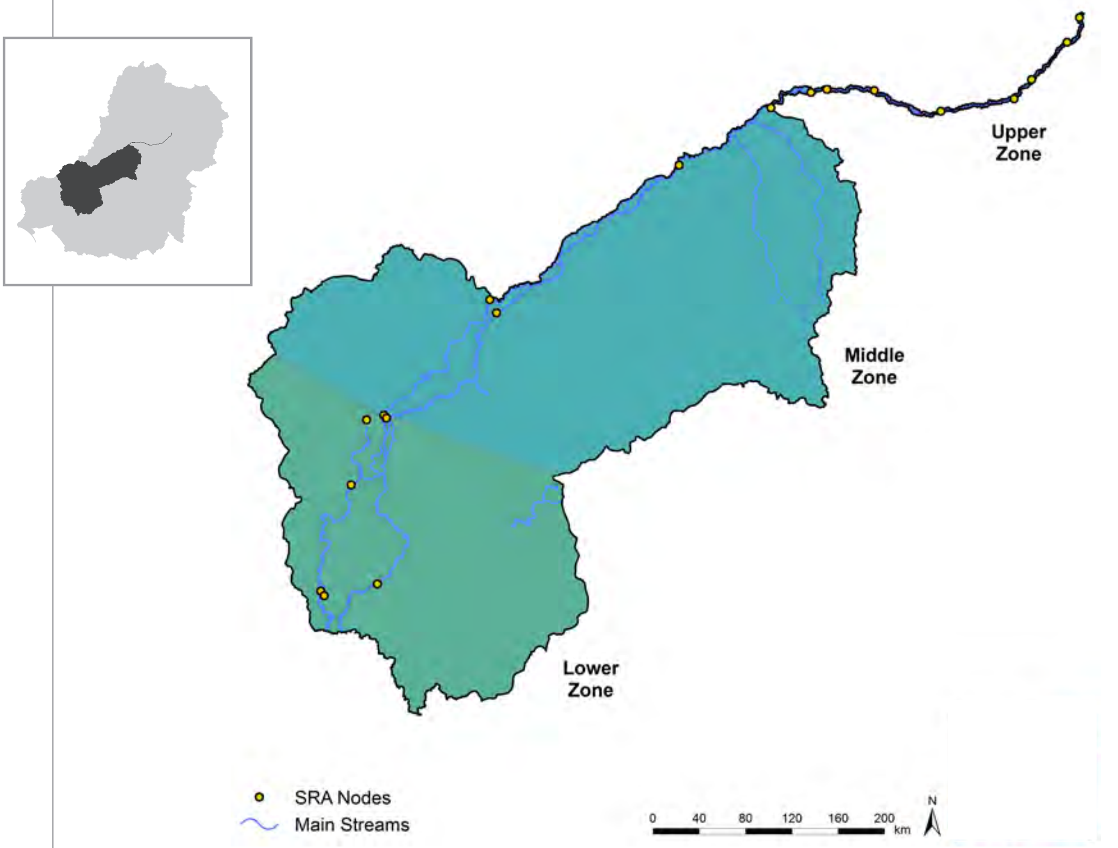

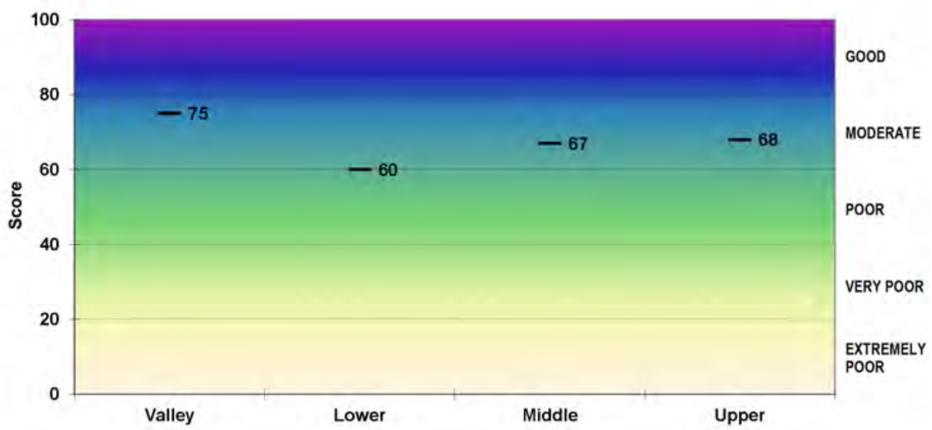

Figure DRL 6: Darling Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

Graph shows SR–HI scores as horizontal bars.

Hydrology

The Hydrology of the Darling Valley river system was in Moderate condition, with an aggregate Hydrology Index (SR–HI) score of 75. The Upper, Middle and Lower zones were all in Moderate condition. The mainstem river system of the Darling Valley was in Moderate condition. High flows were reduced, the duration and frequency of high flow spells were reduced, monthly flow variation was increased, inter-flood durations for low over bank flows were increased and inter-flood durations for high over bank flows were increased throughout all of the mainstem river system. There was also widespread change in the frequency of low flow spells and reduced duration of low over bank flows. Throughout much of the mainstem river system both mean flows and the amplitude of seasonal flow variations were reduced relative to reference. Headwater stream scores did not receive any weight in the valley assessment because all zones in the Darling Valley are classed as Lowland and flow alterations in mainstem rivers are hydrologically dominant in the Lowland zones.

The Darling River and its tributaries drain the northern area of the Basin. Most of the tributaries rise on the flanks of the Great Dividing Range in south-eastern Queensland and north-eastern New South Wales. In addition, the Paroo and Warrego rivers drain the arid north-western region. The main contributors are the Border Rivers (35 percent of long-term annual discharge), Namoi (25 percent), Condamine (20 percent), Gwydir (10 percent), Castlereagh and Macquarie (5 percent) and Paroo and Warrego valleys (five percent) (Thoms *et al.* 2004). All but the Macquarie are summer flow rivers, in that much of their annual discharge originates from summer rainfall. The Paroo and Warrego are highly episodic; their flows usually do not reach the Darling. There is little diversion from the Paroo or Warrego, and their current flow regimes are considered equivalent to Reference Condition. There are major irrigation storages on the Condamine, Border Rivers, Gwydir, Namoi, and Macquarie; the major (volumetric) tributaries of the Darling. There are no instream storages on the Darling, other than low-level weirs to provide domestic and stock supply during zero-flow periods. There are 15 such weirs on the Darling upstream of Menindee, ponding some 640 km of the river (Thoms *et al.* 1996). Most diversions take the form of opportunistic harvesting of high flows, and licences preclude pumping at other times. The major irrigated crop is cotton, with citrus and grapes in the lower reaches. A series of annexed deflation lakes at Menindee regulates flow to the lower river, including the Great Anabranch.

In the Darling Valley, hydrological condition is assessed using metrics of hydrological alteration available for 11,006 km of mainstem rivers and headwater streams. There is 2,794 km of mainstem river extending across the Upper, Middle and Lower zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by monthly water resource modelling in 1% of river reaches and daily modelling in the remainder. In the Darling Valley there is 8,212 km of headwater stream (Lower zone: 1,040 km; Middle zone: 7,158 km; Upper zone: 14 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries of the Darling Valley, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Darling Valley there is 7,066 km of these mid-size tributaries (1,273 km in the Lower zone; 5,685 km in the Middle zone; 108 km in the Upper zone)-- which is 0.6 times the stream length for which metrics are available.

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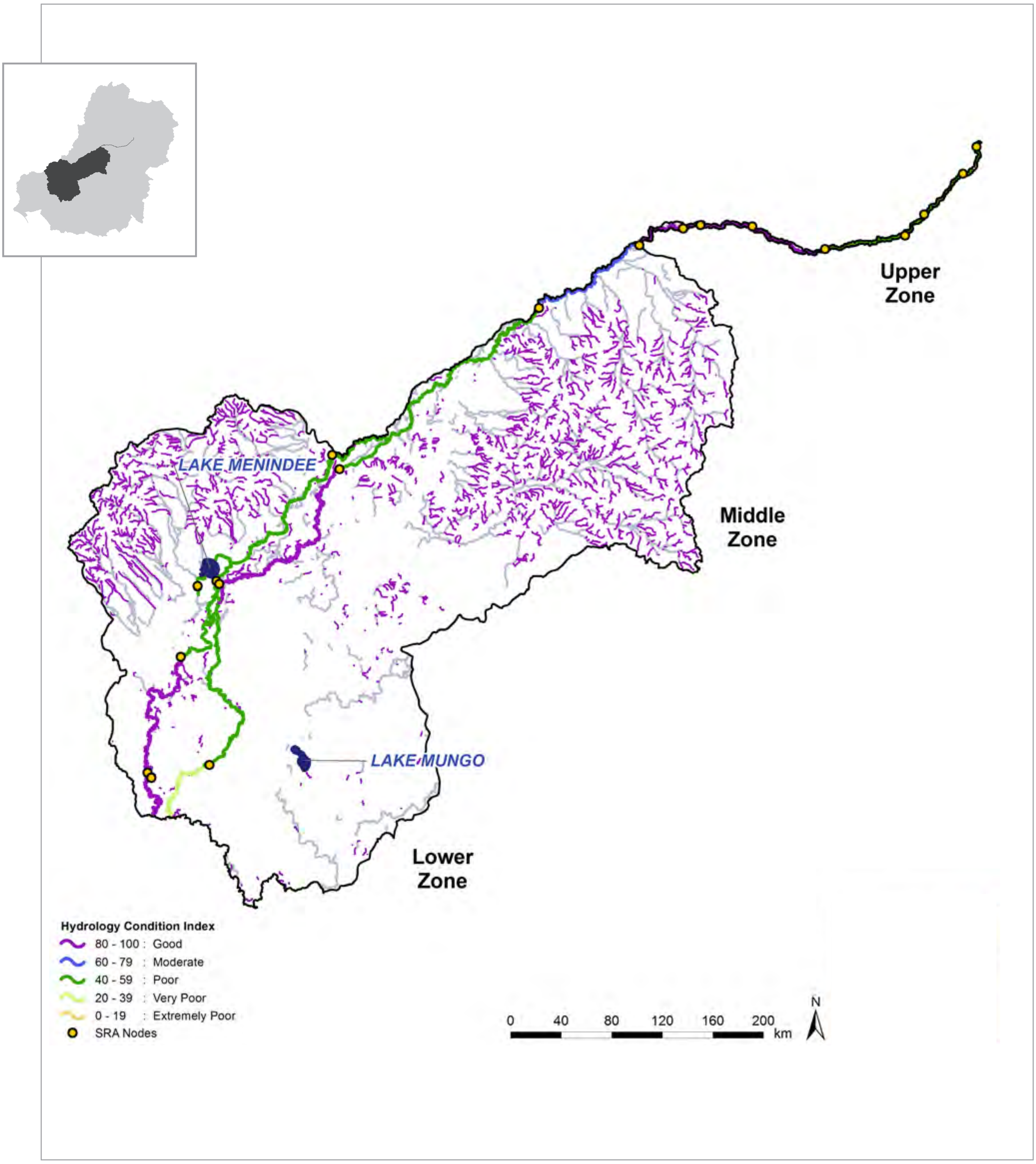

Figure DRL 7: Darling Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures DRL 6 and DRL 7 show values of the Hydrology Condition Index (SR–HI) for the Darling Valley and its river network, and Table DRL 11 and DRL 12 show the Index, sub-index, indicator and metric values. Analyses showed a moderate difference from Reference Condition for the Darling Valley, with:

- The Hydrology Condition Index for the whole valley = 75, indicating Moderate hydrological condition.
- The Hydrology Condition Index for the Lower, Middle and Upper zones = 60, 67 and 68 all indicating Moderate hydrological condition.
- The Hydrology Condition Index for headwater streams (valley-wide) = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 65, indicating Moderate hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 46, indicating Poor condition and a large difference from Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 93, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed a large difference from Reference Condition. Results for the Flow Duration metric showed a very significant alteration from Reference Condition in 4% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lower zone. Results for the Mean Annual Flow Duration metric show a very significant alteration from Reference Condition in 65% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 8% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

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High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to reference.

In the mainstem rivers, the High Flow Events sub-indicator showed a large difference from Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 82% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 18% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone. Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 98% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 2% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a significant alteration from reference in 23% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone and most in the Middle zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a significant alteration from reference in 6% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone and some in the Upper zone. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 4% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lower zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 16% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from reference in 61% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to reference. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a moderate difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 47% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 26% of the mainstem river length (mostly associated with a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Lower, Middle and Upper zones. Results for the Seasonal Period metric showed a significant alteration from reference in 8% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with most in the Lower zone and a small proportion in the Upper zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed only small variations from reference throughout the headwater river length (mostly associated with increased amplitude). Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed a large difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 8% of the mainstem river length (associated with both increased and reduced variability) and a significant alteration from reference in 92% of the mainstem river length (mostly associated with increased variability). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed only small variations from reference throughout the headwater river length (associated with both increased and reduced variability).

Low Over Bank Floods

The Low Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 1-year flood in the reference regime. It is calculated from a combination of the Low Over Bank Flood Duration metric and the Low Over Bank Flood Spells metric. The Low Over Bank Flood Duration metric quantifies change in the duration of flooding of low-level floodplain areas relative to reference. The Low Over Bank Flood Spells metric quantifies change in the duration of time between low-level floodplain inundation events relative to reference. The Low Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly timestep.

In the mainstem rivers, the Low Over Bank Floods indicator showed a moderate difference from Reference Condition. Results for the Low Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 68% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 28% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 7% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 70% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and a small portion in the Upper zone.

High Over Bank Floods

The High Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 8-year flood in the reference regime. It is calculated from a combination of the High Over Bank Flood Duration metric and the High Over Bank Flood Spells metric. The High Over Bank Flood Duration metric quantifies change in the duration of flooding of high-level floodplain areas relative to reference. The High Over Bank Flood Spells metric quantifies change in the duration of time between high-level floodplain inundation events relative to reference. The High Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly timestep.

In the mainstem rivers, the High Over Bank Floods indicator showed near Reference Condition. Results for the High Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 8% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from reference in 92% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone. Results for the High Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 25% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lower zone, some in the Middle zone and some in the Upper zone.

Summary: mainstem rivers

The mainstem river system of the Darling Valley was in Moderate condition. High Flows were reduced, the duration and frequency of High Flow Spells were reduced, monthly flow variation was increased, inter-flood durations for Low Over Bank Flows were increased and inter-flood durations for High Over Bank Flows were increased throughout all of the mainstem river system. There was also widespread change in the frequency of Low Flow Spells and reduced duration of Low Over Bank Flows. Throughout much of the mainstem river system both mean flows and the amplitude of seasonal flow variations were reduced relative to Reference Condition.

Summary: headwater streams

The headwater streams of the Darling Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume relative to Reference Condition. Headwater stream scores did not receive any weight in the valley assessment because all zones in the Darling Valley are classed as Lowland and flow alterations in mainstem rivers are hydrologically dominant in the Lowland zones.

Table DRL 11: Darling Valley SRA Hydrology Condition Index at valley and zone scales.

Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone		
		Upper	Middle	Lower
Hydrology Condition SR–HI	75	68	67	60

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Table DRL 12: Darling Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**65 (3–100)**	**100 (90–100)**
Sub-Index	In-Channel Flow Regime	46 (1–100)	100 (90–100)
Indicator	In-Channel Flow Regime A (volume and flow events)	64 (20–99)	100 (75–100)
Sub-ind.	Flow Gross Volume	55 (1–98)	100 (97–100)
Metric	Mean Annual Flow	0.52 (0.05–0.92)	1.00 (0.96–1.10)
Metric	Flow Duration	0.95 (0.85–1.04)	0.98 (0.90–1.07)
Sub-ind.	High Flow Events	59 (19–93)	97 (47–100)
Metric	High Flow	0.39 (0.02–0.91)	0.89 (0.32–1.43)
Metric	High Flow Spells	0.45 (0.26–0.66)	
Sub-ind.	Low and Zero Flow Events	89 (44–98)	99 (90–99)
Metric	Zero Flows Proportion	1.03 (0.69–1.85)	1.00 (0.96–1.00)
Metric	Low Flow	0.97 (0.55–1.24)	0.98 (0.66–1.19)
Metric	Low Flow Spells	1.06 (0.49–1.71)	
Indicator	In-Channel Flow Regime B (seasonality & variability)	47 (8–92)	100 (83–100)
Sub-ind.	Flow Seasonality	68 (18–98)	100 (71–100)
Metric	Flow Seasonal Amplitude	0.61 (0–1.00)	0.99 (0.89–1.57)
Metric	Flow Seasonal Period	0.84 (0.54–0.93)	0.99 (0.92–1.00)
Sub-ind.	Flow Variability	47 (30–91)	98 (64–100)
Metric	Flow Variation	1.37 (1.10–1.80)	0.97 (0.78–1.00)
Sub-Index	Over Bank Flow Regime	93 (24–99)	
Indicator	Over Bank Floods Low	75 (44–85)	
Metric	OB Flow Duration (ARI 1)	0.51 (0.28–1.00)	
Metric	OB Flow Spells (ARI 1)	0.75 (0.33–1.01)	
Indicator	Over Bank Floods High	84 (20–98)	
Metric	OB Flow Duration (ARI 8)	0.72 (0.26–2.00)	
Metric	OB Flow Spells (ARI 8)	0.84 (0.17–1.16)	

	Zone					
	Mainstem rivers			Headwater streams		
	Upper	Middle	Lower	Upper	Middle	Lower
	68	**67**	**60**	**100**	**100**	**100**
	50	50	39	100	100	100
	57	**68**	**62**	**100**	**100**	**100**
	45	54	62	100	100	100
	0.43	0.51	0.59	1.00	1.00	1.00
	0.96	0.95	0.94	0.98	0.98	0.97
	58	63	54	99	97	96
	0.33	0.45	0.35	0.93	0.89	0.87
	0.49	0.46	0.43			
	85	92	87	97	99	99
	1.01	1.00	1.08	1.00	1.00	1.00
	0.99	1.00	0.92	0.89	0.98	0.99
	1.17	1.16	0.86			
	58	**51**	**35**	**100**	**100**	**100**
	67	67	69	100	100	99
	0.58	0.59	0.65	0.99	0.99	1.00
	0.87	0.85	0.81	0.99	0.99	0.99
	56	51	38	98	98	95
	1.30	1.34	1.46	0.97	0.97	0.95
	86	95	93			
	82	74	73			
	0.55	0.50	0.51			
	0.82	0.72	0.75			
	74	87	86			
	0.66	0.67	0.81			
	0.67	0.90	0.85			

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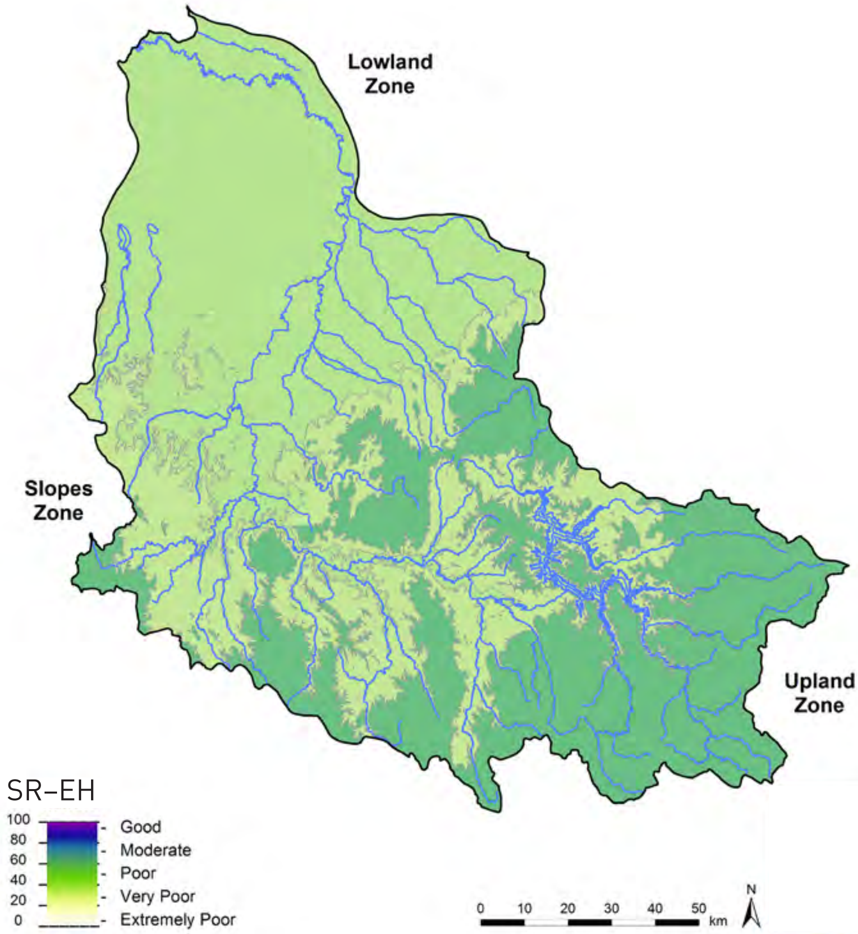

Figure GLB 1: Goulburn Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure GLB 1 shows the Ecosystem Health ratings for the Goulburn Valley and Tables GLB 1 and GLB 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Goulburn Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Poor and Poor condition respectively, while Physical Form and Hydrology were in Good and Poor condition respectively.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Goulburn Valley river system. River Ecosystem Health was rated as Very Poor (Lowland zone: Very Poor; Slopes zone: Very Poor; Upland zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Goulburn Valley river ecosystem was in Very Poor health. River Ecosystem Health for the zones was as follows: Upland Poor; Slopes and Lowland Very Poor. The Fish community was in Extremely Poor condition. Some expected species were absent. Species counts and abundance were dominated by native species but biomass was dominated by aliens. Recruitment levels among the remaining native species were reduced. The Macroinvertebrate community was in Poor condition, with substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Poor condition overall; with reduced abundance, stability and nativeness in the Near Riparian and Lowland Floodplain domains, and a large increase in fragmentation in the Lowland Floodplain. The Physical Form of the river system was in Good condition with bank dynamics in Good condition, moderate levels of channel simplification and enlargement and moderate to high levels of floodplain sediment deposition. The river system's Hydrology was in Poor condition, with substantial alteration relative to Reference Condition in mainstem river flow variability and flow seasonality, low and zero flow events and high flow events and flow gross volume.

Ecosystem Health

The Goulburn Valley scored in the lower 50% of the 23 SRA valleys for all condition indices. It was ranked among the four lowest rated valleys in Very Poor health (see Table 5.2). It was rated the lowest score for Hydrological Condition and the second lowest for Macroinvertebrate Condition. It was 12th of 23 valleys for Physical Form, 17th for Vegetation and equal 18th (with the Murrumbidgee) for Fish.

The Goulburn River is highly regulated, primarily through the large in-stream storage (3334 GL capacity) of Lake Eildon, and the Very Poor rating for Hydrology is entirely driven by the Lowland zone stream system situated downstream of this dam. The river supports extensive irrigation in the Goulburn Valley and, through inter-valley transfer via Waranga Basin, the Campaspe and Loddon valleys. The Goulburn system has experienced extreme drought conditions for the period 2001-2009 inclusive. Regulation of flow for downstream uses has contributed to nullifying threats from extremes of low flow, but other ecologically significant components of the flow regime have been significantly curtailed (Cottingham *et al.* 2003, 2007).

All fish and macroinvertebrate samples have been collected during the drought and future samples should describe any improvement in their condition following a return to more benign climatic conditions. Given the current low level of fish and macroinvertebrate condition this improvement might be expected to be large, though it is quite possible that physical factors directly and indirectly linked to water management and use will limit the capacity of the riverine ecosystem to respond.

Fish Theme

The Fish Condition Index SR–FI = 15, indicating Extremely Poor condition (Lowland zone: Extremely Poor; Slopes zone: Extremely Poor; Upland zone: Very Poor). The Expectedness indicator = 15, indicating Extremely Poor condition, and an extreme difference from Reference Condition. The Nativeness indicator = 46, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 39, indicating Very Poor condition, and a very large difference from Reference Condition.

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In general, the fish community of the Goulburn had lost much of its native species richness and alien species contributed over 60% of the biomass in samples. The Upland zone in particular had few native fish and lacked 83% of the predicted native species.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 55, indicating Poor condition (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Moderate). The simOE metric = 43 indicating a large difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Poor to Extremely Poor condition was high overall (61%), especially in the Lowland zone; six of the 34 rated sites (18%) were in Good condition.

Family richness generally was high, though low compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 46, indicating Poor condition overall (Lowland zone: Very Poor; Slopes zone: Very Poor; Upland zone: Good). The Vegetation Abundance and Diversity indicator = 60, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and stability of major vegetation groups within Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 55 indicating Poor condition and a large difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups within Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is moderately affected by clearing. The abundance of major vegetation groups in the sampled floodplain area shows a moderate difference from Reference Condition but the degree of fragmentation shows a large difference.

Physical Form Theme

The Physical Form Condition Index SR–PI = 82, indicating Good condition (Lowland zone: Moderate; Slopes zone: Good; Upland zone: Good). The Channel Form indicator = 79, the Bed Dynamics indicator = 70 and the Floodplain Form indicator = 66; all indicating Moderate condition and showing a minor difference from Reference Condition. The Bank Dynamics indicator = 94, indicating Good condition and near Reference Condition.

The valley's riverine physical form was characterised by channel simplification and enlargement, particularly in the Lowland zone. There was also indication of elevated sediment loads and floodplain sediment deposition in the Lowland zone over the period since European settlement.

Hydrology Theme

The Hydrology Condition Index SR–HI = 43, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Moderate; Upland zone: Good). The In-Channel Flow Regime indicator = 20, indicating Very Poor condition and a very large difference from Reference Condition for the flow regime within the channels.

Mainstem river reaches were characterised by substantial alteration in Flow Variability and Flow Seasonality, considerable alteration in Low and Zero Flow Events and High Flow Events and minor alteration in Flow Gross Volume. In contrast, the headwater streams were generally characterised by little or no alteration in any of these indicators.

Table GLB 1: Goulburn Valley Ecosystem Health and condition assessments.

Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	UPLAND	SLOPES	LOWLAND
		Very Poor	Poor	Very Poor	Very Poor

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	15 (9–20) Ext' Poor	21 (0–26) Very Poor	8 (4–13) Ext' Poor	18 (9–27 Ext' Poor
Macro-invertebrates	SCORE RATING	55 (49–62) Poor	66 (43–85) Moderate	69 (62–75) Moderate	43 (34–53) Poor
Vegetation	SCORE RATING	46 Poor	100 Good	24 Very Poor	36 Very Poor

Table GLB 2: Goulburn Valley Physical Form and Hydrology condition assessments.

Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	82 (73–90) Good	96 (86–100) Good	95 (87–99) Good	67 (52–84) Moderate
Hydrology	SCORE RATING	43 Poor	100 Good	62 Moderate	20 Very Poor

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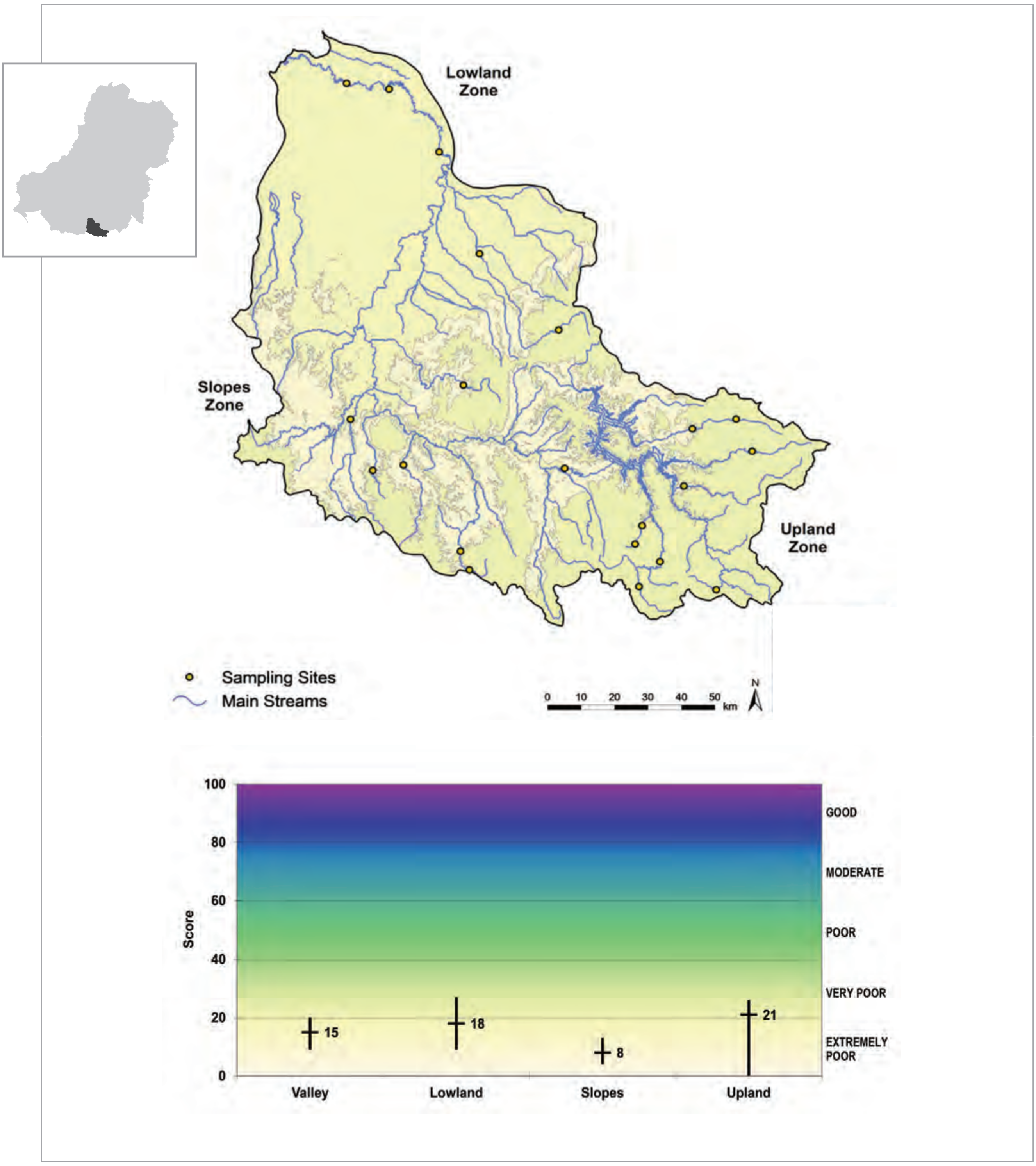

Figure GLB 2: Goulburn Valley map with sampling sites and zones coloured by SRA Fish Index (SR-FI) scores.

Graph shows mean SR-FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Goulburn Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 15. The condition of the fish community in the zones was as follows: Upland Very Poor; Slopes Extremely Poor; and Lowland Extremely Poor. The fish community was characterised by an Extremely Poor score for expected native fish species, a Poor score for nativeness and a Very Poor score for native fish recruitment. The Upland zone in particular had few native fish and lacked 83% of the predicted native species. The valley had lost much of its native species richness and alien species contributed over 60% of the biomass in samples. Native fish recruitment was Good, Extremely Poor and Very Poor in the Upland, Slopes and Lowland zones respectively.

Twenty-one sites were surveyed across the Goulburn Valley in November–December 2008, yielding 754 fish. Analyses showed an extreme difference from Reference Condition for the Goulburn Valley, with:

- SRA Fish Index (SR–FI) = 15 (CL 9–20), indicating Extremely Poor condition of the fish community.
- The Expectedness indicator = 15 (CL 10–21), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Only 52% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 46 (CL 34–58), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 39 (CL 19–46), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for nine of the 13 native species observed in the valley.

Figure GLB 2 shows sampling sites, zones and corresponding SR–FI values, and Table GLB 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Goulburn Valley was sixth lowest for all valleys, and close to that for the Kiewa and Murrumbidgee valleys. The Slopes zone community was in worse condition (SR–FI = 8) than that in either the Lowland zone (SR–FI = 18) or the Upland zone (SR–FI = 21). The Condition Index for the Upland zone would have been considerably lower except for the high Recruitment score for the two remaining native species caught in that zone.

Expectedness was Extremely Poor in the valley as a whole, and especially in the Upland and Slopes zones. Of the 12 native species expected in the Upland zone under Reference Condition (RC–F), only one galaxias and 30 two-spined blackfish were caught. The proportion of expected species caught in each zone was: Upland zone; 17%, Slopes zone; 25%, Lowland zone; 41%.

Nativeness was rated as Poor in the in the valley as a whole; Very Poor in the Upland zone and Poor for the Slopes and Lowland zones. Six alien species were caught in the Goulburn Valley.

All six were present in the Lowland zone and there were three alien species in each of the Upland and Slopes zones. The number of alien fish caught was small relative to other valleys, as was their biomass with the exception of common carp (the 28 common carp caught weighed an average of over 2 kg each). This tended to compensate for the low catches of native fish in the estimation of Nativeness.

The Goulburn Valley had the seventh lowest biomass of fish per site (5.5 kg) amongst the 23 valleys. With the exception of Murray cod (average weight 955 g) and golden perch (1.8 kg per fish) the native fish caught were all small. Likewise, with the exception of common carp at a little over 2 kg each, alien fish were small—even potentially large species such as brown trout (average weight 66 g), rainbow trout (44 g) and redfin perch (31 g).

Table GLB 4 shows native species abundances in the Goulburn Valley compared with Reference Condition. The most common native fish were two-spined blackfish in the Upland and Slopes zones and gudgeon in the Lowland zone. Murray cod and golden perch were present in the Lowland zone but freshwater catfish and trout cod were not present in any samples. One silver perch was caught in the Lowland zone. Six alien species were present. Common carp were notably few in number (and absent from the Upland zone) but contributed over 49% of the fish biomass in the Goulburn Valley.

Recruitment varied in all zones. Throughout the valley nine of the 13 native species observed showed evidence of recruitment in at least one site. Murray cod showed signs of recruitment in all three Lowland sites in which it was caught, and there was evidence of two-spined blackfish recruiting in five of the nine sites at which it was caught. Notably, common carp and goldfish showed no evidence of recruitment throughout the valley. Both species of trout were recorded as recruiting in all three zones.

In general, the fish community of the Goulburn had reduced numbers of expected native species and moderate numbers and biomass of fish, both native and alien.

Table GLB 3: Goulburn Valley SRA Fish Condition Index, indicators, metrics and derived variable

Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	15 (9–20)	21 (0–26)	8 (4–13)	18 (9–27)
Indicator	Expectedness	15 (10–21)	3 (1–7)	7 (5–10)	24 (16–36)
Metric	O/E	0.23 (0.14–0.30)	0.17 (0.07–0.31)	0.20 (0.15–0.24)	0.27 (0.12–0.42)
Metric	O/P (Zone level)	0.31 (0.31–0.31)	0.17 (0.17–0.17)	0.25 (0.25–0.25)	0.41 (0.41–0.41)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Nativeness	46 (34–58)	28 (3–52)	56 (41–72)	47 (28–66)
Metric	Proportion biomass native	0.30 (0.17–0.44)	0.28 (0.02–0.58)	0.30 (0.11–0.57)	0.32 (0.13–0.50)
Metric	Proportion abundance native	0.54 (0.39–0.69)	0.30 (0.02–0.58)	0.72 (0.58–0.86)	0.52 (0.26–0.79)
Metric	Proportion species native	0.50 (0.36–0.63)	0.33 (0.10–0.62)	0.55 (0.40–0.71)	0.54 (0.31–0.75)
Indicator	Recruitment	39 (19-46)	89 (0-91)	19 (2-34)	32 (18-46)
Metric	Proportion of sites with native recruits	0.50 (0.28–0.56)	0.98 (0–1.00)	0.37 (0.12–0.50)	0.39 (0.24–0.51)
Metric	Proportion of native taxa with recruits	0.68 (0.51–0.83)	1.00 (0–1.00)	0.50 (0.33–1.00)	0.67 (0.50–0.86)
Metric	Proportion of abundance as recruits	0.34 (0.23–0.43)	0.55 (0–0.59)	0.10 (0.01–0.26)	0.40 (0.37–0.59)
Variables					
	Number of sites sampled	21	7	7	7
	Total number of species	19	5	7	15
	Number of native species	13	2	4	9
	Number of predicted species	25	12	16	22
	Number of alien species	6	3	3	6
	Mean number of fish per site	36	26	23	59
	Biomass/site all species (g)	5530	1105	1535	13950
	Mean native biomass/fish (g)	95	24	15	126
	Mean alien biomass/fish (g)	263	47	183	810

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Table GLB 4: Goulburn Valley number of fish by zone.

Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone		
		Upland	Slopes	Lowland
Sites sampled	21	7	7	7
Native species				
Australian smelt	71	0	0	71
Barred galaxias	0	0		
Bony herring	0			0
Congolli	0			0
Dwarf flathead gudgeon	0			0
Flathead gudgeon	15		0	15
Freshwater catfish	0		0	0
Galaxias	6	1	5	
Golden perch	7		0	7
Gudgeon	194	0	0	194
Macquarie perch	1	0	0	1
Mountain galaxias	8	0	8	
Murray cod	32	0	0	32
Murray hardyhead	0			0
Murry jollytail	0		0	0
Murray–Darling rainbowfish	25			25
Obscure galaxias complex	4	0	0	4
River blackfish	20	0	20	

Fish species	Valley	Zone		
		Upland	Slopes	Lowland
Shortheaded lamprey	0			0
Silver perch	1		0	1
Southern purple-spotted gudgeon	0			0
Southern pygmy perch	0	0	0	0
Trout cod	0	0	0	0
Two-spined blackfish	105	30	75	0
Unspecked hardyhead	0			0
Alien species				
Brown trout	105	44	42	19
Common carp	28		3	25
Gambusia	15			15
Goldfish	2			2
Rainbow trout	99	92	5	2
Redfin perch	16	13		3

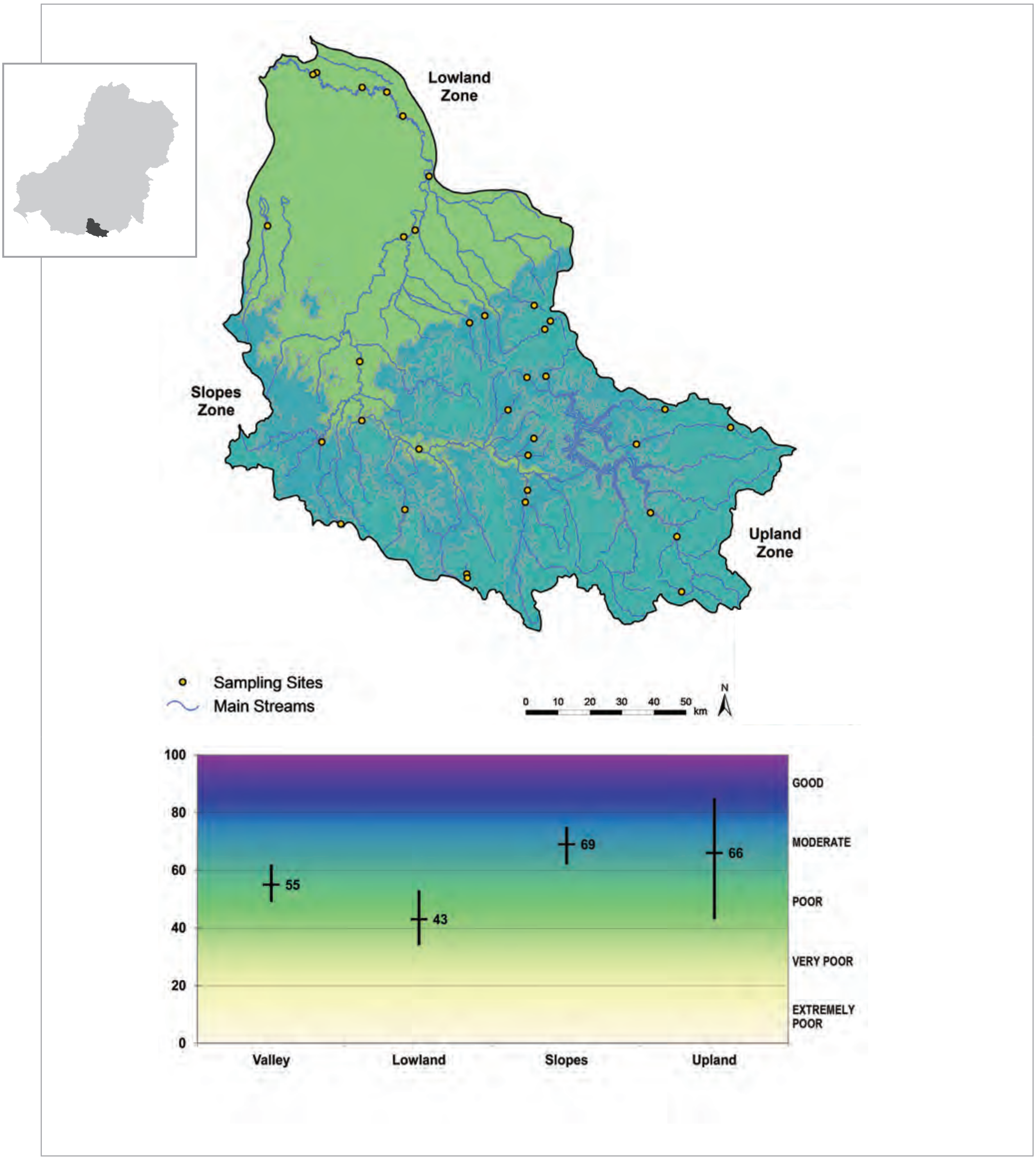

Figure GLB 3: Goulburn Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Goulburn Valley river system was in Poor condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 55. The condition of the macroinvertebrate community in the zones was as follows: Upland Moderate; Slopes Moderate; Lowland Poor. The proportion of sites in Poor to Extremely Poor condition was high overall (57%), especially in the Lowland zone. Family richness generally was high, though low compared to Reference Condition.

Thirty-five sites were surveyed across the Goulburn Valley in November–December 2009 yielding 11,415 macroinvertebrates in 82 families (87% of Basin families). Analyses showed a large difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 55 (CL 49–62), indicating Poor condition of benthic macroinvertebrate communities.
- The simOE metric = 43 (CL 40–46) indicating a large difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Poor to Extremely Poor condition was high across all zones (57% overall) and especially in the Lowland zone (86% of sites); six of the 34 rated sites (18%) were in Good condition (four of which were in the Upland zone).
- The number of families found was lowest in the Lowland zone (53 families) and highest in the Upland zone (65 families), and the Upland and Slopes zones had the highest average number of families per site (30 and 31, respectively).

Figure GLB 3 shows sampling sites, zones and SR–MI values, and Table GLB 5 shows Index and metric values. The SR–MI score for the Goulburn Valley indicated Poor condition of macroinvertebrate communities, rating 22nd out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Upland and Slopes zones showed moderate differences from Reference Condition (SR–MI = 66 and 69, respectively). A very wide confidence interval (42 points) for the Upland zone SR–MI value value reflects the presence of four of the 10 sites in that zone being in Good condition (SR–MI > 80) and one site in Extremely Poor condition (SR–MI = 10.1). Expectedness (simOE) was Moderate overall in the two upper zones, but low in the Lowland zone; and varied by up to 26 points among sites.

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Table GLB 6 shows that only 41% of the sites had Moderate to Good SR–MI values, with six rated in Good condition (most in the Upland zone). The Slopes zone had only one site (8% of the zone's sites) with a low simOE score (<40 points), though the Lowland zone had eight (57%). Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

Family richness generally was low compared to Reference Condition, despite diversity being high (average 28 families per site). The Lowland zone was the least diverse at site scale (average 23 families per site). The valley contained 87% of the families found across the Basin (Table GLB 6), with the Upland and Lowland zones having the highest (69%) and lowest (56%) representations of Basin-wide fauna respectively. Most (79%) of the fauna of the valley was found in the Upland zone.

Table GLB 5: Goulburn Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower – upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	55 (49–62)	66 (43–85)	69 (62–75)	43 (34–53)
Metric	SimOE	43 (40–46)	49 (38–60)	47 (44–50)	37 (34–41)

Table GLB 6: Goulburn Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone		
		Upland	Slopes	Lowland
Sites				
Number of sites sampled	35	9	12	14
Number of sites with index values*	34	8	12	14
N sites by SR–MI condition band				
Good (80–100)	6	4	2	
Moderate (60–80)	8		6	2
Poor (40–60)	13	3	4	6
Very or Extremely Poor (0–40)	7	1		6
Families				
Number of families sampled	82	65	62	53
No. families/site (min-max)	28 (7–44)	30 (7–44)	31 (20–42)	23 (14–35)
Percent of families in Basin	87	69	66	56
Percent of families in valley	100	79	76	65

*simOE values could occasionally not be derived for every sample site.

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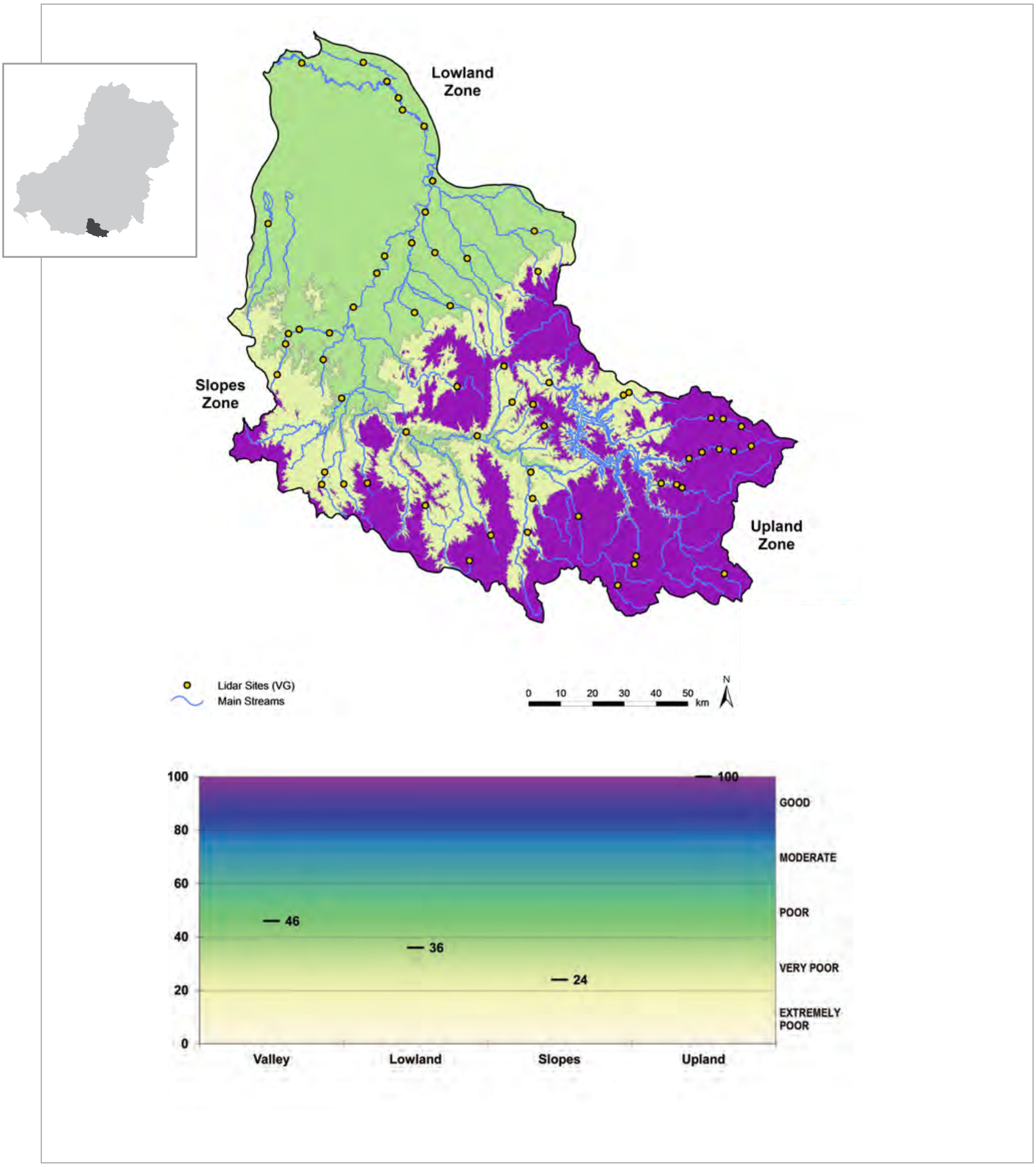

Figure GLB 4: Goulburn Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Goulburn Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 46. Overall condition for the three zones in this valley was: Upland Good; Slopes Very Poor; Lowland Very Poor.

The Abundance and Diversity indicator score was 60 for the valley, indicating a Moderate rating overall. In the three zones it was: Upland Good; Slopes Poor; Lowland Poor.

The Quality and Integrity indicator score was 55 for the valley, indicating a Poor rating overall. In the three zones it was: Upland Good; Slopes Poor and Lowland Poor.

The SRA Vegetation assessment for the Goulburn Valley considers riverine vegetation in two spatial domains: Near Riparian, along 2,507 km of stream, and Lowland Floodplain, for 281 km^2 of flooding land in the Lowland zone, which is part of the floodplain in the Lowland zone. Much (49%) of the stream length is in the Lowland zone, and the length of stream assessed per zone is as follows: Upland, 523 km; Slopes, 757 km; and Lowland, 1,227 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 63 sites along the stream network, set back 50 m from the top of the bank. LiDAR sites are distributed amongst the three zones as follows: Upland, 15 sites; Slopes, 21 sites; Lowland, 27 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure GLB 4 shows values of the Vegetation Index (SR–VI) for the Goulburn Valley and Table GLB 7 shows the Index, indicator and sub-indicator values. Tables GLB 8 and GLB 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a large difference from Reference Condition for the Goulburn Valley with:

- SRA Vegetation Index (SR–VI) = 46, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 60, indicating a moderate difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 55, indicating a large difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is moderately affected by clearing. The abundance of major vegetation groups in the sampled area shows a moderate difference from Reference Condition but the degree of fragmentation shows a large difference.

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The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with MVGs in near Reference Condition in the Upland zone, and showing a large difference from Reference Condition in the Slopes and Lowland zones. The Moderate rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wise abundance in the Near Riparian domain shows a large difference from reference and in the Lowland Floodplain a moderate difference. MVG richness is maintained in both Near Riparian and Lowland Floodplain domains, as no MVG has been completely reduced. Vegetation in the Lowland Floodplain domain has 73% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Poor condition overall, with marked contrast between zones. The Quality and Integrity indicator is near Reference Condition in the Upland zone and shows a large difference from reference in the Slopes and Lowland zones. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table GLB 8 as well as other native but non-specific MVGs. Valley-wide Nativeness shows a large difference from Reference Condition in the Near Riparian domain, and a moderate difference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain shows a large difference from reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain, is in Good condition overall, and the metrics show no loss of any MVG from any of the zones in the Near Riparian domain, and no loss of any MVG from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Poor condition overall, and the metrics show large differences between zones and domains. Abundance in the Near Riparian domain is near Reference Condition in the Upland zone, and shows a very large difference from reference in the Slopes and Lowland zones; and in the Lowland Floodplain domain, it shows a moderate difference from reference.

Stability

- Floodplain areas in the Lowland Floodplain domain are in Moderate condition, with moderate evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Poor condition overall, and the metrics show large differences between zones and domains. Nativeness in the Near Riparian domain is near Reference Condition in the Upland zone and shows a very large difference from reference in the Slopes and Lowland zones; and in the Lowland Floodplain domain, nativeness shows a moderate difference from reference.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Good condition overall, and in Good condition in all three zones. This sub-indicator refers only to height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of MVGs is in Poor condition. All MVGs show some fragmentation. Eucalypt Woodlands, the most extensive MVG in the Goulburn Valley, shows an increase in patch number and a decrease in mean patch size relative to Reference Condition, consistent with dissection.

Under Reference conditions, the riverine vegetation in the Goulburn Valley was characterised as follows:

- Upland zone: The Near Riparian domain was mostly Eucalypt Open Forests (58% of the domain area) and Eucalypt Tall Open Forests (28%). Only one of the other four MVGs covered 5% or more of the domain.
- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (57% of domain area) and Eucalypt Open Forests (32%). Only one of the other two MVGs covered 5% or more of the domain.
- Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (92% of domain area). Five other MVGs were present and none was more than 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (88% of domain area) with three other MVGs but none was much as 5% of the domain.

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Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced, particularly in the lower zones, in some domains and zones but not all.

- Upland zone: In the Near Riparian domain, although cleared, Eucalypt Open Forests are still the most extensive MVG (49% of the domain area) with Eucalypt Tall Open Forests (26%). About 16% of the domain is cleared or non-native vegetation. The MVGs most affected are Eucalypt Open Forest reduced from 58% of the domain to 49%, Eucalypt Woodlands, reduced from 10% under Reference Condition to 4%, and Acacia Shrublands reduced from 0.14% of the domain to 0.06%.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands have been reduced and now Eucalypt Open Forests are the most extensive MVG (18%) in the domain. About 44% is now cleared or non-native vegetation. The most affected MVG is Eucalypt Woodlands, reduced from 57% under Reference Condition of the domain to 7%.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands have been reduced but are still the most extensive MVG (35%). About 58% of the domain is cleared or non-native vegetation. The most proportionally reduced MVGs are Tussock Grasslands, from 0.99% of the domain to 0.17%, and Callitris Forests and Woodlands, reduced from 0.16% to 0.03% of the domain, while the greatest absolute reduction in area is in Eucalypt Woodlands.

- Lowland zone: In the Lowland Floodplain domain, although much reduced, Eucalypt Woodlands are still the most extensive NVG (66% of the domain area). About 24% is cleared or non-native vegetation. The most proportionally reduced MVGs are Tussock Grassland, from 1.11% to 0.28%, and Other Grasslands, Herblands, Sedgelands and Rushlands, from 1.07% to 0.32%.

Unlike the other Themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping is 2004, whereas the LiDAR was flown in June 2010. This means that the Structure Sub-indicator and the abundance, richness and nativeness metrics are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees present. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

The riverine vegetation of the Goulburn Valley is notable for the marked contrast in condition between the Upland and other zones, and for the difference between the Near Riparian and Lowland Floodplain domain in the Lowland zone. Most of the metrics are based on vegetation mapping which is not current and can be of variable quality: in the Lowland zone, for example, there is about 5% of the Near Riparian domain which is not assigned to an MVG, and in the Lowland Floodplain domain this is 9%. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of any of the zones and of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation in the best condition in the Goulburn Valley is in the Upland zone, where metrics and sub-indicators for abundance, nativeness, richness and structure in the Near Riparian domain are near Reference Condition. It is poorest in the Slopes zone, which has Very Poor scores for abundance and nativeness. The Lowland zone has the most influence on the valley score.

In the Lowland zone, there is a marked difference in condition between the two domains. The Near Riparian domain has low scores for abundance and nativeness indicative of clearing and loss of native vegetation but without losing any MVGs. In contrast, the Lowland Floodplain domain is in better condition, with scores that are moderate to near Reference Condition: only fragmentation has a low score. These two domains assess differing but overlapping parts of the landscape: the Lowland Floodplain domain is land that floods near the main river channels, whereas the Near Riparian domain is a continuous strip centred on all channels in the zone, and is more extensive.

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Table GLB 7: Goulburn Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	46	100	24	36
Indicator	Abundance and diversity	60	99	40	56
Metric	LF stability	0.73			0.73
Sub-ind.	NRLF richness	100			100
Metric	NR richness	1	1	1	1
Metric	LF richness	1			1
Sub-ind.	NRLF abundance	45			45
Metric	NR abundance	0.46	0.84	0.32	0.39
Metric	LF abundance	0.73			0.73
Indicator	Quality and integrity	55	98	40	46
Sub-ind.	NRLF nativeness	45			45
Metric	NR nativeness	0.46	0.84	0.32	0.39
Metric	LF nativeness	0.73			0.73
Sub-ind.	NR structure	82 (78–85)	86 (82–90)	80 (75–85)	82 (75–87)
Sub-ind.	LF fragmentation	54			54

Table GLB 8: The most abundant MVGs in the Near Riparian domain in the Goulburn Valley.

Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone		
	Upland	Slopes	Lowland
MVG			
2. Eucalypt Tall Open Forests	28	9	
3. Eucalypt Open Forests	58	32	
5. Eucalypt Woodlands	10	57	92

Table GLB 9: Most abundant MVGs in the Lowland Floodplain domain in the Goulburn Valley.

Showing percentage of domain area under Reference Condition in the Goulburn Valley, and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
5. Eucalypt Woodlands	88	1.81	0.41

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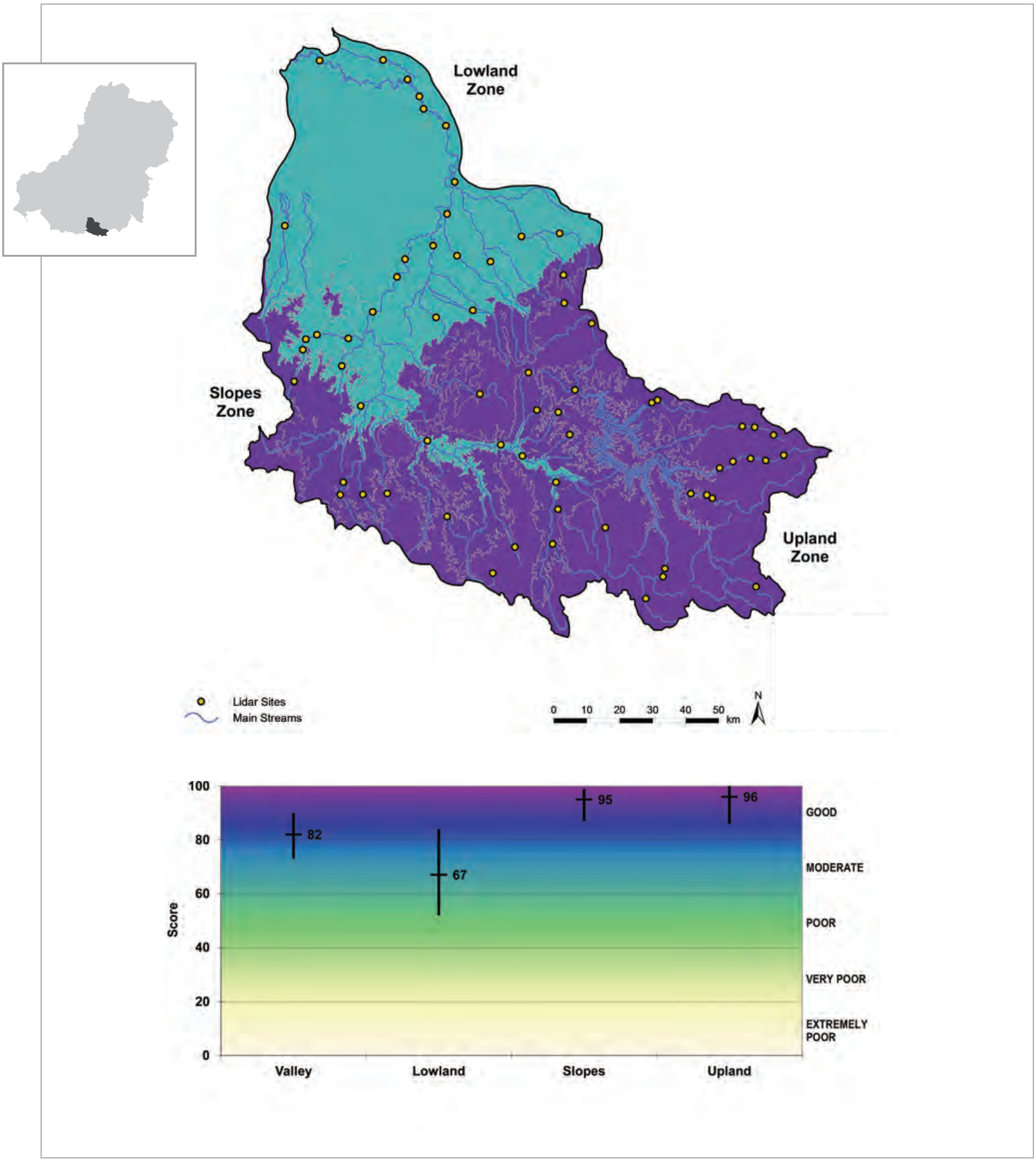

Figure GLB 5: Goulburn Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Goulburn Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 82. The condition of Physical Form in the zones was: Upland and Slopes Good; Lowland Moderate. The valley's river Channel Form was rated as Moderate. Bank Dynamics was rated as Good. Bed Dynamics and Floodplain Dynamics were rated as Moderate. The valley's riverine physical Form was characterised by channel simplification and enlargement, particularly in the Lowland zone. There was also indication of elevated sediment loads and floodplain sediment deposition in the Lowland zone over the period since European settlement.

The SRA Physical Form assessment considers physical form and processes along 2,507 km of stream across the valley. It is based on LiDAR data collected at 66 sites along river channels, as well as modelling of all 173 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure GLB 5 shows values of the Physical Form Index (SR–PI) for the Goulburn Valley and Table GLB 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a near Reference Condition for the Goulburn Valley with:

- SRA Physical Form Condition Index (SR–PI) = 82 (CL 73-90), indicating Good Physical Form condition
- the Channel Form indicator = 79 (CL 72-85), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 70 (CL 67-74), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 94 (CL 90-97), showing a near Reference Condition
- the Floodplain indicator = 66 (CL 57-75), showing a moderate difference from Reference Condition.

Upland zone

There were 16 LiDAR survey sites and 19 SedNet river segments in the Upland zone of the Goulburn Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upland zone. At these sites Channel Sediment Ratio was generally increased (a few sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period. Bank Variability was modified from reference in more than half of the Upland zone. At these sites Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width and Channel Depth were modified from Reference Condition for approximately half of the Upland zone. At these sites Channel Width was generally increased (a few sites having large increases) and results show both increases and decreases in Channel Depth across the zone. Channel Width Variability, Sinuosity and Meander Wavelength were modified from reference for less than half of the Upland zone. At these sites Channel Width Variability was generally reduced, Sinuosity was generally increased (a few sites having large increases) and Meander Wavelength was generally increased (many sites having large increases). Channel Sediment Deposition was largely unmodified from reference in the Upland zone. These results are consistent with field observations (Erskine *et al.* 1993).

Slopes zone

There were 21 LiDAR survey sites and 71 SedNet river segments in the Slopes zone of the Goulburn Valley. Based on these samples, Channel Sediment Ratio was modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases). Channel Width, Channel Depth, Bank Variability and Floodplain Sediment Deposition were modified from reference in more than half of the Slopes zone. At these sites Channel Width was generally increased (a few sites having large increases), results show both increases and decreases in Channel Depth across the zone, Bank Variability was generally increased indicating enhanced Bank Dynamics and there was a moderate increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Meander Wavelength was modified from reference for approximately half of the Slopes zone. At these sites Meander Wavelength was generally increased (many sites having large increases). Channel Width Variability was modified from reference for less than half of the Slopes zone. At these sites Channel Width Variability was generally reduced. Sinuosity and Channel Sediment Deposition were largely unmodified from reference in the Slopes zone. With the exception of Channel Sediment Deposition, these results are generally consistent with field observations (Erskine *et al.* 1993). Channels of the slopes are commonly gullied, and deposition of sand is very common in the cleared parts of the Slopes zone.

Lowland zone

There were 29 LiDAR survey sites and 83 SedNet river segments in the Lowland zone of the Goulburn Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period. Channel Depth and Bank Variability were modified from reference in more than half of the Lowland zone. At these sites Channel Depth was generally increased (many sites having large increases) and results show both increases and decreases in Bank Variability across the zone. Channel Width was modified from reference for approximately half of the Lowland zone. At these sites Channel Width was generally increased. Channel Width Variability, Sinuosity, Meander Wavelength and Channel Sediment Deposition were modified from reference for less than half of the Lowland zone. At these sites Channel Width Variability was generally reduced (with a large reduction at over half of these sites), results show both increases and decreases in Sinuosity across the zone, Meander Wavelength was generally increased (many sites having large increases) and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period. These results are generally consistent with field observations (Erskine *et al.* 1993).

Channel Form

There was little change from Reference Condition in Channel Form in the Upland zone. The more serious impact was channel simplification which was indicated at 60% of sites mostly as a result of channel straightening. There was widespread evidence of channel enlargement but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Slopes zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from Reference Condition had little influence on scores when aggregated at the zone scale.

There was minor change from Reference Condition in Channel Form in the Lowland zone. The most serious impact was channel enlargement. An enlarged channel was indicated at 80% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Upland, Slopes and Lowland zone, although Bank Variability exceeded Reference Conditions at 40-60% of sites. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result.

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was little change from Reference Condition in Bed Dynamics in the Upland zone although there was a widespread elevated sediment load (100% of the SedNet river segments). There was minor change from Reference Condition in Bed Dynamics in the Slopes and Lowland zones produced by a widespread elevated sediment load (100% of the SedNet river segments). SedNet modelling did indicate some enhanced in-channel deposition of sediment. However, this result is not consistent with field observations that suggest widespread deposition in channels of the slope zone (Erskine *et al.* 1993).

There was little change from Reference Condition in Floodplain Sedimentation in the Slopes zone (for 80% of SedNet river segments). There was considerable change from reference in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

Table GLB 10: Goulburn Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Physical Form Condition (SR–PI)	82 (73–90)	96 (86–100)	95 (87–99)	67 (52–84)
Indicator	Channel Form (volume and flow events)	79 (72–85)	81 (70–92)	84 (75–93)	74 (64–86)
Sub-ind.	Cross-section Form	80 (74–87)	87 (76–95)	84 (72–93)	75 (65–85)
Metric	Channel Depth (mean)	1.22 (1.13–1.34)	1.04 (0.95–1.20)	1.10 (0.98–1.24)	1.38 (1.19–1.58)
Metric	Channel Width (mean)	1.17 (1.11–1.23)	1.10 (1.01–1.25)	1.26 (1.13–1.39)	1.15 (1.07–1.23)
Sub-ind.	Cross-section Form (variability)	91 (86–95)	93 (85–99)	96 (93–99)	87 (77–95)
Metric	Channel Width (CV)	0.93 (0.90–0.96)	0.93 (0.88–0.98)	0.96 (0.92–0.98)	0.91 (0.85–0.96)
Sub-ind.	Channel Planform	82 (74–89)	79 (63–93)	82 (72–92)	84 (73–92)
Metric	Sinuosity	1.02 (1.00–1.04)	1.02 (0.99–1.06)	1.00 (0.99–1.00)	1.03 (0.99–1.07)
Metric	Meander Wavelength	1.08 (1.03–1.14)	1.16 (1.05–1.34)	1.06 (0.99–1.13)	1.06 (0.99–1.14)

Continued/,,,,

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Bed Dynamics	70 (67-74)	83 (77-93)	78 (74-81)	60 (54-66)
Metric	Channel Sediment Ratio	82 (63-103)	33 (9-50)	59 (39-81)	118 (83-161)
Metric	Channel Sediment Depth	0.002 (0.001–0.004)	0 (0–0)	0.0005 (0–0.002)	0.005 (0.002–0.007)
Indicator	Bank Dynamics	94 (90-97)	99 (98-100)	98 (97-99)	89 (81-96)
Metric	Bank Variability (longitudinal)	1.08 (1.03-1.14)	1.10 (1.03-1.17)	1.15 (1.09-1.22)	1.03 (0.95-1.12)
Indicator	Floodplain	66 (57-75)	69 (47-94)	83 (73-96)	54 (41-67)
Metric	Floodplain Sediment Deposition	3.00 (1.97-4.00)	1.59 (0.47-3.00)	1.29 (0.74-1.80)	4.00 (3.00-7.00)

GOULBURN VALLEY

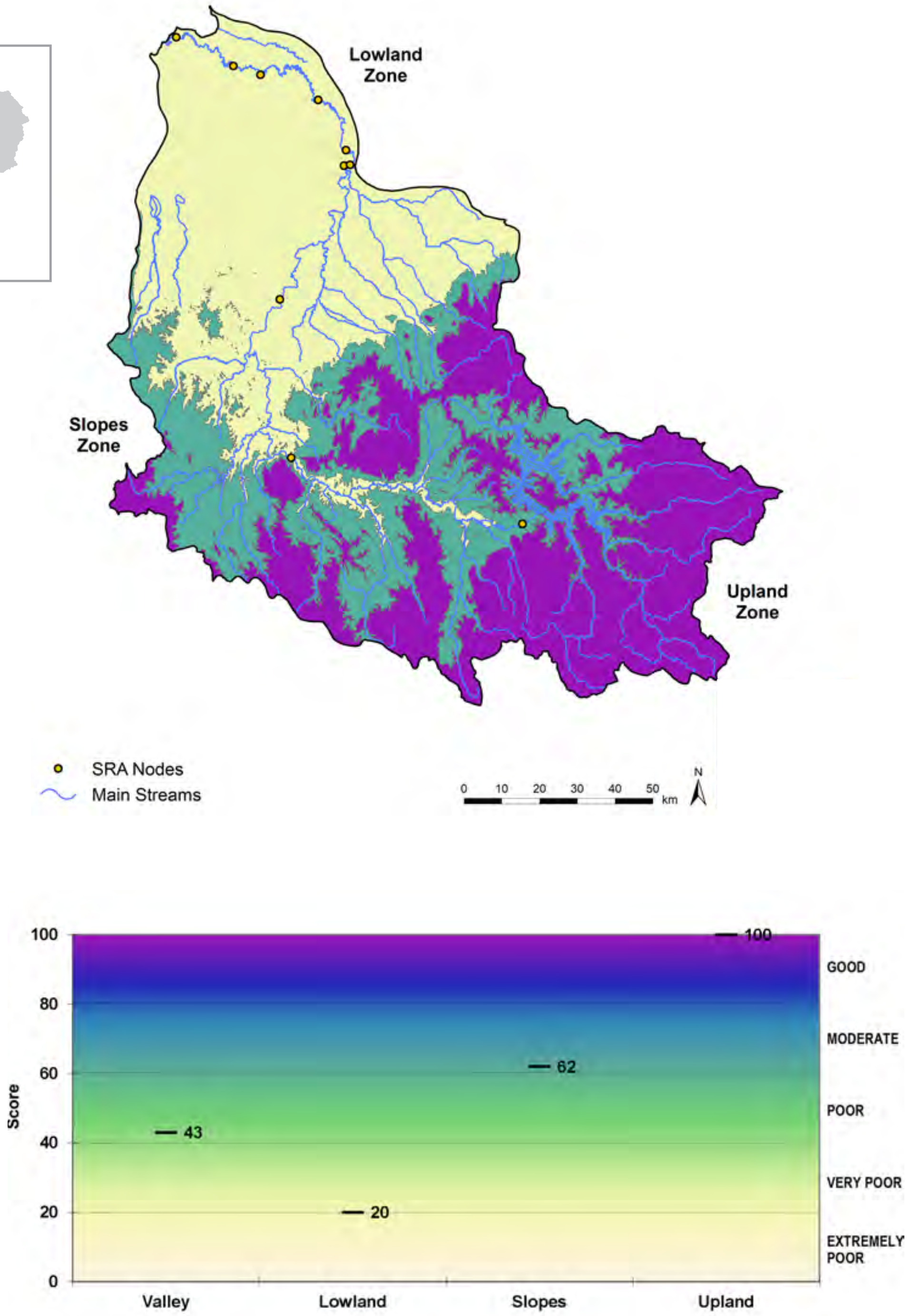

Figure GLB 6: Goulburn Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

Hydrology

The Hydrology of the Goulburn Valley river system was in Poor condition, with an aggregate Hydrology Index score (SR–HI) of 43. The Upland zone was in Good condition. The Slopes zone was in Moderate condition and the Lowland zone was in Very Poor condition.

The mainstem river system of the Goulburn Valley was rated in Very Poor condition. The timing of seasonal flow variations was altered, relative to Reference Conditions, throughout all of the mainstem river system. There was also widespread reduction of low and high flows with reduced amplitude of seasonal flow variations.

The headwater streams of the Goulburn Valley were rated in Good condition. Throughout some of the headwater streams the amplitude of seasonal flow variations was increased relative to Reference Condition.

The Goulburn River rises in the Great Dividing Range, in the angle where the axis changes from a north-south to east-west orientation, and joins the Murray upstream of Echuca. Headwater streams join the Goulburn at the point now occupied by Lake Eildon, and in the upper three-quarters of its length, upstream of Shepparton. There are two instream storages, Lake Eildon (3,334 GL) and Goulburn Reservoir (25.5 GL), and the latter, impounded by Goulburn Weir, is connected to an offstream storage, Waranga Basin (432 GL). Water from here is transferred to the Loddon or Campaspe valleys. Another offstream storage is Greens Lake (28 GL). The Goulburn River is intensively regulated and supports extensive irrigation areas (>150,000 ha).

In the Goulburn Valley, hydrological condition is assessed using metrics of hydrological alteration available for 3,196 km of mainstem rivers and headwater streams. There is 348 km of mainstem river extending across the Lowland and Slopes zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by monthly water resource modelling. It is not possible to calculate the Over Bank flow metrics, the High Flow Spells metric or the Low Flow Spells using monthly data. Consequently, these metrics have not been included in the analysis for this valley. In the Goulburn Valley there is 2,848 km of headwater stream (Upland zone: 710 km, Slopes zone: 1,049 km; Lowland zone: 1,089 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Goulburn Valley there is 1,226 km of these mid-size tributaries (109 km in the Upland zone; 416 km in the Slopes zone; 701 km in the Lowland zone) which is 0.4 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures GLB 6 and GLB 7 show values of the Hydrology Condition Index (SR–HI) for the Goulburn Valley and its river network, and Table GLB 11 and GLB 12 show the Index, sub-index, indicator and metric values. Analyses showed a large difference from Reference Condition for the Goulburn Valley, with:

- The Hydrology Condition Index for the whole valley = 43, indicating Poor hydrological condition.

GOULBURN VALLEY

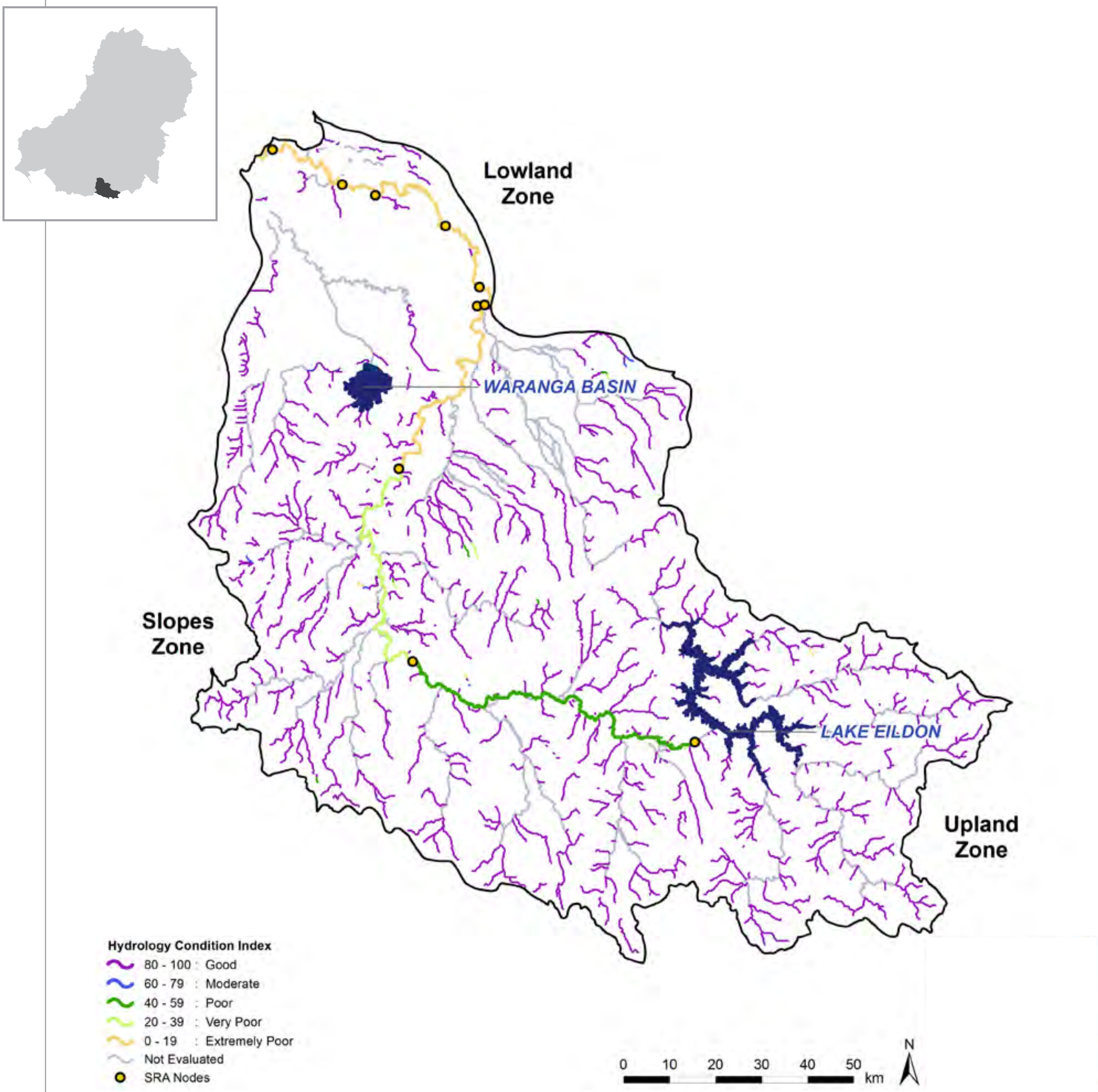

Figure GLB 7: Goulburn Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

- The Hydrology Condition Index for the Upland, Slopes and Lowland zones = 100, 62 and 20 indicating Good, Moderate and Very Poor hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 20, indicating Very Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 20, indicating Very Poor condition and a very large difference from Reference Condition for the flow regime within the channels.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a significant alteration from Reference Condition in 51% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. In addition, results for the Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with reduced flows).

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to reference.

In the mainstem rivers, the High Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 51% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 22% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. The High Flow Spells metric could not be calculated for this valley.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 2% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 22% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

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Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a large difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 100% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 19% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 32% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. The Low Flow Spells metric could not be calculated for this valley.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with reduced flows) and a significant alteration from reference in 17% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a very large difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 73% of the mainstem river length (mostly with reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 49% of the mainstem river length and a significant alteration from reference in 51% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 4% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 34% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed only small variations from Reference Condition throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed a large difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 19% of the mainstem river length (mostly associated with increased variability) and a significant alteration from reference in 54% of the mainstem river length (associated with both increased and reduced variability). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 6% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Goulburn Valley was generally characterised by substantial alteration in Flow Seasonality, considerable alteration in Flow Variability and Low and Zero Flow Events, minor alteration in High Flow Events and little or no alteration in Flow Gross Volume relative to Reference Condition. The timing of seasonal flow variations was altered, relative to reference, throughout all of the mainstem river system. There was also widespread reduction of low and high flows with reduced amplitude of seasonal flow variations.

Summary: headwater streams

The headwater streams of the Goulburn Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume, relative to Reference Condition. Throughout some of the headwater streams the amplitude of seasonal flow variations was increased.

Table GLB 11: Goulburn Valley SRA Hydrology Condition Index at valley and zone scales.

Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	43		100	62	20

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Table GLB 12: Goulburn Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**20 (0–47)**	**99 (7–100)**
Sub-Index	In-Channel Flow Regime	20 (0–47)	99 (7–100)
Indicator	**In-Channel Flow Regime A (volume and flow events)**	**50 (14–92)**	**100 (30–100)**
Sub-ind.	Flow Gross Volume	83 (59–100)	99 (66–100)
Metric	Mean Annual Flow	0.79 (0.52–1.00)	1.04 (0.58–1.20)
Metric	Flow Duration	0.91 (0.80–1.04)	1.00 (0.74–1.41)
Sub-ind.	High Flow Events	64 (23–100)	97 (32–100)
Metric	High Flow	0.55 (0.18–1.08)	1.11 (0.60–1.90)
Metric	High Flow Spells		
Sub-ind.	Low and Zero Flow Events	44 (24–75)	97 (23–99)
Metric	Zero Flows Proportion	0.78 (0.42–1.02)	0.99 (0.96–1.00)
Metric	Low Flow	0.45 (0.08–1.58)	0.97 (0.01–1.86)
Metric	Low Flow Spells		
Indicator	**In-Channel Flow Regime B (seasonality & variability)**	**20 (6–45)**	**97 (20–100)**
Sub-ind.	Flow Seasonality	23 (17–29)	93 (63–100)
Metric	Flow Seasonal Amplitude	0.40 (0.10–0.83)	1.17 (0.89–1.70)
Metric	Flow Seasonal Period	0.43 (0.21–0.65)	0.97 (0.78–1.00)
Sub-ind.	Flow Variability	47 (27–88)	90 (0–100)
Metric	Flow Variation	1.14 (0.65–1.55)	0.92 (0.39–1.00)
Sub-Index	Over Bank Flow Regime	Not assessed	
Indicator	**Over Bank Floods Low**		
Metric	OB Flow Duration (ARI 1)		
Metric	OB Flow Spells (ARI 1)		
Indicator	**Over Bank Floods High**		
Metric	OB Flow Duration (ARI 8)		
Metric	OB Flow Spells (ARI 8)		

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
		47	**20**		**100**	**99**
		47	20		100	99
		72	**49**		**100**	99
		100	83		99	98
		1	0.78		1.02	1.05
		0.99	0.91		1.01	1.01
		100	63		99	96
		1.08	0.54		1.06	1.16
		54	44		98	97
		1.02	0.78		1.00	0.98
		0.25	0.46		1.01	1.01
		45	19		99	97
		24	23		97	92
		0.83	0.38		1.08	1.19
		0.21	0.43		0.99	0.96
		88	45		98	89
		0.89	1.14		0.98	0.91

GWYDIR VALLEY

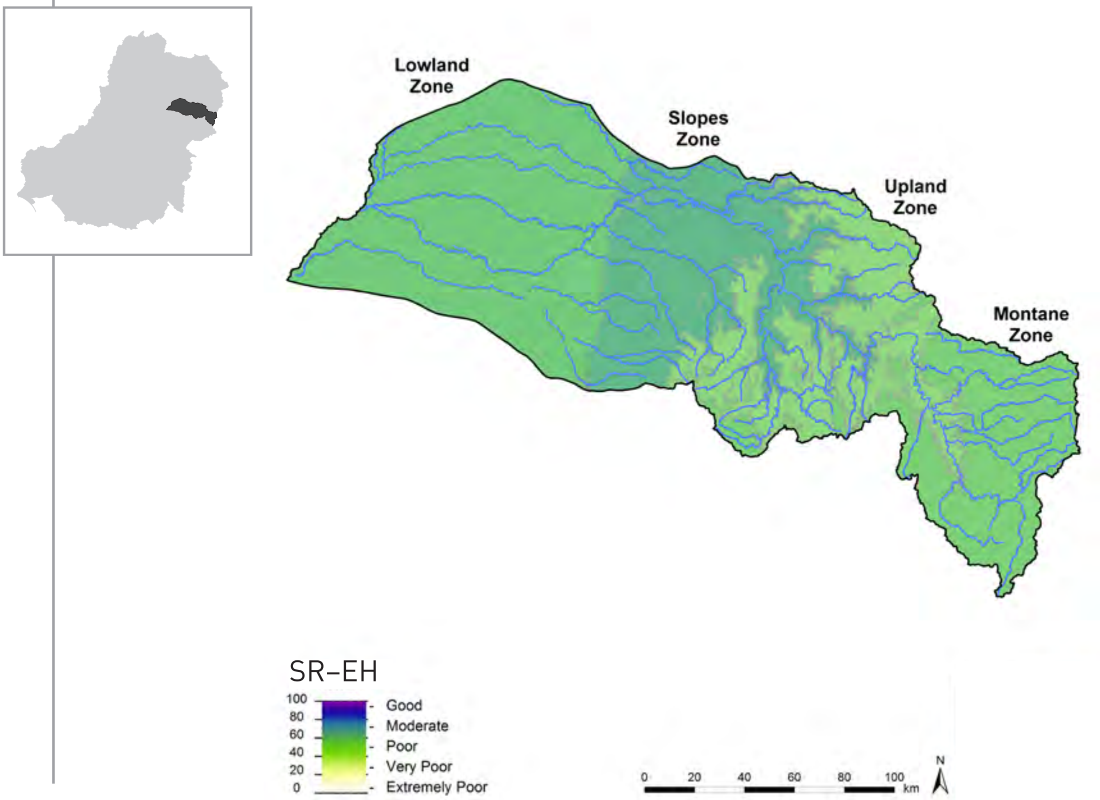

Figure GWY 1: Gwydir Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure GWY 1 shows the Ecosystem Health ratings for the Gwydir Valley and Tables GWY 1 and GWY 2 also show the Index values and ratings for each theme. Ecosystem Health shows a large difference from Reference Condition for the Gwydir Valley as a whole. The river system's Fish, Macroinvertebrate and Riverine Vegetation communities were in Poor, Moderate and Moderate condition respectively, while Physical Form and Hydrology were in Moderate and Poor condition respectively.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Gwydir Valley river system. River Ecosystem Health was rated as Poor (Lowland zone: Poor; Slopes zone: Poor; Upland zone: Poor; Montane zone: Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

Ecosystem Health

The Gwydir ranked ninth amongst the SRA valleys in terms of River Ecosystem Health, among the middle group of all valleys rated as being in Poor Health (see Table 5.2). This score noticeably

The Gwydir Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Montane, Upland, Slopes and Lowland zones Poor. The Fish community was in Poor condition. Some expected species were absent; species count and abundance were dominated by native species, but biomass was dominated by aliens. Recruitment levels among the remaining native species were high. The Macroinvertebrate community was in Moderate condition, with substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Moderate condition overall, with moderate alteration from Reference Condition in all indicators for both the Near Riparian and Lowland Floodplain domains. The Physical Form of the river system was in Moderate condition with channel form and bank dynamics in Good condition, bed dynamics in Poor condition and with high levels of floodplain sediment deposition. The river system's Hydrology was in Poor condition, with substantial alteration from Reference Condition in low over bank floods, flow variability and low and zero flow events in mainstem river reaches.

surpasses the assessment of the valley's physical condition as it ranked 20th for Hydrology and equal 19th (with the Condamine) for Physical Form out of the 23 SRA valleys. Macroinvertebrate Condition also ranked 20th.

Flow is regulated via the Copeton Dam in the upper Gwydir but high flow (opportunistic) diversions also occur in the lower reaches. Reduced over bank flows, variability and low- and zero-flow events are the aspects of channel flow most affected. Macroinvertebrate condition was poorer in the Lowland zone compared to the zones further upstream but the condition of Fish communities was poorest in the Upland and Montane zones (Moderate in the Slopes zone and Poor in the Lowland zone). This does not align with the Hydrology assessments, the results of which appear to reflect the impacts of regulation and diversion).

The implication is that factors other than Hydrology (or those Hydrology components assessed in the SRA) are influencing the condition of Fish communities in the upper reaches. [Note that the condition of Physical Form and Macroinvertebrates follows a similar pattern to Hydrology] Further investigation is needed here. It is likely that small unregulated streams are more susceptible (as fish habitats) to the effects of extended drought than are larger and more managed streams, both directly through the loss of habitat complexity or through related factors such as increased predation pressure or loss of connectivity. Such conjecture needs to be tested under non-drought conditions.

Fish Theme

The Fish Condition Index SR–FI = 51, indicating Poor condition (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Very Poor; Montane zone: Very Poor). The Expectedness indicator = 57, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 54, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 56, indicating Poor condition, and a large difference from Reference Condition.

The Fish community of the Gwydir had reduced numbers of expected native species. Overall condition and fish community composition and recruitment was highly variable amongst zones.

GWYDIR VALLEY

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 62, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Moderate; Montane zone: Moderate). The simOE metric = 44, indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. Most sites (56% overall) were rated in Moderate condition, though 6 sites were in Poor to Extremely Poor condition in the Lowland zone. Only two of the 36 rated sites (6%) were in Good condition.

Family richness generally was moderate, but was low compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 61, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Poor; Upland zone: Poor; Montane zone: Moderate). The Vegetation Abundance and Diversity indicator = 67, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 60, indicating Moderate condition and a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is moderately affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled floodplain area are moderately different from Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 71, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate; Upland zone: Good; Montane zone: Good). The Channel Form indicator = 84 and the Bank Dynamics indicator = 97, both indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 56 and the Floodplain Form indicator = 38, both indicating Very Poor condition and showing a very large difference from Reference Condition.

Overall, the valley's Physical Form was characterised by elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain. There was also evidence of adjustments in channel dimensions in the Upland and Lowland zones and widespread channel straightening and simplification.

Hydrology Theme

The Hydrology Condition Index SR–HI = 49, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Poor; Upland zone: Good; Montane zone: Good). The In-Channel Flow Regime indicator = 24, indicating Very Poor condition and a major difference from Reference Condition for the flow regime within the channels. The Over Bank Flow Regime indicator = 70, indicating Moderate condition and a minor difference from Reference Condition for the wetting regime in riparian and floodplain areas.

The mainstem river reaches were generally characterised by considerable alteration in Low Over Bank Floods, Flow Variability and Low and Zero Flow Events relative to Reference Condition, minor alteration in Flow Seasonality and High Flow Events and little or no alteration in High Over Bank Floods and Flow Gross Volume. The headwater streams were generally characterised by little or no alteration in these indicators.

Table GWY 1: Gwydir Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	MONTANE	UPLAND	SLOPES	LOWLAND
		Poor	Poor	Poor	Poor	Poor

THEME		VALLEY	ZONE			
			MONTANE	UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	51 (40–56) Poor	25 (18–29) Very Poor	26 (12–32) Very Poor	79 (59–88) Moderate	43 (30–54) Poor
Macro-invertebrates	SCORE RATING	62 (57–66) Moderate	65 (60–71) Moderate	64 (60–69) Moderate	67 (57–75) Moderate	51 (41–61) Poor
Vegetation	SCORE RATING	61 Moderate	74 Moderate	55 Poor	48 Poor	73 Moderate

Table GWY 2: Gwydir Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE			
			MONTANE	UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	71 (63–75) Moderate	90 (88–92) Good	84 (71–89) Good	60 (50–67) Moderate	64 (46–76) Moderate
Hydrology	SCORE RATING	49 Poor	99 Good	98 Good	40 Poor	24 Very Poor

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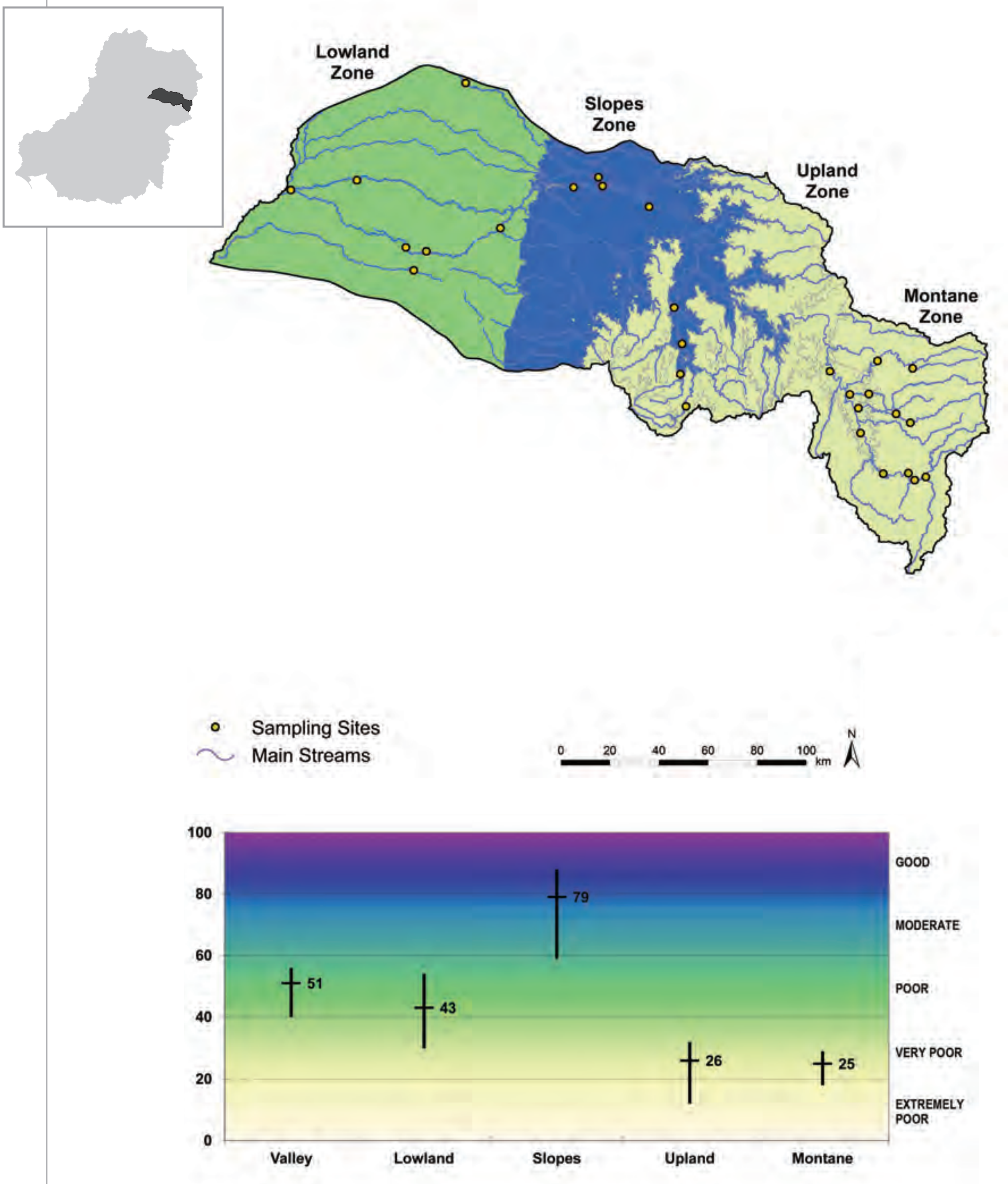

Figure GWY 2: Gwydir Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Gwydir Valley river system was in Poor condition, with an aggregate Fish Index score (SR–FI) of 51. The condition of the Fish community in the zones was as follows: Montane Very Poor; Upland Very Poor; Slopes Moderate; and Lowland Poor. The Fish community was characterised by a Poor score for expected native fish species, a Poor score for nativeness and a Poor score for native fish recruitment. The Upland zone in particular had few native fish and lacked 64% of the predicted native species. The valley had lost some native species richness and alien species contributed over 50% of the biomass in samples. Native fish recruitment was Extremely Poor, Poor, Moderate and Poor in the Montane, Upland, Slopes, and Lowland zones respectively.

28 sites were surveyed across the Gwydir Valley in March–April 2010, yielding 7,452 fish. Analyses showed a large difference from Reference Condition for the Gwydir Valley, with:

- SRA Fish Index (SR–FI) = 51 (CL 40–56), indicating Poor condition of the fish community.
- The Expectedness indicator = 57 (CL 51–61), indicating Poor condition, and a large difference from Reference Condition. 73% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 54 (CL 45–63), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 56 (CL 37–64), indicating Poor condition, and a large difference from Reference Condition. Evidence of recruitment was observed for 9 of the 11 native species observed in the valley.

Figure GWY 2 shows sampling sites, zones and corresponding SR–FI values, and Table GWY 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Gwydir Valley was fifth highest of all Basin valleys, and close to that for the Darling Valley. The Slopes zone community was in much better condition (SR–FI = 79) than that in the Montane and Upland zones (SR–FI = 25 and 26 respectively), whilst the Lowland zone was intermediate (SR–FI = 43). The Montane zone received a very low score for Nativeness and Recruitment and the Upland zone receiving low Expectedness and Recruitment scores.

Expectedness was assessed as Poor for the Gwydir Valley. Scores for individual zones ranged from Very Poor in the Upland zone, with only five of the 14 species expected under Reference Condition (RC–F) caught in samples, to Good in the Slopes zone where nine out of 13 expected fish species were caught.

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Nativeness varied amongst zones. It was assessed as Moderate in the Slopes zone where nine of the expected native species were present, totalling 1,595 fish, as well as 678 individuals from three alien taxa. The Montane zone was rated as Extremely Poor for Nativeness with four of the six expected species represented by a total of 3,237 individuals and three alien species totalling 1,692 fish. However, native fish were numerically dominant to aliens in the Slopes zone (1,595 native fish to 678 alien fish) and marginally so in the Lowland zone (1,156:1,040). This is in notable contrast to the situation in the Montane zone (37:1,692).

Table GWY 4 shows native species abundances in the Gwydir Valley compared with Reference Condition. Bony herring, restricted to the lower altitude zones, was the most numerous native species. Gudgeons were also numerous in all but the Montane zone. Significant numbers of large-bodied native species, freshwater catfish (71), Murray cod (55), and golden perch (32), were caught during sampling. Five small Murray cod (average weight 11 g) were caught in the Montane zone, though not predicted to occur there under Reference Condition. Silver perch was expected to occur in the lower three zones but was not caught. Other expected species that were not caught throughout the valley were the Darling River hardyhead, olive perchlet, and the southern purple-spotted gudgeon.

Four alien species were caught in the Gwydir Valley, common carp, gambusia, goldfish and redfin perch, though all four were present together only in the Upland zone. Gambusia was the most numerous and wide-spread. Redfin perch were also numerous but restricted mainly to the Montane zone. This is a large-bodied species, but the mean weight of individuals in this case was 12.6 g in the Montane zone and 31 g in the Upland zone. The mean biomass of common carp ranged substantially, from 47 g in the Lowland zone to nearly 1.2 kg in the Slopes zone.

Recruitment varied among zones, from moderate in the Slopes zone to Extremely Poor in the Montane zone, where only one of the four expected native species found to be present, the gudgeon, showed evidence of recruitment (and at one site only). The alien species gambusia and Redfin perch were both observed to recruit at six of the seven sites sampled in this zone. The large-bodied natives showed evidence of recruitment. Murray cod were caught in nine sites across the Upland, Slopes and Lowland zones. It was assessed as recruiting in four sites, all in the Slopes zone. Freshwater catfish populations in the Upland zone were assessed as recruiting in one of the seven sites in which the species was caught. Golden perch were caught in seven sites across the Upland, Slopes and Lowland zones, but recruitment was noted in only two sites, both in the Lowland zone. All four alien species recruited in some parts of the valley. Common carp recruited in all seven sites in the Lowland zone and five of seven sites in the Slopes zone but did not show evidence of recruitment in the Upland zone. Goldfish occurred in all four zones but recruited only in the Lowland zone.

In general, the fish community of the Gwydir had reduced numbers of expected native species. Overall condition was variable amongst zones and amongst indicators within zones. The Gwydir Valley had the fifth highest fish biomass of all Basin valleys (11.7 kg/site), but fish community composition was highly variable among zones.

Table GWY 3: Gwydir Valley SRA Fish Condition Index, indicators, metrics and derived variables.
Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	51 (40–56)	25 (18–29)	26 (12–32)	79 (59–88)	43 (30–54)
Indicator	Expectedness	57 (51–61)	67 (54–81)	33 (28–40)	82 (75–86)	45 (36–53)
Metric	O/E	0.52 (0.45–0.59)	0.51 (0.31–0.71)	0.45 (0.37–0.55)	0.70 (0.59–0.76)	0.42 (0.30–0.54)
Metric	O/P (Zone level)	0.56 (0.56–0.56)	0.67 (0.67–0.67)	0.36 (0.36–0.36)	0.69 (0.69–0.69)	0.50 (0.50–0.50)
Indicator	Nativeness	54 (45–63)	11 (3–25)	53 (35–73)	77 (62–93)	46 (32–60)
Metric	Proportion biomass native	0.40 (0.27–0.52)	0.16 (0.03–0.36)	0.42 (0.16–0.71)	0.52 (0.25–0.80)	0.35 (0.19–0.51)
Metric	Proportion abundance native	0.55 (0.40–0.69)	0.04 (0.01–0.10)	0.53 (0.25–0.80)	0.78 (0.55–0.95)	0.49 (0.26–0.72)
Metric	Proportion species native	0.57 (0.51–0.62)	0.40 (0.24–0.52)	0.53 (0.47–0.62)	0.75 (0.68–0.82)	0.49 (0.40–0.57)
Indicator	Recruitment	56 (37–64)	3 (0–14)	34 (8–45)	60 (39–68)	65 (36–85)
Metric	Proportion of sites with native recruits	0.55 (0.42–0.61)	0.12 (0.00–0.25)	0.44 (0.20–0.52)	0.64 0.47–0.69)	0.58 (0.38–0.73)
Metric	Proportion of native taxa with recruits	0.75 (0.63–0.85)	0.25 (0.00–0.33)	0.60 (0.25–0.75)	0.78 (0.62–0.88)	0.83 (0.67–1.00)
Metric	Proportion of abundance as recruits	0.59 (0.62–0.43)	0.25 (0.00–0.33)	0.42 (0.25–0.53)	0.52 (0.42–0.57)	0.72 (0.46–0.82)

Continued/...

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Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Variables						
	Number of sites sampled	28	7	7	7	7
	Total number of species	15	8	9	12	9
	Number of native species	11	5*	5	9	6
	Number of predicted species	15	6	14	13	12
	Number of alien species	4	3	4	3	3
	Mean number of fish per site	266	247	179	325	314
	Biomass/site all species (g)	11709	2526	5927	31421	6962
	Mean native biomass/fish (g)	43	23	37	71	10
	Mean alien biomass/fish (g)	44	10	30	158	36

*Includes one native species not predicted to occur in this zone.

Table GWY 4: Gwydir Valley number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks. Numbers in brackets are counts of native species not expected under Reference Condition.

Fish species	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Sites sampled	28	7	7	7	7
Native species					
Australian smelt	10		0	6	4
Bony herring	1579			670	909
Darling River hardyhead	0	0	0	0	
Freshwater catfish	71	4	62	5	0
Golden perch	32		1	10	21
Gudgeon	1285	6	461	696	122
Mountain galaxias	14	14	0		
Murray cod	55	[5]	3	46	1
Murray–Darling rainbowfish	88		0	88	0
Olive perchlet	0		0	0	0
River blackfish	8	8	0		
Silver perch	0		0	0	0
Southern purple-spotted gudgeon	0	0	0	0	0
Spangled perch	136		8	29	99
Unspecked hardyhead	45		0	45	0
Alien species					
Common carp	871		7	91	773
Gambusia	2062	668	598	581	215
Goldfish	161	21	82	6	52
Redfin perch	1035	1003	32		

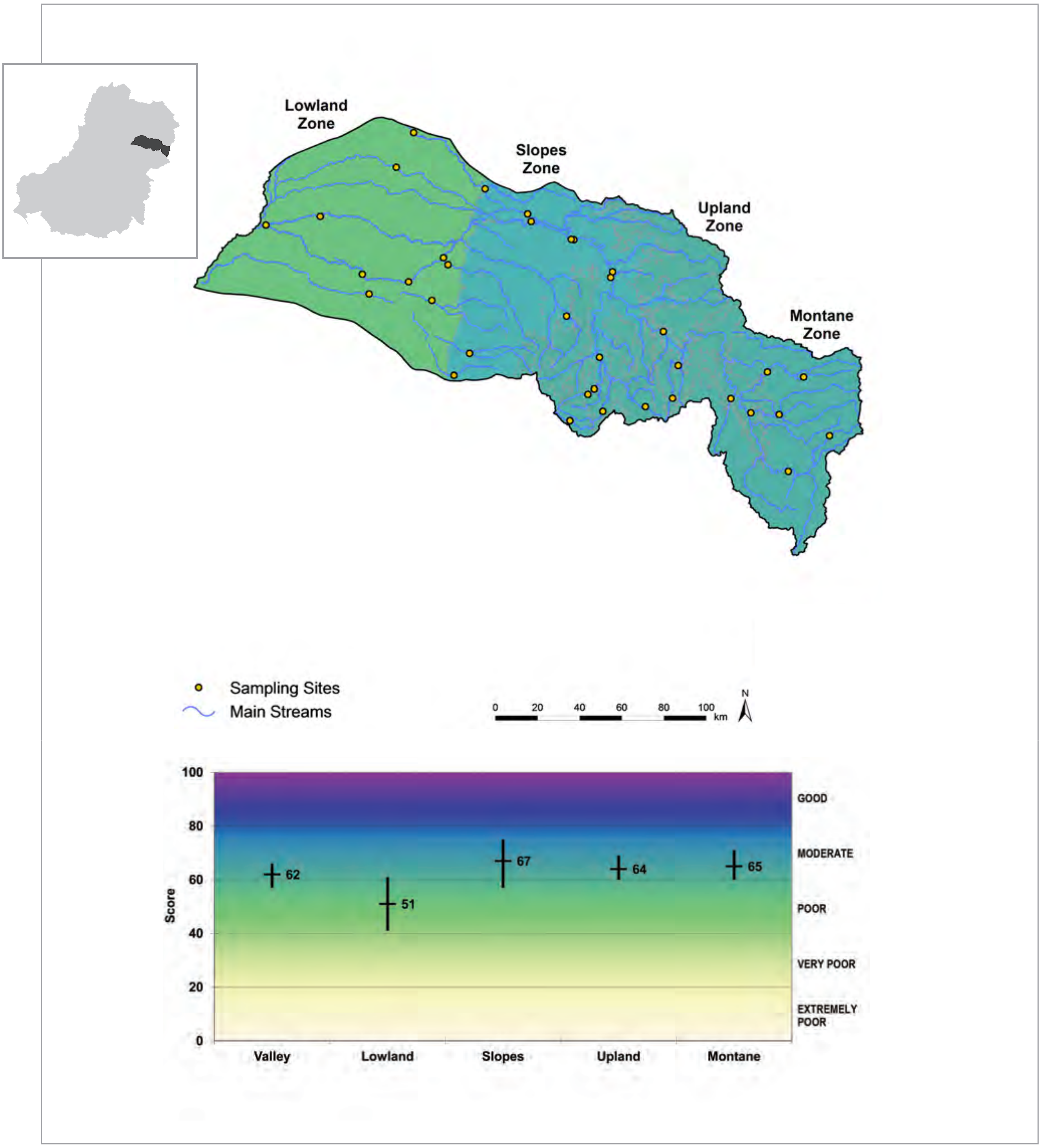

Figure GWY 3: Gwydir Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Gwydir Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 62. The condition of the Macroinvertebrate community in the zones was as follows: Montane Moderate; Upland Moderate; Slopes Moderate; Lowland Poor. Most sites (56% overall) were rated in Moderate condition, though 54% of sites in the Lowland zone were in Poor to Extremely Poor condition. Family richness generally was Moderate, and was low compared to Reference Condition.

Thirty-six sites were surveyed across the Gwydir Valley in March–April 2010 yielding 4,882 macroinvertebrates in 65 families (69% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 62 (CL 57–66), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 44 (CL 43–46) indicating a moderate to large difference from Reference Condition in both presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- Most sites (56% overall) were rated in Moderate condition, though six sites were in Poor to Extremely Poor condition in the Lowland zone. Only two of the 36 rated sites (6%) were in Good condition (both in the Slopes zone). The number of families found was lowest in the Lowland zone (38 families) and highest in the Slopes zone (55 families), though the Montane zone had the highest average number of families per site (35).
- The number of families found was lowest in the Lowland zone (31 families) and highest in the Montane zone (57 families), and the Lowland zone had by far the lowest average number of families per site (13).

Figure GWY 3 shows sampling sites, zones and SR–MI values, and Table GWY 5 shows Index and metric values. The SR–MI score for the Gwydir Valley indicated Moderate condition of macroinvertebrate communities, rating 20th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

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The communities of the Montane, Upland and Slopes zones showed moderate differences from Reference Condition (SR–MI = 65, 64 and 67, respectively), while this difference was rated as large for the Lowland zone (SR–MI = 51) which was rated in Poor condition overall. A wide confidence interval (20 points) for the Lowland zone SR–MI value indicates slightly more variability there. Most sites showed a moderate difference from Reference Condition. Expectedness (simOE) was moderate overall and varied by up only 14 points among sites.

Table GWY 6 shows that most sites (56%) across all zones had moderate SR–MI values. Only two sites were rated in Good condition. No site's macroinvertebrate community was rated as in Extremely Poor condition, but 14 sites (39%) were rated in Poor to Very Poor condition, including almost half of the sites in the Lowland zone. Six sites had a low simOE score (< 40 points). Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

Family richness generally was low compared to Reference Condition. Diversity was moderate (average 23 families per site), with the Montane and Upland zones being most diverse at site scale (average 36 and 32 families per site respectively). The valley contained 69% of the families found across the Basin (Table GWY 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (69–88%) of the fauna of the valley was found in each of the Upland and Montane zones, but this fell to only 48% in the Lowland zone.

Table GWY 5: Gwydir Valley Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	62 (57–66)	65 (60–71)	64 (60–69)	67 (57–75)	51 (41–61)
Metric	SimOE	44 (43–46)	45 (43–48)	45 (43–47)	47 (43–50)	40 (36–44)

Table GWY 6: Gwydir Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Sites					
Number of sites sampled	36	6	7	12	11
Number of sites with index values*	36	6	7	12	11
N sites by SR–MI condition band					
Good (80–100)	2			2	
Moderate (60–80)	20	4	5	6	5
Poor (40–60)	10	2	2	3	3
Very or Extremely Poor (0–40)	4			1	3
Families					
Number of families sampled	65	57	45	41	31
No. families/site (min–max)	23 (4–50)	36 (28–50)	32 (18–39)	19 (12–29)	13 (4–22)
Percent of families in Basin	69	61	48	44	33
Percent of families in valley	100	88	69	63	48

*simOE values could occasionally not be derived for every sample site.

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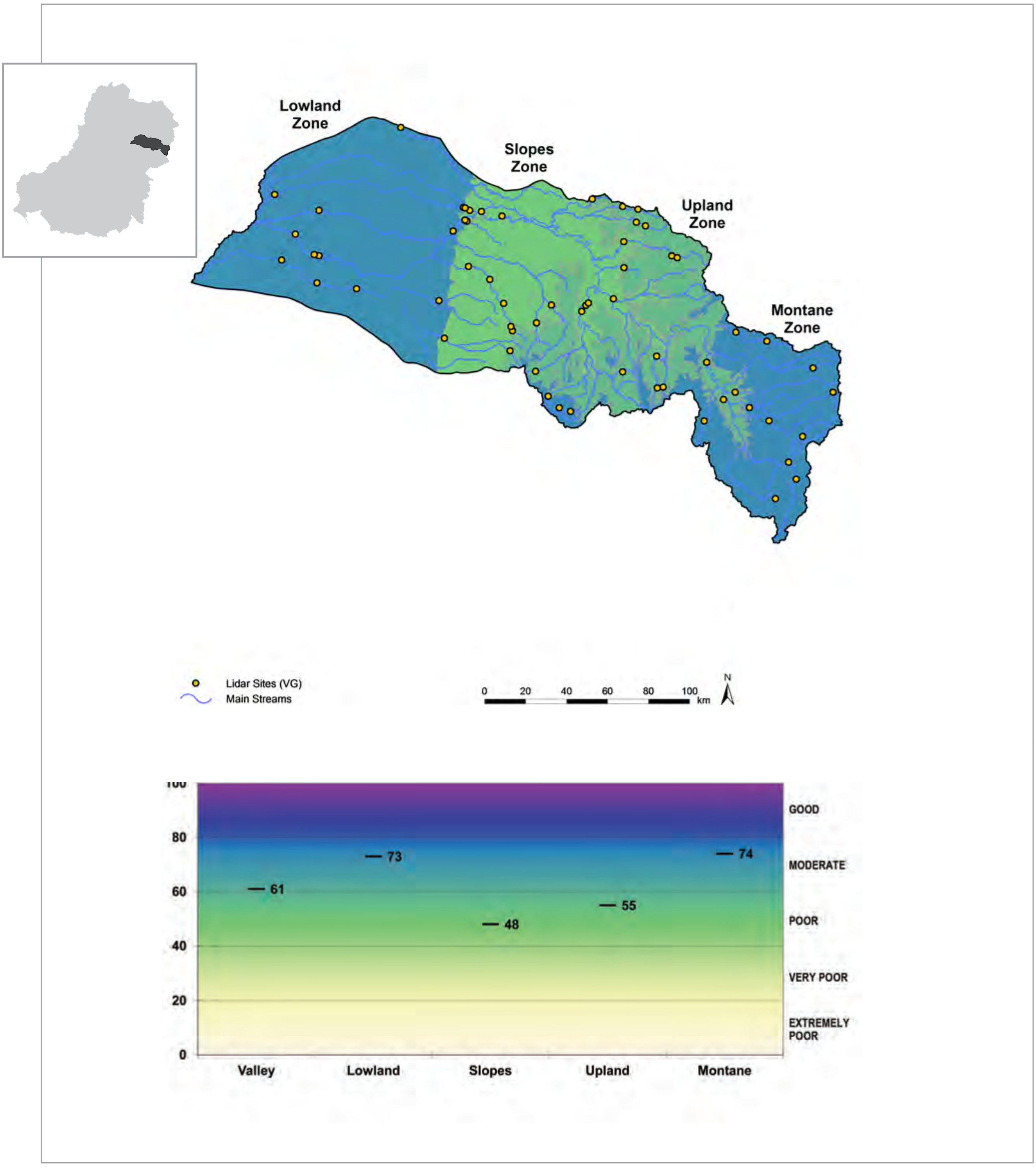

Figure GWY 4: Gwydir: map with LiDAR sites and zones coloured by SRA Vegetation Index scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Gwydir Valley river system was in Moderate condition, with an aggregate Vegetation Index score (SR–VI) of 61. Overall condition for the four zones in this valley was: Montane Moderate; Upland Poor; Slopes Poor; Lowland Moderate.

The Abundance and Diversity indicator score was 67 for the valley, indicating a Moderate rating overall. Each of the four zones also received a Moderate ranking.

The Quality and Integrity indicator score was 60 for the valley, indicating a Moderate rating overall. In the four zones this was: Montane Moderate; Upland Moderate; Slopes Poor and Lowland Moderate.

The SRA Vegetation assessment for the Gwydir Valley considers riverine vegetation in two spatial domains: Near Riparian, along 7,599 km of stream, and Lowland Floodplain, for 432 km^2 of flooding land which is part of the floodplain in the Lowland zone. Most (35% and 28%) of the stream length is in the Slopes and Lowland zones, and the length of stream assessed per zone is as follows: Montane 1,391 km; Upland 1,475 km; Slopes, 2,627 km; and Lowland 2,106 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 62 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream network amongst the four zones as follows: Montane 12 sites; Upland 13 sites; Slopes 22 sites; and Lowland 15 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure GWY 4 shows values of the Vegetation Index (SR–VI) for the Gwydir Valley and Table GWY 7 shows the Index, indicator and sub-indicator values. Tables GWY 8 and GWY 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a moderate difference from Reference Condition for the Gwydir Valley with:

- SRA Vegetation Index (SR–VI) = 61, indicating Moderate condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 67, indicating a moderate difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 60, indicating a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is moderately affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is moderately different from Reference Condition.

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The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with a moderate difference from reference for all four zones. The Moderate rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wide abundance in the Near Riparian domain shows a moderate difference from reference, and the Lowland Floodplain domain shows a moderate difference. MVG richness is maintained in both Near Riparian and Lowland Floodplain domains, as no MVG has been completely reduced. Vegetation in the Lowland Floodplain domain has 64% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, with MVGs showing a moderate difference from reference in all zones except Slopes which is Poor. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table GWY 8 as well as other native but non-specific MVGs. Valley-wide Nativeness in the Near Riparian domain shows a large difference from reference, and a moderate difference in the Lowland Floodplain domain. The degree of MVG fragmentation is moderately different from reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show no loss of any MVG in any of the zones from the Near Riparian domain, and no loss of any MVG from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Moderate condition overall, and the metrics show differences between zones and domains. Abundance in the Near Riparian domain shows a large difference from reference in the Montane, Upland and Slopes zones, and a moderate difference in the Lowland zone; and in the Lowland Floodplain, it shows a moderate difference from Reference Condition.

Stability

- Floodplain areas in the Lowland Floodplain domain are in Moderate condition, with moderate evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Moderate condition overall, and the metrics show differences between zones and domains. Nativeness in the Near Riparian domain shows a large difference from reference in the

Montane, Upland and Slopes zones and a moderate difference in the Lowland zones; and in the Lowland Floodplain domain, nativeness shows a moderate difference from Reference Condition.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with differences between zones. Structure is near reference in the Montane and Upland zones, moderately different from reference in the Slopes zone, and largely different in the Lowland zone. This sub-indicator refers only to height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows the integrity of MVGs is in Moderate condition. For most of the MVGs, the number of patches and mean patch area is near reference. Eucalypt Woodlands, with substantially reduced number of patches and severely reduced patch area, is the most fragmented MVG.

Under Reference Conditions, the riverine vegetation in the Gwydir Valley was characterised as follows:

- Montane zone: The Near Riparian domain was mostly Eucalypt Open Forest (50% of area) and Eucalypt Woodlands (43%) and four other MVGs, none of which was as much as 5% of the domain.

- Upland zone: The Near Riparian domain was mostly Eucalypt Woodlands (52%) and Eucalypt Open Forests (25%) and four other MVGs of which only one was more than 5% of the domain.

- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (57%): four of the other nine MVGs present were more than 5% of the domain.

- Lowland zone: The Near Riparian domain was mostly a mix of three MVGs: Eucalypt Open Woodlands (32%), Eucalypt Tall Open Forest (29%) and Eucalypt Woodlands (21%). Two of the other four MVGs present covered as much as 5% of the domain.

- Lowland zone: The Lowland Floodplain domain is a mix of Eucalypt Open Woodlands (39%), Eucalypt Tall Open Forests (31%) and Eucalypt Woodlands (16%). Only one of the other five MVGs present was more than 5% of the domain.

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Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the vegetation in the valley has been reduced in all domains. The effect on individual MVGs is variable, with the two dominant MVGs, Eucalypt Open Forest and Eucalypt Woodlands, generally being the most affected and some MVGs not being reduced at all.

- Montane zone: In the Near Riparian domain, Eucalypt Open Forest and Eucalypt Woodlands, although reduced, are still the most extensive MVGs. About 45% of the domain is cleared or non-native vegetation. Eucalypt Open Forest and Eucalypt Woodlands are the most reduced vegetation types, from 50% under Reference Conditions to 26% and from 43% to 22% respectively: the abundance of the other MVGs is near Reference Condition.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands is very reduced (6% of domain area) and Eucalypt Open Forest slightly reduced (21%) but still the most extensive MVG. About 50% is cleared or non-native vegetation. Eucalypt Woodlands is the most reduced MVG, from 52% under Reference Conditions to 6%; the abundance of other MVGs is near reference.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands is very reduced (7% of domain area) and Tussock Grasslands is now the most extensive MVG in the domain (12%). About 53% is cleared or non-native vegetation. Eucalypt Woodlands is the most reduced MVG, from 57% to 7% of the domain: the abundance of all other MVGs is near reference.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands is very reduced and two MVGs form the mix of vegetation types: Eucalypt Tall Open Forests (29% of domain area) and Eucalypt Open Woodlands (16%). About 38% of the domain is cleared or non-native vegetation. Eucalypt Woodlands is the most reduced MVG, from 21% under Reference Conditions to 2% of the domain, and Eucalypt Open Woodland is reduced from 32% to 16%. Most of the other MVGs are near reference.

- Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands is very reduced (now less than 1% of the domain area), and Eucalypt Open Woodlands is reduced (21%), and Eucalypt Tall Open Forests is now the most extensive MVG (31% of the domain). About 36% of the domain is cleared or non-native vegetation. Eucalypt Open Woodlands is the most reduced of all MVGs, having dropped from 39% under Reference Conditions to 21%, while Eucalypt Woodlands is reduced from 16% under Reference Conditions to 1%. Most of the remaining MVGs are close to reference.

Unlike the other themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping may range from 1997 to 2004, whereas the LiDAR was flown in November 2009. This means that the Structure Sub-indicator and the abundance, richness and nativeness metrics are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees present. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

Most of the metrics are based on vegetation mapping, which is not up to date and can be of variable quality. About 5% of the Montane and Uplands zones are not assigned to an MVG. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Gwydir Valley is notable for how condition changes between zones down the valley, and for the Slopes being the zone in poorest condition.

Riverine vegetation is in better condition in the Montane and Lowland zones than in the Upland and Slopes zones, with higher scores for abundance and nativeness. The Slopes zone is in the poorest condition, has the greatest stream length and the most influence on the valley score. Within the Lowland zone, the Near Riparian and Lowland Floodplain domains have similar scores for most metrics, but the Near Riparian is notable for having poor and highly variable Structure. These two domains assess differing but overlapping parts of the landscape: the Lowland Floodplain domain is land that floods associated with the major distributaries whereas the Near Riparian domain is a continuous strip centred on all types of stream channels, and covers an area nearly ten times greater than the Lowland Floodplain.

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Table GWY 7: Gwydir Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.
LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	61	74	55	48	73
Indicator	Abundance and diversity	67	70	62	60	78
Metric	LF stability	0.64				0.64
Sub-ind.	NRLF richness	100				100
Metric	NR richness	1	1	1	1	1
Metric	LF richness	1				1
Sub-ind.	NRLF abundance	66				66
Metric	NR abundance	0.52	0.53	0.48	0.47	0.62
Metric	LF abundance	0.64				0.64
Indicator	Quality and integrity	60	69	61	55	60
Sub-ind.	NRLF nativeness	66				66
Metric	NR nativeness	0.52	0.53	0.48	0.47	0.62
Metric	LF nativeness	0.64				0.64
Sub-ind.	NR structure	73 (67–79)	88 (73–95)	89 (79–95)	73 (62–81)	53 (36–69)
Sub-ind.	LF fragmentation	71				71

Table GWY 8: The most abundant MVGs in the Near Riparian domain in the Gwydir Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone			
	Montane	Upland	Slopes	Lowland
MVG				
2. Eucalypt Tall Open Forests				29
3. Eucalypt Open Forests	50	25	6	
5. Eucalypt Woodlands	43	52	57	21
8. Casuarina Forests and Woodlands			6	
11. Eucalypt Open Woodlands			8	32
17. Other Shrublands				10
19. Tussock Grasslands		7	12	7

Table GWY 9: Most abundant MVGs in the Lowland Floodplain domain in the Gwydir Valley.
Showing percentage of domain area under Reference Condition and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
2. Eucalypt Tall Open Forests	31	1	1
5. Eucalypt Woodlands	16	0.38	0.13
11. Eucalypt Open Woodlands	39	0.89	0.61
17. Other Shrublands	8	1	1

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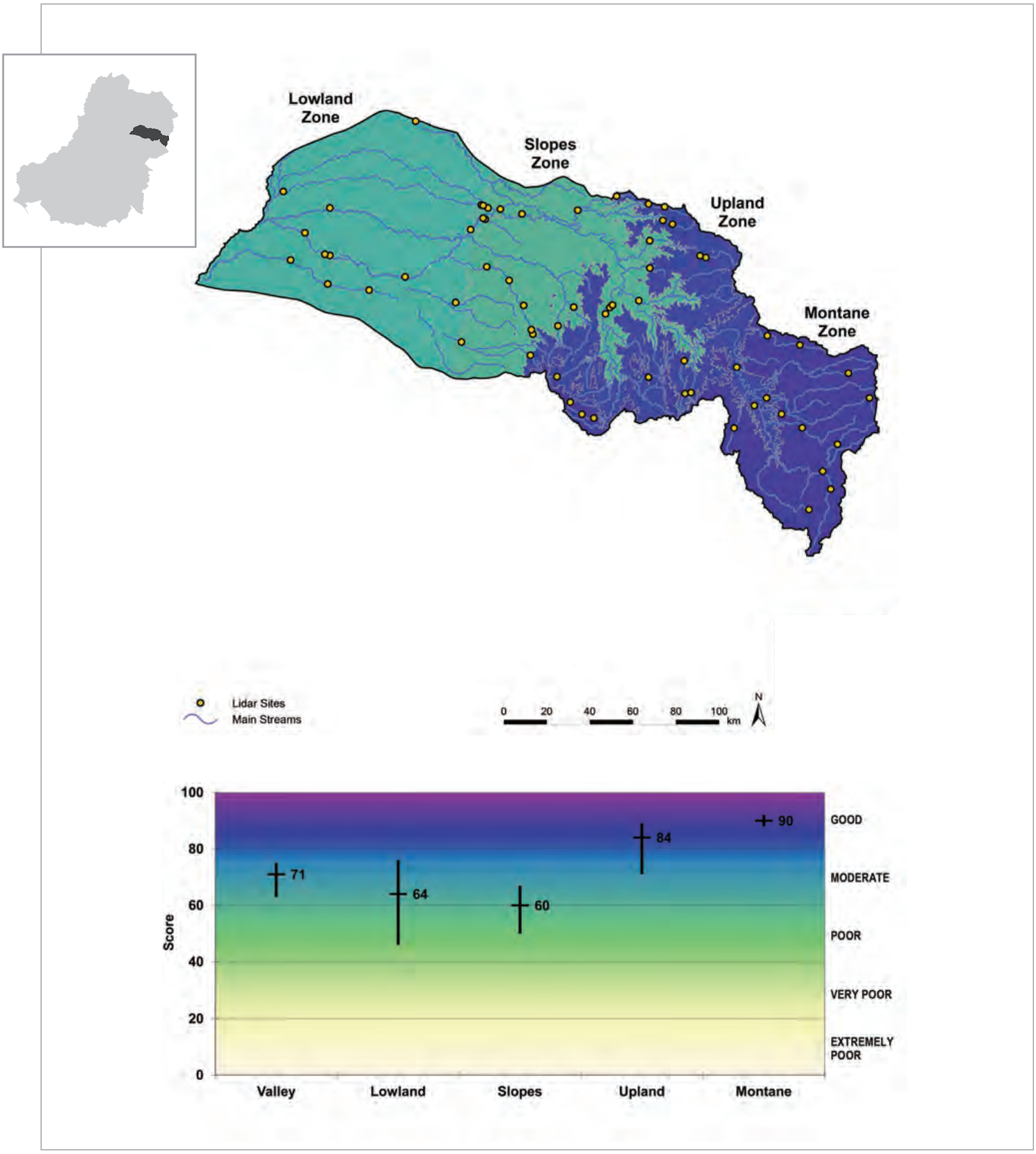

Figure GWY 5: Gwydir Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Gwydir Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 71. The condition of Physical Form in the zones was: Montane and Upland Good; Slopes and Lowland Moderate. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics was rated as Poor. Floodplain Dynamics was rated as Very Poor. Overall, the valley's physical form was characterised by elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain. There was also evidence of adjustments in channel dimensions in the Upland and Lowland zones and widespread channel straightening and simplification.

The SRA Physical Form assessment considers physical form and processes along 7,599 km of stream across the valley. It is based on LiDAR data collected at 64 sites along river channels, as well as modelling of all 234 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure GWY 5 shows values of the Physical Form Index (SR–PI) for the Gwydir Valley and Table GWY 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Gwydir Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 71 (CL 63–75), indicating Moderate Physical Form condition.
- the Channel Form indicator = 84 (CL 79–89), showing near Reference Condition
- the Bed Dynamics indicator = 56 (CL 52–59), showing a large difference from Reference Condition
- the Bank Dynamics indicator = 97 (CL 95–99), showing near Reference Condition
- the Floodplain indicator = 38 (CL 32–45), showing a very large difference from Reference Condition.

Montane zone

There were 12 LiDAR survey sites and 30 SedNet river segments in the Montane zone of the Gwydir Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were mo3dified from Reference Condition throughout most of the Montane zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 20% of the zone for the post-European period. Channel Depth, Sinuosity, Meander Wavelength and Bank Variability were modified from reference for approximately half of the Montane zone. At these sites Channel Depth and Sinuosity were generally reduced, Meander Wavelength was generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability was modified from reference for less than half of the Montane zone. At these sites Channel Width Variability was generally increased. Channel Width and Channel Sediment Deposition were largely unmodified from reference in the Montane zone.

Upland zone

There were 13 LiDAR survey sites and 47 SedNet river segments in the Upland zone of the Gwydir Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from reference throughout most of the Upland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 30% of the zone for the post-European period. Bank Variability was modified from reference for approximately half of the Upland zone. At these sites results show both increases and decreases in Bank Variability across the zone. Channel Depth, Channel Width Variability, Sinuosity and Meander Wavelength were modified from reference for less than half of the Upland zone. At these sites Channel Depth was generally increased (a few sites having large increases), Channel Width Variability was generally increased and results show both increases and decreases in Sinuosity and Meander Wavelength across the zone. Channel Width and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

Slopes zone

There were 23 LiDAR survey sites and 86 SedNet river segments in the Slopes zone of the Gwydir Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from reference throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 50% of the zone for the post-European period. Channel Width Variability and Channel Sediment Deposition were modified from reference for approximately half of the Slopes zone. At these sites Channel Width Variability was generally reduced and there was a large increase in Channel Sediment Deposition across 50% of the zone for the post-European period. Channel Depth, Sinuosity, Meander Wavelength and Bank Variability were modified from reference for less than half of the Slopes zone. At these sites Channel Depth was generally increased (many sites having large increases), Sinuosity was generally reduced, Meander Wavelength was generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width was largely unmodified from reference in the Slopes zone.

Lowland zone

There were 16 LiDAR survey sites and 71 SedNet river segments in the Lowland zone of the Gwydir Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 40% of the zone for the post-European period. Channel Depth and Sinuosity were modified from reference in more than half of the Lowland zone. At these sites Channel Depth was generally increased (a few sites having large increases) and Sinuosity was generally reduced. Channel Width and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites results show both increases and decreases in Channel Width across the zone and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period. Meander Wavelength and Bank Variability were modified from reference for less than half of the Lowland zone. At these sites Meander Wavelength was generally increased (a few sites having large increases) and Bank Variability was generally reduced indicating enhanced bank stability. Channel Width Variability was largely unmodified from reference in the Lowland zone.

Channel Form

There was little change from Reference Condition in Channel Form in the Montane zone. There was widespread evidence of channel contraction, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Upland zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 50% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Adjustments to - in the Montane and Upland zones will be constrained by bedrock. Local knowledge is required to interpret any departures from reference planform in bedrock channels.

There was little change from Reference Condition in Channel Form in the Slopes zone. There was widespread evidence of channel enlargement, channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was minor change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was changes in channel size. There was evidence of both channel enlargement and contraction across this zone. An enlarged channel was indicated at 50% of sites as a result of channel widening and bed degradation. Channel contraction was indicated at 40% of sites as a result of channel narrowing and bed aggradation. There was widespread evidence of channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Montane zone. Bank variability exceeded Reference Conditions at 50% of sites. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result. There was little change from Reference Condition in Bank Dynamics in the Upland, Slopes and Lowland zones.

There was minor change from Reference Condition in Bed Dynamics in the Montane and Upland zones mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was substantial change from Reference Condition in Bed Dynamics in the Slopes zone as a result of widespread sedimentation (50% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). There was minor change from Reference Condition in Bed Dynamics in the Lowland zone as a result of widespread sedimentation (40% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In the Slopes and Lowland zones, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Local knowledge is required to resolve these conflicting results.

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was substantial change from reference in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (100% of SedNet river segments). There was considerable change from reference in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

Table GWY 10: Gwydir Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.
(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Physical Form Condition (SR–PI)	71 (63–75)	90 (88–92)	84 (71–89)	60 (50–67)	64 (46–76)
Indicator	Channel Form (volume and flow events)	84 (79–89)	93 (85–100)	83 (67–96)	86 (76–94)	77 (65–90)
Sub-ind.	Cross-section Form	80 (73–87)	91 (81–98)	79 (58–95)	80 (69–92)	72 (57–87)
Metric	Channel Depth (mean)	1.21 (1.08–1.37)	0.99 (0.84–1.11)	1.33 (0.99–1.78)	1.16 (1.01–1.35)	1.33 (0.98–1.69)
Metric	Channel Width (mean)	1.19 (1.07–1.36)	1.02 (0.95–1.10)	1.25 (1.02–1.51)	1.32 (0.99–1.71)	1.11 (0.96–1.36)

Continued/....

Table GWY 10: Gwydir Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.
(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Sub-ind.	Cross-section Form (variability)	98 (96–100)	100 (99–100)	99 (99–100)	97 (94–100)	97 (92–100)
Metric	Channel Width (CV)	1.00 (0.97–1.02)	1.01 (0.99–1.04)	1.02 (0.99–1.06)	0.98 (0.94–1.02)	0.99 (0.95–1.01)
Sub-ind.	Channel Planform	88 (82–92)	86 (76–94)	89 (77–99)	90 (82–96)	84 (72–93)
Metric	Sinuosity	0.98 (0.96–1.01)	0.95 (0.92–0.98)	0.99 (0.96–1.01)	0.98 (0.96–1.00)	0.99 (0.94–1.10)
Metric	Meander Wavelength	1.03 (0.99–1.06)	1.02 (0.94–1.09)	1.01 (0.92–1.10)	1.02 (0.98–1.08)	1.04 (0.97–1.11)
Indicator	Bed Dynamics	56 (52–59)	70 (70–70)	64 (57–69)	39 (30–48)	60 (52–68)
Metric	Channel Sediment Ratio	77 (71–84)	82 (67–101)	79 (69–89)	85 (74–99)	63 (54–75)
Metric	Channel Sediment Depth	0.004 (0.003–0.005)	0 (0–0)	0.002 (0–0.005)	0.009 (0.006–0.011)	0.003 (0.001–0.004)
Indicator	Bank Dynamics	97 (95–99)	98 (96–100)	97 (93–99)	98 (95–100)	95 (89–100)
Metric	Bank Variability (longitudinal)	1.03 (1.01–1.07)	1.12 (1.03–1.23)	1.03 (0.97–1.11)	1.05 (1.00–1.10)	0.96 (0.92–1.00)
Indicator	Floodplain	38 (32–45)	59 (44–82)	34 (20–52)	28 (17–40)	41 (27–54)
Metric	Floodplain Sediment Deposition	7 (6–8)	2 (1.50–3)	5 (3–6)	11 (8–15)	6 (4–9)

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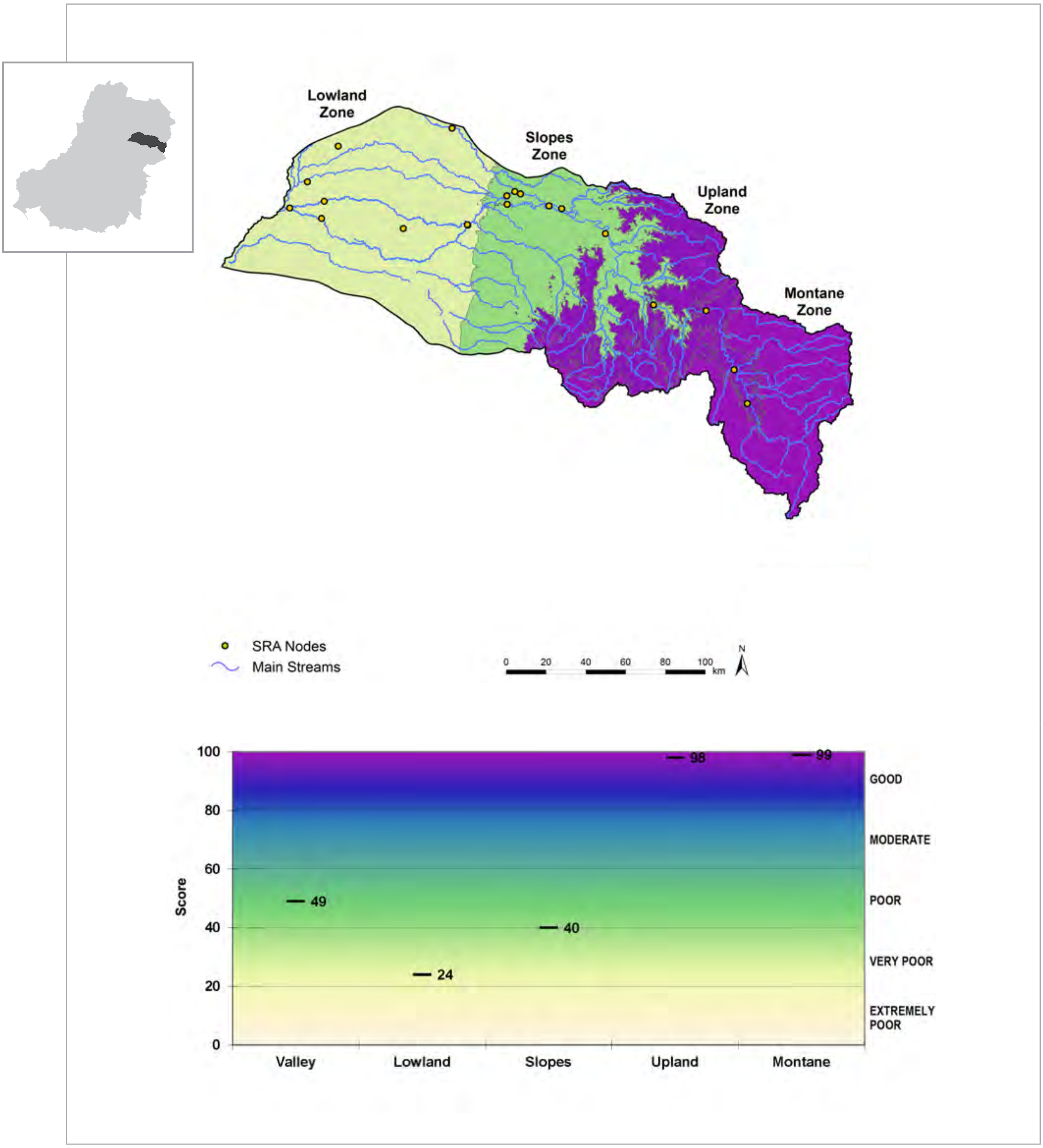

Figure GWY 6: Gwydir Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Gwydir Valley river system was in Poor condition, with an aggregate Hydrology Index (SR–HI) score of 49. The Upland and Montane zones were in Good condition. The Slopes zone was in Poor condition. The Lowland zone was in Very Poor condition. The mainstem river system of the Gwydir Valley was rated in Very Poor condition. Throughout most of the mainstem river system there was reduced frequency and duration of both flood and high flow spells relative to Reference conditions. This was accompanied by increased low flow magnitudes and reduced frequency of low flow spells. There was also widespread change in flow seasonality with altered timing and reduced amplitude of seasonal flow variations relative to Reference Condition. The headwater streams of the Gwydir Valley were rated in Good condition. Throughout some of the headwater streams the magnitude of low flows was reduced.

The Gwydir River rises on the western slopes of the Great Dividing Range, near Armidale, and flows west. Near Moree it divides as the Gwydir and Lower Gwydir rivers. The latter divides as distributaries, some feeding wetland complexes. Copeton Dam (1,345 GL) provides instream storage on the upper Gwydir. The Gwydir and several of its tributaries and distributaries support irrigation. Diversions include opportunistic pumping to offstream storages.

In the Gwydir Valley, hydrological condition is assessed using metrics of hydrological alteration available for 3,806 km of mainstem rivers and headwater streams. There are 908 km of mainstem river extending across the Lowland, Slopes and Upland zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily water resource modelling. In the Gwydir Valley there is 2,898 km of headwater stream (Montane zone: 817 km; Upland zone: 848 km; Slopes zone: 889 km; Lowland zone: 343 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Gwydir Valley there is 2,390 km of these mid-size tributaries (335 km in the Montane zone; 251 km in the Upland zone; 717 km in the Slopes zone; 1,086 km in the Lowland zone) which is 0.6 times the stream length for which metrics are available.

In contrast to the other themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures GWY 6 and GWY 7 show values of the Hydrology Condition Index (SR–HI) for the Gwydir Valley and its river network, and Table GWY 11 and GWY 12 show the Index, sub-index, indicator and metric values. Analyses showed a large difference from Reference Condition for the Gwydir Valley, with:

- The Hydrology Condition Index for the whole valley = 49, indicating Poor hydrological condition.

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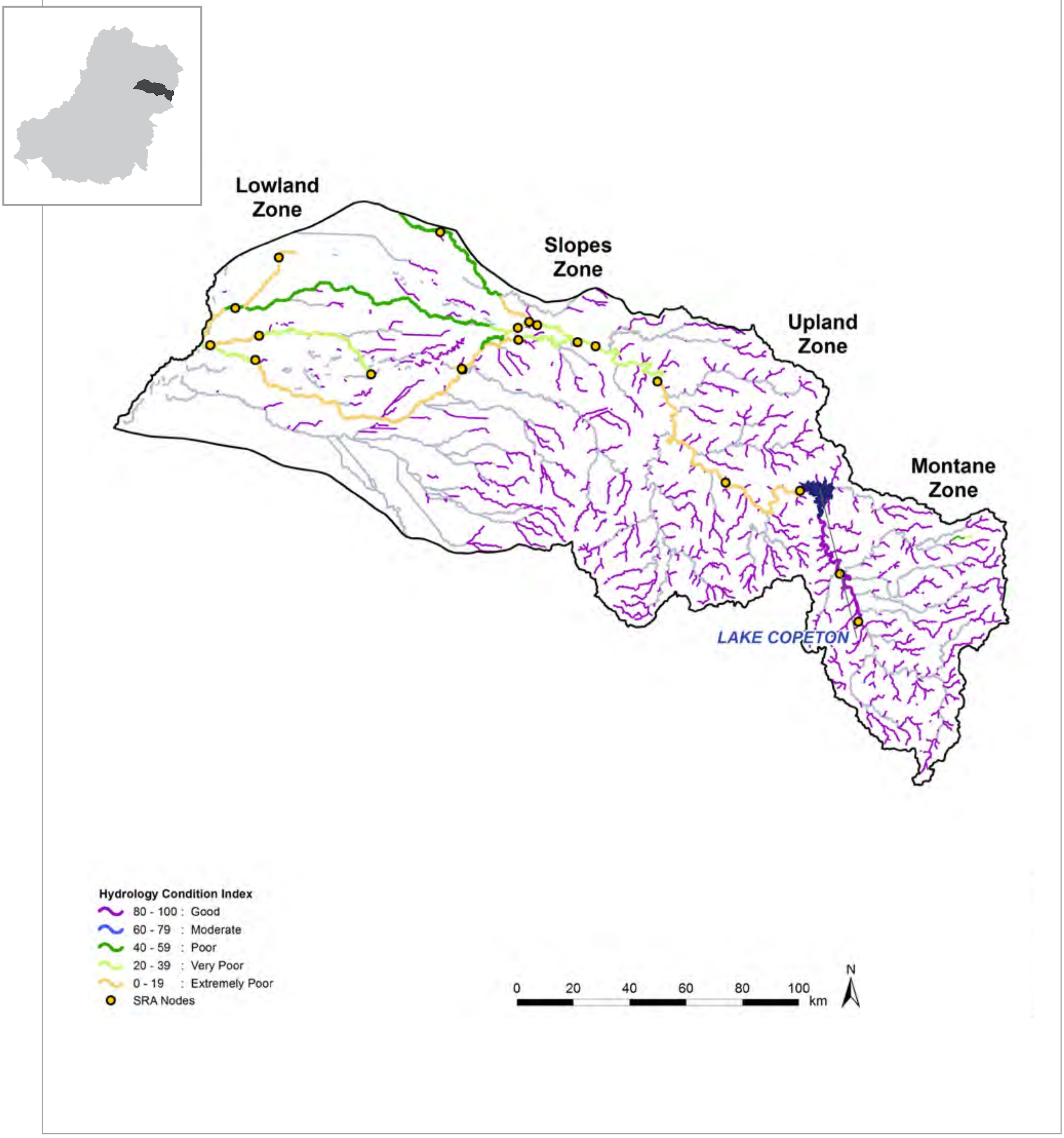

Figure GWY 7: Gwydir Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

- The Hydrology Condition Index for the Montane, Upland, Slopes and Lowland zones = 99, 98, 40 and 24 indicating Good, Good, Poor and Very Poor hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 28, indicating Very Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 24, indicating Very Poor condition and a very large difference from Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 70, indicating Moderate condition and a moderate difference from Reference Condition for the wetting regime in riparian and floodplain areas.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a very significant alteration from Reference Condition in 15% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 9% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Slopes zone and most in the Lowland zone. In addition, results for the Flow Duration metric showed a very significant alteration from Reference Condition in 5% of the mainstem river length (mostly associated with reduced flows). These river reaches are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to reference.

In the mainstem rivers, the High Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 15% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 43% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 20% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 70% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a significant alteration from reference in 7% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with most in the Montane zone, some in the Upland zone and a small proportion in the Slopes zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a large difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 69% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 10% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 12% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and most in the Lowland zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 83% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 7% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with reduced flows) and a significant alteration from reference in 30% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a moderate difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 15% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 44% of the mainstem river length (mostly associated with a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 13% of the mainstem river length and a significant alteration from reference in 75% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 1% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 9% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, some in the Upland zone and some in the Slopes zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed a large difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 17% of the mainstem river length (mostly associated with reduced variability) and a significant alteration from reference in 64% of the mainstem river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes and Lowland zones.

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In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 2% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, a small proportion in the Upland zone and a small proportion in the Slopes zone.

Low Over Bank Floods

The Low Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 1-year flood in the reference regime. It is calculated from a combination of the Low Over Bank Flood Duration metric and the Low Over Bank Flood Spells metric. The Low Over Bank Flood Duration metric quantifies change in the duration of flooding of low-level floodplain areas relative to reference. The Low Over Bank Flood Spells metric quantifies change in the duration of time between low-level floodplain inundation events relative to reference. The Low Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly rather than daily timestep.

In the mainstem rivers, the Low Over Bank Floods indicator showed a large difference from Reference Condition. Results for the Low Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 49% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 23% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the upland zone, some in the Slopes zone and some in the Lowland zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 55% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 27% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small portion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

High Over Bank Floods

The High Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 8-year flood in the reference regime. It is calculated from a combination of the High Over Bank Flood Duration metric and the High Over Bank Flood Spells metric. The High Over Bank Flood Duration metric quantifies change in the duration of flooding of high-level floodplain areas relative to reference. The High Over Bank Flood Spells metric quantifies change in the duration of time between high-level floodplain inundation events relative to reference. The High Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly rather than daily timestep.

In the mainstem rivers, the High Over Bank Floods indicator showed near Reference Condition. Results for the High Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 49% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 29% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone. Results for the High Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 49% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 29% of the mainstem river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Gwydir Valley was generally characterised by considerable alteration in Low Over Bank Floods, Flow Variability and Low and Zero Flow Events, moderate alteration in Flow Seasonality and High Flow Events and little or no alteration in High Over Bank Floods and Flow Gross Volume, relative to Reference Condition. Throughout most of the mainstem river system there was reduced frequency and duration of flooding and high flow spells relative to reference. This was accompanied by increased low flow magnitudes and reduced frequency of low flow spells. There was also widespread change in flow seasonality with altered timing and reduced amplitude of seasonal flow variations.

Summary: headwater streams

The headwater streams of the Gwydir Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume, relative to Reference Condition. Throughout some of the headwater streams the magnitude of low flows was reduced relative to reference.

Table GWY 11: Gwydir Valley SRA Hydrology Condition Index at valley and zone scales.
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	49	99	98	40	24

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Table GWY 12: Gwydir Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**28 (0–100)**	**100 (7–100)**
Sub-index	In-Channel Flow Regime	24 (1–100)	100 (7–100)
Indicator	In-Channel Flow Regime A (volume and flow events)	41 (2–100)	100 (29–100)
Sub-ind.	Flow Gross Volume	82 (0–100)	99 (82–100)
Metric	Mean Annual Flow	0.85 (0–1.43)	1.03 (0.72–1.21)
Metric	Flow Duration	1.05 (0.91–1.14)	0.99 (0.81–1.11)
Sub-ind.	High Flow Events	74 (8–99)	99 (64–100)
Metric	High Flow	0.95 (0–1.54)	1.01 (0.44–1.52)
Metric	High Flow Spells	0.55 (0.05–1.00)	
Sub-ind.	Low and Zero Flow Events	40 (8–98)	96 (23–99)
Metric	Zero Flows Proportion	1.03 (0–2.00)	0.99 (0.88–1.00)
Metric	Low Flow	1.46 (0.18–2.00)	0.86 (0.01–1.21)
Metric	Low Flow Spells	1.78 (0.79–2.00)	
Indicator	In-Channel Flow Regime B (seasonality & variability)	47 (6–100)	99 (20–100)
Sub-ind.	Flow Seasonality	64 (18–100)	97 (73–100)
Metric	Flow Seasonal Amplitude	0.69 (0–1.23)	1.06 (0.89–1.53)
Metric	Flow Seasonal Period	0.68 (0.42–1.00)	0.96 (0.81–1.00)
Sub-ind.	Flow Variability	41 (0–100)	93 (1–100)
Metric	Flow Variation	0.80 (0.42–1.43)	0.93 (0.53–1.00)
Sub-index	Over Bank Flow Regime	70 (1–100)	
Indicator	Over Bank Floods Low	49 (1–99)	
Metric	OB Flow Duration (ARI 1)	0.50 (0–1.23)	
Metric	OB Flow Spells (ARI 1)	0.64 (0–2.00)	
Indicator	Over Bank Floods High	81 (46–98)	
Metric	OB Flow Duration (ARI 8)	0.52 (0–1.24)	
Metric	OB Flow Spells (ARI 8)	1.05 (0.36–1.38)	

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
	97	**14**	**24**	**99**	**100**	**100**
	98	18	14	99	100	100
	99	37	34	100	100	100
	100	97	71	98	99	100
	1.00	1.01	0.74	1.06	1.04	1.02
	1.00	1.10	1.03	1.00	1.00	0.99
	98	83	65	98	99	99
	1.03	1.25	0.79	1.11	1.05	0.98
	0.99	0.58	0.45			
	96	26	38	96	97	96
	1.00	1.08	1.02	0.98	0.99	0.99
	1.02	1.83	1.35	0.85	0.91	0.86
	1.02	1.92	1.84			
	97	50	36	98	100	99
	99	70	56	95	97	98
	0.99	0.85	0.57	1.12	1.07	1.04
	0.98	0.56	0.69	0.93	0.96	0.97
	97	38	33	90	95	95
	0.98	0.69	0.82	0.91	0.94	0.94
	95	57	77			
	94	55	40			
	0.97	0.49	0.42			
	1.05	1.03	0.37			
	98	78	78			
			0.52			
			1.05			

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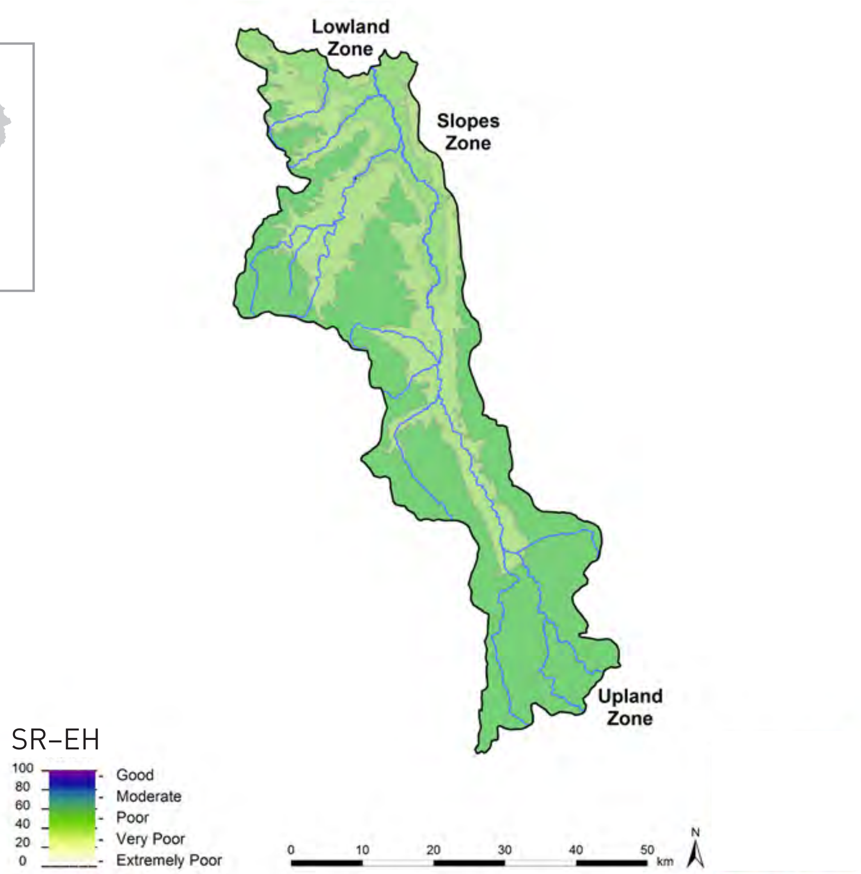

Figure KWA 1: Kiewa Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure KWA 1 shows the Ecosystem Health ratings for the Kiewa Valley and Tables KWA 1 and KWA 2 also show the Index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Kiewa Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Good and Poor condition respectively, while Physical Form and Hydrology were both in Good condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Kiewa Valley river system. River Ecosystem Health was rated as Poor (Upland zone: Poor; Slopes and Lowland zones: Very Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Kiewa Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Upland Poor; Slopes and Lowland Very Poor. The Fish community was in Extremely Poor condition. Some expected species were absent; species count and abundance were dominated by native species (but biomass was dominated by aliens) and recruitment levels among the remaining native species were extremely low in the Slopes and Upland zones. The Macroinvertebrate community was in Good condition, with minor to no decline in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Poor condition overall, with greatly reduced abundance and nativeness in the Near Riparian domain. The Physical Form of the river system was in Good condition with channel form and bank dynamics in Good condition and bed dynamics in Moderate condition. There were moderate levels of floodplain sediment deposition. The river system's Hydrology was in Good condition, with all indicators close to or in Reference Condition, based on assessment of headwater streams only.

Ecosystem health

The Kiewa Valley has an Ecosystem Health rating in the lower 50% of valleys, being ranked 14 out of 23 and among the four lowest valleys rated in Poor Health (see Table 5.2). This is a considerably inferior ranking to the assessments of Hydrology and Physical Form, with the Kiewa ranking equal fourth in both of these. The Kiewa ranked fifth for Macroinvertebrates, equal 18th for Vegetation, and 17th for Fish.

The condition of vegetation reflected the fact that a significant part of the upper catchment of the Kiewa is public land whereas the slopes and floodplain are given over to horticulture and dairying. Hydrology and Physical Form were in uniformly Good condition in all three zones along the Kiewa (noting that no mainstem reaches were assessed for the Hydrology Theme). For Macroinvertebrates, the Lowland zone was in slightly worse condition than were the two upstream zones, whereas the opposite applied to the Fish community which was in significantly better condition in the Lowland zone relative to the others. In terms of trends in fish condition, both the Slopes and Upland zones showed a significant decline in recruitment and the SR–FI score, and the Slopes zone also showed a significant decline in the Expectedness Index. There were no statistically significant trends observed in the Lowland zone fish community.

It is likely that the smaller upper catchment streams are more susceptible to the effects of extended and severe drought, though it is also true that for the Kiewa and perhaps similar streams even in Reference Condition native fish species richness is low and as a consequence estimates of condition are sensitive to small changes. Three native fish species are expected to be present in the Upland zone of the Kiewa but in this assessment (SRA2) only one was captured (two-spined blackfish)—and even this species showed no evidence of recruiting in the zone. However it should be noted that these native fish were outnumbered nearly 5:1 by large-bodied alien predators, which might be expected to exert considerable predation pressure on small native species (and recruits) in stream habitats severely reduced in size, complexity and connectivity by drought conditions. Under these circumstances it might be concluded that the indices do reflect actual current condition, which is being determined by a complex array of impacts that may differ (in nature or intensity) amongst zones.

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Fish Theme

The Fish Condition Index SR–FI = 16, indicating Extremely Poor condition (Lowland zone: Poor; Slopes zone: Extremely Poor; Upland zone: Extremely Poor). The Expectedness indicator = 28, indicating Very Poor condition, and a very large difference from Reference Condition. The Nativeness indicator = 25, indicating Very Poor condition, and a very large difference from Reference Condition. The Recruitment indicator = 27, indicating Very Poor condition, and a very large difference from Reference Condition.

The valley's fish community had lost much of its native species richness and alien species contributed over 78% of fish biomass. The Upland zone in particular had few fish and lacked two of the three predicted native species. Native fish recruitment was Extremely Poor in both the Upland and Slopes zones, but Good in the Lowland zone.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 84, indicating Good condition (Lowland zone: Moderate; Slopes zone: Good; Upland zone: Good). The simOE metric = 56, indicating a small difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Good condition was high across all zones (69% overall) and only one site was rated in Poor condition. None of the 35 rated sites were in Very or Extremely Poor condition.

Family richness generally was high (average 28 families per site), and was also high compared to Reference Condition at most sites except in the Lowland zone.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 40, indicating Poor condition (Lowland zone: Extremely Poor; Slopes zone: Extremely Poor; Upland zone: Good). The Vegetation Abundance and Diversity indicator = 48, indicating Poor condition and a large difference from Reference Condition for the abundance of major vegetation groups within the Near Riparian domain. The Vegetation Quality and Integrity indicator = 48, indicating Poor condition and a large difference from Reference Condition for the structure and nativeness of communities and vegetation groups within the Near Riparian domain.

The Lowland Floodplain domain was not assessed for the Kiewa Valley.

Physical Form Theme

The Physical Form Condition Index SR–PI = 94, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good). The Channel Form indicator = 88, the Bank Dynamics indicator = 98 and the Floodplain Form indicator = 82; all indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 79, indicating Moderate condition and showing a minor difference from Reference Condition.

Overall, the valley's Physical Form was characterised by elevated sediment loads since European settlement and associated sedimentation within the Lowland zone floodplain, while Channel, Bed and Bank Dynamics are generally close to or in Reference Condition.

Hydrology Theme

The Hydrology Condition Index SR–HI = 99, indicating Good condition (Slopes zone: Good; Upland zone: Good). The headwater streams were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume relative to Reference Condition. No mainstem river reaches were assessed for the Hydrology Theme.

Table KWA 1: Kiewa Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	UPLAND	SLOPES	LOWLAND
		Poor	Poor	Very Poor	Very Poor

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	16 (11–27) Ext' Poor	0 (0–1) Ext' Poor	10 (5–18) Ext' Poor	45 (28–52) Poor
Macro-invertebrates	SCORE RATING	84 (80–88) Good	91 (86–94) Good	84 (80–89) Good	75 (58–88) Moderate
Vegetation	SCORE RATING	40 Poor	99 Good	12 Ext' Poor	3 Ext' Poor

Table KWA 2: Kiewa Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE		
			UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	94 (86–99) Good	99 (93–100) Good	96 (88–100) Good	82 (59–100) Good
Hydrology	SCORE RATING	99 Good	100 Good	100 Good	

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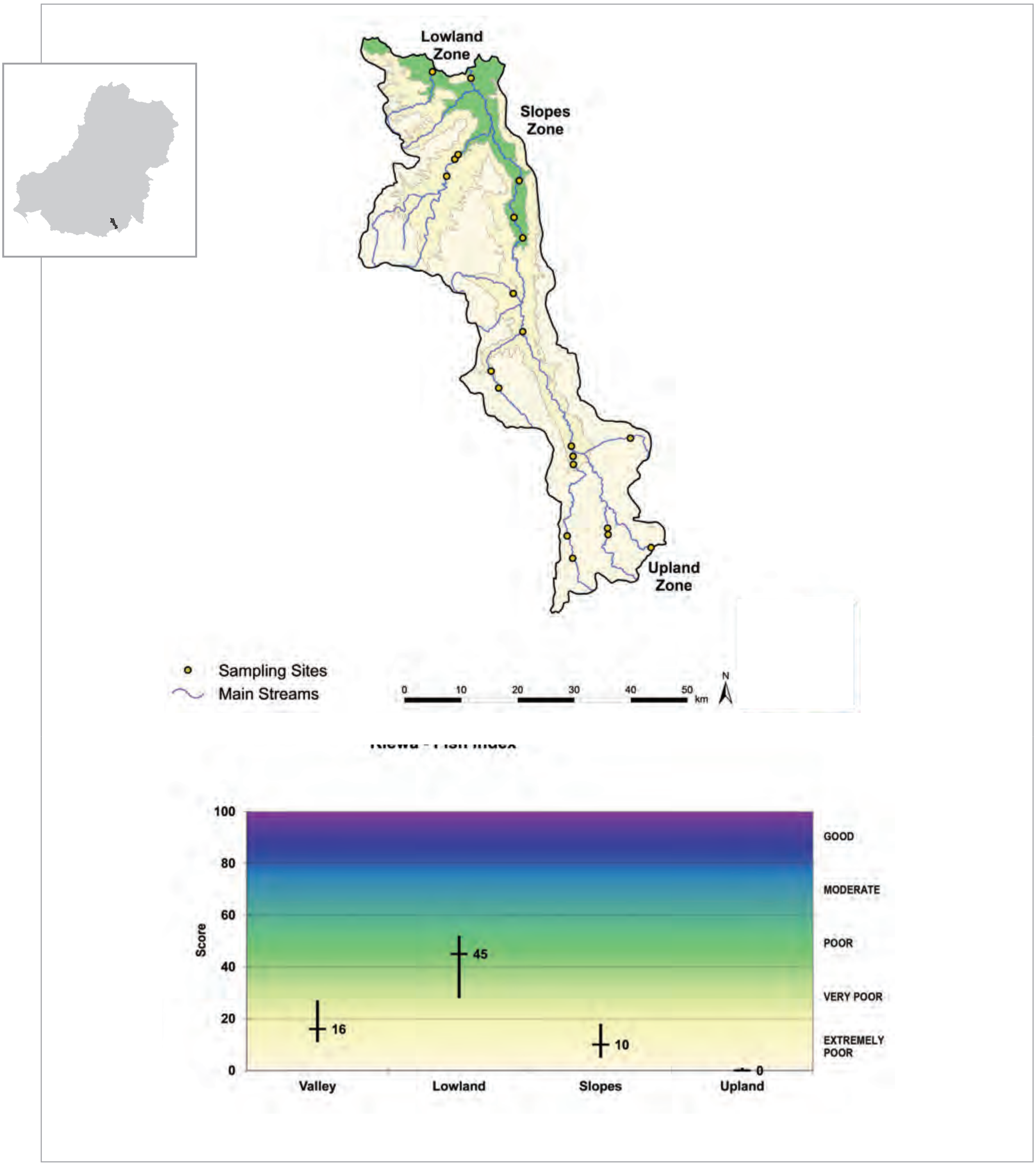

Figure KWA 2: Kiewa Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Kiewa Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 16. The condition of the fish community in the zones was as follows: Upland Extremely Poor; Slopes Extremely Poor; and Lowland Poor. The fish community was characterised by a Very Poor score for expected native fish species, a Very Poor score for nativeness and a Very Poor score for native fish recruitment. The Upland zone in particular had few fish and lacked two of the three predicted native species. The valley had lost much of its native species richness and alien species contributed over 78% of the biomass in samples. Native fish recruitment was Extremely Poor in both the Upland and Slopes zones, but Good in the Lowland zone.

Twenty-one sites were surveyed across the Kiewa Valley in March 2009, yielding 1,759 fish. Analyses showed an extreme difference from Reference Condition for the Kiewa Valley, with:

- SRA Fish Index (SR–FI) = 16 (CL 11–27), indicating an Extremely Poor condition of the fish community.
- The Expectedness indicator = 28 (CL 23–35), indicating Very Poor condition, and a very large difference from Reference Condition. Only 41% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 25 (CL 17–32), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 27 (CL 16–43), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for all seven of the native species observed in the valley but was restricted mainly to the Lowland zone.

Figure KWA 2 shows sampling sites, zones and corresponding SR–FI values, and Table KWA 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Kiewa Valley was the seventh lowest for all valleys, and close to that for the Upper Murray, Goulburn and Murrumbidgee valleys. The Lowland zone community was in much better condition (SR–FI = 45) than that in the other two zones (SR–FI = 10 for Slopes zone and zero for Upland zone).

Expectedness was rated as Very Poor for the valley. Of the 17 native species predicted to be present under Reference Condition (RC–F), only seven appeared in samples from the 21 sites. The proportion of predicted native species captured was similar in all three zones; 33% in the Upland zone, 38% in the Slopes zone, and 35% in the Lowland zone. The Upland zone (together with the Montane zone of the Ovens valley) had the lowest number of species expected under Reference Condition (three) of the 68 zones throughout the Basin.

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Nativeness varied significantly amongst zones, reflecting, amongst other things, differences in biomass, in the number of native species captured and the number of alien species. The proportion of fish caught per zone that were native species was 16% for the Upland zone, 24% for the Slopes zone, and 21% for the Lowland zone. The equivalent data for fish biomass are 8.6%, 6.1%, and 35% respectively.

Table KWA 4 shows native species abundances in the Kiewa Valley compared with Reference Condition. Of the 17 native species expected under Reference Condition, nine did not appear at any site. These included four of the five long-lived native species: golden perch, Macquarie perch, silver perch, and trout cod. Murray cod, river blackfish, and two-spined blackfish were caught in all zones in which they were expected. Seven alien species including oriental weatherloach were caught. Common carp, brown trout, rainbow trout, and redfin perch, all with the potential to reach large body mass, were present in two out of three zones. Only common carp reached significant biomass, averaging 2 kg per fish. The other alien species averaged 113g, 49g, and 32g respectively. Murray cod—at 980g per fish—was the only native species to reach substantial biomass.

Recruitment varied substantially, ranging from Extremely Poor in the Upland zone to Good in the Lowland zone. The only native species captured in the Upland zone, two-spined blackfish, showed no evidence of recruiting—though it was observed as recruiting in a total of three sites in the other zones. Only two of the five native species caught in the Slopes zone, galaxias and two-spined blackfish, showed evidence of recruitment. All six native species caught in the Lowland zone were recorded as recruiting. These included the two blackfish species and Murray cod. Two alien species, common carp and oriental weatherloach, did not recruit in any zones in which they occurred.

In general, the fish community of the Kiewa had reduced numbers of expected native species. There was considerable variation among zones, particularly in Recruitment and Nativeness.

Table KWA 3: Kiewa Valley SRA Fish Condition Index, indicators, metrics and derived variables.
Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	16 (11–27)	0 (0–1)	10 (5–18)	45 (28–52)
Indicator	Expectedness	28 (23–35)	8 (8–21)	39 (29–50)	33 (27–42)
Metric	O/E	0.36 (0.28–0.47)	0.10 (0–0.31)	0.49 (0.35–0.66)	0.46 (0.37–0.59)
Metric	O/P (Zone level)	0.36 (0.36–0.36)	0.33 (0.33–0.33)	0.38 (0.38–0.38)	0.35 (0.35–0.35)

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Nativeness	25 (17–32)	0 (0–6)	22 (10–38)	56 (38–71)
Metric	Proportion biomass native	0.20 (0.11–0.3)	0.08 (0–0.26)	0.15 (0.05–0.30)	0.41 (0.20–0.64)
Metric	Proportion abundance native	0.31 (0.18–0.45)	0.10 (0–0.31)	0.34 (0.14–0.57)	0.49 (0.23–0.76)
Metric	Proportion species native	0.35 (0.29–0.42)	0.07 (0–0.21)	0.39 (0.30–0.47)	0.62 (0.48–0.75)
Indicator	Recruitment	27 (16–43)	0 (0–0)	12 (0–20)	83 (48–90)
Metric	Proportion of sites with native recruits	0.36 (0.21–0.41)	0 (0–0)	0.29 (0.00–0.40)	0.90 (0.50–0.99)
Metric	Proportion of native taxa with recruits	0.44 (0.30–0.69)	0 (0–0)	0.40 (0.00–0.67)	1.00 (0.80–1.00)
Metric	Proportion of abundance as recruits	0.13 (0.09–0.22)	0 (0–0)	0.02 (0.00–0.04)	0.47 (0.32–0.60)
Variables					
	Number of sites sampled	21	7	7	7
	Total number of species	14	3	11	11
	Number of native species	7	1	5	6
	Number of predicted species	17	3	13	17
	Number of alien species	7	2	6	5
	Mean number of fish per site	84	42	79	130
	Biomass/site all species (g)	9485	1873	10819	15763
	Mean native biomass/fish (g)	120	23	34	206
	Mean alien biomass/fish (g)	111	49	170	99

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Table KWA 4: Kiewa Valley number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone		
		Upland	Slopes	Lowland
Sites sampled	21	7	7	7
Native species				
Australian smelt	56		0	56
Dwarf flathead gudgeon	0			0
Flathead gudgeon	0			0
Galaxias	56	0	56	0
Golden perch	0		0	0
Gudgeon	4		0	4
Macquarie perch	0		0	0
Mountain galaxias	0	0	0	0
Murray cod	41		1	40
Murray jollytail	0		0	0
Obscure galaxias complex	31		21	10
River blackfish	83		10	73

Fish species	Valley	Zone		
		Upland	Slopes	Lowland
Silver perch	0			0
Southern pygmy perch	0		0	0
Trout cod	0		0	0
Two-spined blackfish	100	48	47	5
Alien species				
Brown trout	243	128	115	
Common carp	59		26	33
Gambusia	923		248	675
Goldfish	7		1	6
Oriental weatherloach	3			3
Rainbow trout	124	119	5	
Redfin perch	29		23	6

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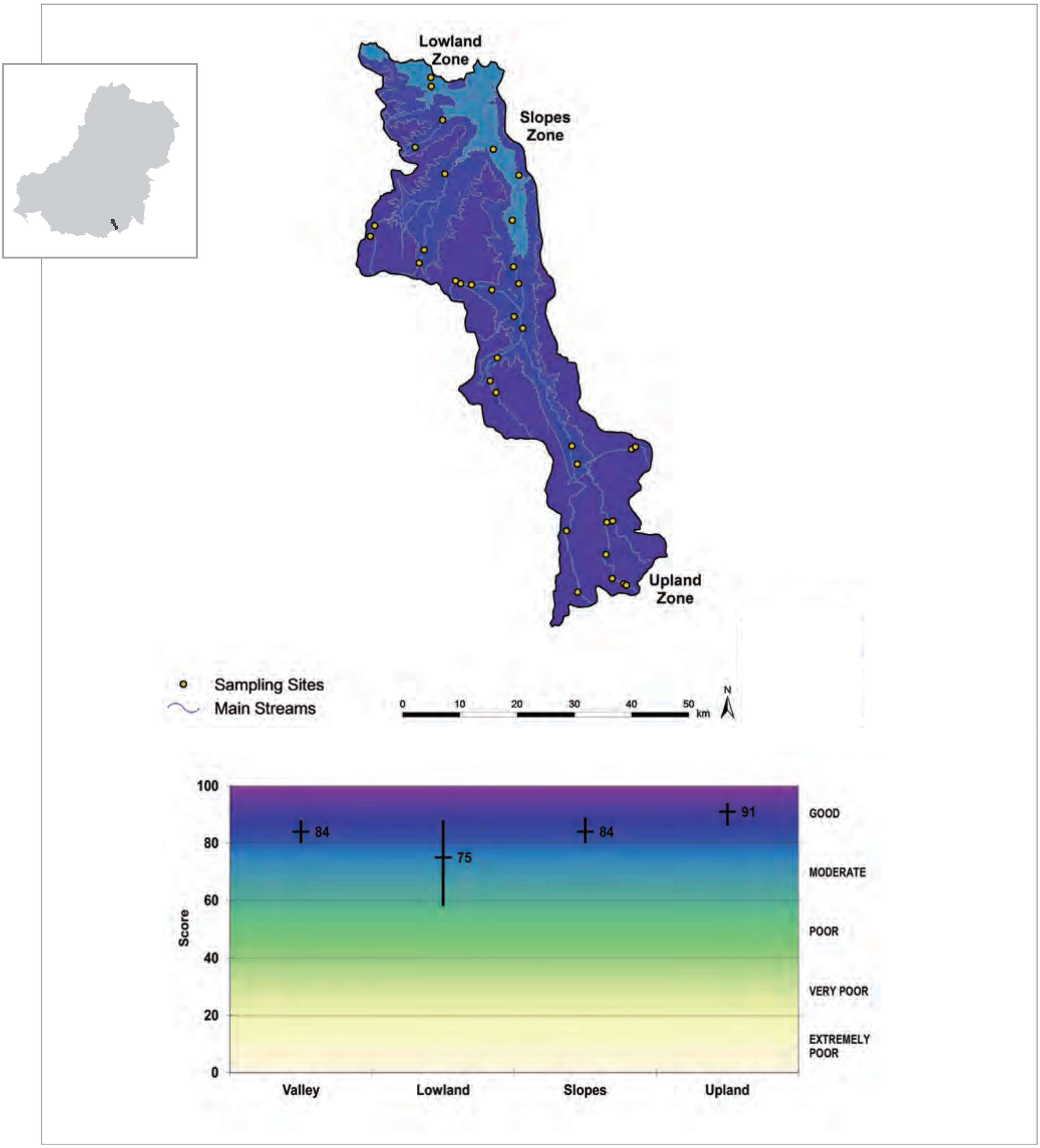

Figure KWA 3: Kiewa Valley map with sampling sites and zones coloured by Macroinvertebrate Index (SR–MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Kiewa Valley river system was in Good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 84. The condition of the macroinvertebrate community in the zones was as follows: Upland Good; Slopes Good; Lowland Moderate. The proportion of sites in Good condition was high across all zones (69%); only one site was rated in Poor condition. Family richness generally was high, and was also high compared to Reference Condition at most sites except in the Lowland zone.

Thirty-five sites were surveyed across the Kiewa Valley in November 2008 yielding 7,128 macroinvertebrates in 73 families (78% of Basin families). Analyses showed a minor difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 84 (CL 80–88), indicating Good condition of benthic macroinvertebrate communities.
- The simOE metric = 56 (CL 53–58) indicating only minor differences from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Good condition was high across all zones (69% overall), only one site was rated in Poor condition. None of the 35 rated sites were in Very or Extremely Poor condition.
- The number of families found was lowest in the Lowland zone (38 families) and highest in the Upland zone (65 families), with both the Upland and Slopes zone having the highest average number of families per site (30).

Figure KWA 3 shows sampling sites, zones and SR–MI values, and Table KWA 5 shows Index and metric values. The SR–MI score for the Kiewa Valley indicated Good condition of macroinvertebrate communities, rating 5th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the Upland and Slopes zones were rated overall as equivalent to Reference Condition (SR–MI = 91 and 84 respectively), with most sites showing no or minor differences from reference. The Lowland zone was rated in Moderate condition, and its SR–MI score exhibited a very wide confidence interval (30 points) indicating high spatial variability. The majority (69%) of sites showed no or minor differences from Reference Condition. Expectedness (simOE) was high to moderate overall and varied by only to 20 points among sites.

Table KWA 6 shows that most sites in both zones had high SR–MI values, with only one site rated in Poor condition (in the Lowland zone) – the only site with a low simOE score (<40 points). Most sites had close to their expected diversities of macroinvertebrates, though occasionally coupled with reductions in frequency of occurrence of some of the families present.

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Family richness generally was high compared to Reference Condition. Diversity was high (average 28 families per site), with the Upland and Slopes zones being most diverse at site scale (average 30 families per site). The valley contained 78% of the families found across the Basin (Table KWA 6), with the Upland and Lowland zones having the highest and lowest representations of Basin-wide fauna (69 and 40% respectively). Most (74–89%) of the fauna of the valley was found in each of the Upland and Slopes zones.

Table KWA 5: Kiewa Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	84 (80–88)	91 (86–94)	84 (80–89)	75 (58–88)
Metric	SimOE	56 (53–58)	59 (56–63)	55 (52–58)	51 (43–57)

Table KWA 6: Kiewa Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone		
		Upland	Slopes	Lowland
Sites				
Number of sites sampled	35	13	16	6
Number of sites with index values*	35	13	16	6
N sites by SR–MI condition band				
Good (80–100)	24	12	9	3
Moderate (60–80)	10	1	7	2
Poor (40–60)				
Very or Extremely Poor (0–40)	1			1
Families				
Number of families sampled	73	65	54	38
No. families/site (min–max)	28 (12–46)	30 (15–46)	30 (18–42)	20 (12–29)
Percent of families in Basin	78	69	57	40
Percent of families in valley	100	89	74	52

*simOE values could occasionally not be derived for every sample site.

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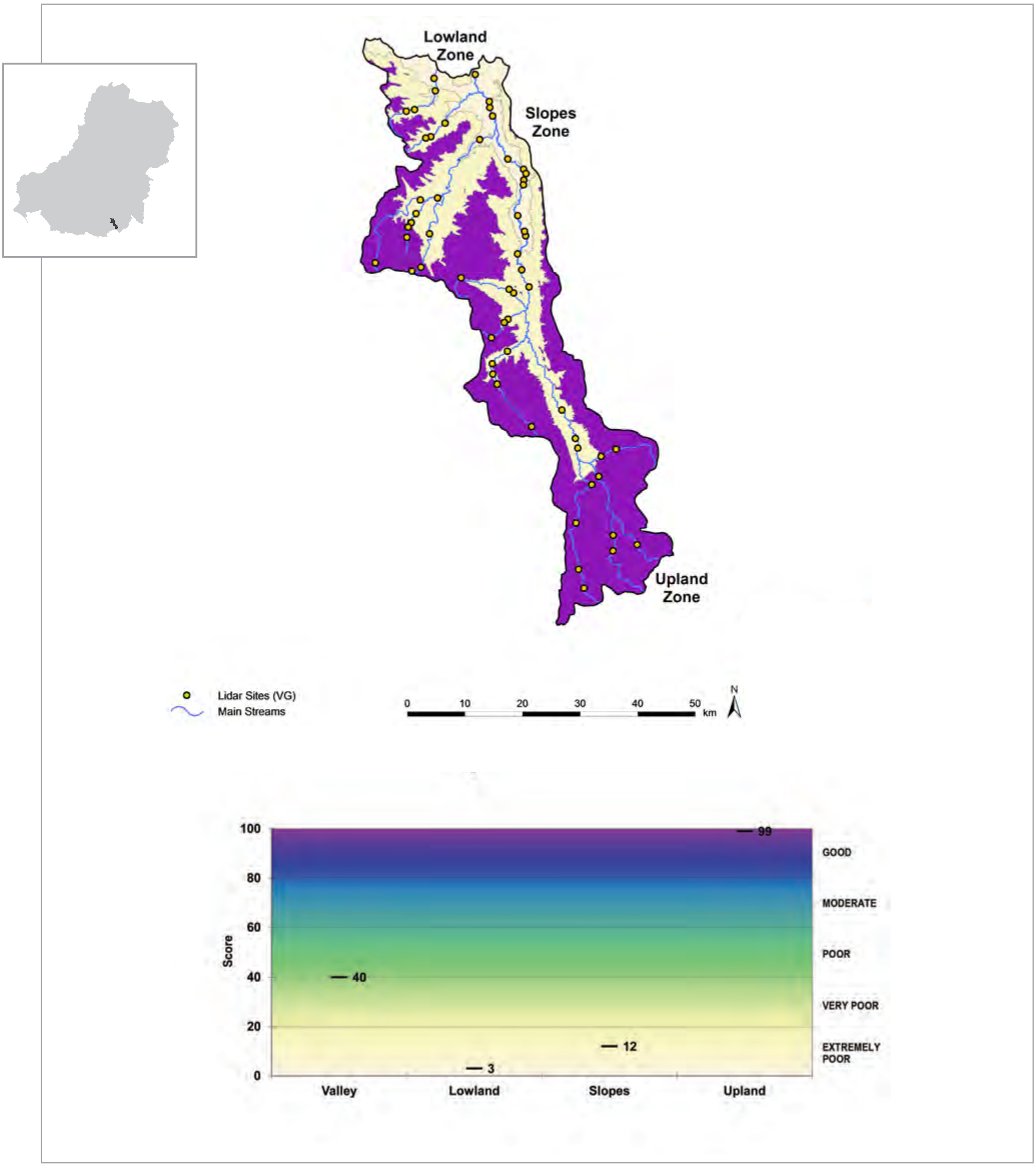

Figure KWA 4: Kiewa Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Kiewa Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 40. Overall condition for the three zones in this valley was: Upland Good; Slopes Extremely Poor; Lowland Extremely Poor.

The Abundance and Diversity indicator score was 48 for the valley, indicating a Poor rating overall. In the three zones it was: Upland Good; Slopes Very Poor; Lowland Extremely Poor.

The Quality and Integrity indicator score was 48 for the valley, indicating a Poor rating overall. In the three zones it was: Upland Good; Slopes Very Poor; Lowland Very Poor.

The SRA Vegetation for the Kiewa Valley assessment considers riverine vegetation in one spatial domain only: Near Riparian, along 395 km of stream. Much (43%) of the stream length is in the Slopes zone, and the length of stream assessed per zone is as follows: Upland, 136 km; Slopes, 169 km; and Lowland, 90 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 58 sites set back 50 m from the top of the bank. LiDAR sites are distributed amongst the three zones as follows: Upland, 16 sites; Slopes, 27 sites; and Lowland, 15 sites. There is no assessment of a Lowland Floodplain domain because no area was identified as inundated within the Lowland zone.

Figure KWA 4 shows values of the Vegetation Index (SR–VI) for the Kiewa Valley and Table KWA 7 shows the Index, indicator and sub-indicator values. Table KWA 8 shows key MVG variables and metrics for the valley and the zones.

Analyses showed a large difference from Reference Condition for the Kiewa Valley with:

- SRA Vegetation Index (SR–VI) = 40, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 48, indicating a large difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian domain.
- The Vegetation Quality and Integrity indicator = 48, indicating a large difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian domain.
- The Lowland Floodplain domain is not assessed for the Kiewa Valley.

The Abundance and Diversity of valley riverine vegetation is in Poor condition overall, with MVGs showing near Reference Condition for the Upland zone, a very large difference from Reference Condition for the Slopes zone, and an extreme difference from reference for the Lowland zone. The Poor rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wide abundance shows a very large difference from reference for the Near Riparian domain. MVG richness is near reference in the Near Riparian domain.

In addition, the Quality and Integrity of valley riverine vegetation is in Poor condition overall, being near Reference Condition in the Upland zone and showing a very large difference from reference in the Slopes and Lowland zones. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table KWA 8 as well as other native but non-specific MVGs. Valley-wide Nativeness shows a very large difference from reference in the Near Riparian domain.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the Near Riparian spatial domain is in near Reference Condition overall, and the metrics show near Reference Condition for the Upland and Slopes zones where there is no loss of any MVG, and large difference from Reference Condition in the Lowland zone where one out of just two MVGs in this zone is completely lost (though originally small in area).

Abundance

- The Abundance of pre–1750 MVGs in the Near Riparian spatial domain is in Very Poor condition overall, and the metrics show big differences between the zones. Abundance shows a moderate difference from Reference Condition in the Upland zone, and an extreme difference from reference in the Slopes and Lowland zones.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the Near Riparian spatial domain is in Very Poor condition overall, and the metrics show a big difference between zones. Nativeness shows a moderate difference from Reference Condition in the Upland zone, and an extreme difference from reference in the Slopes and Lowland zones.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR is in Moderate condition overall, with minor differences between zones. Structure is near reference in the Upland zone, is moderately different from reference in the Slopes zone, and near reference in the Lowland zone. Structure refers only to the height of the upper canopy of individual patches of woody vegetation types near the channel.

Under Reference Conditions, the riverine vegetation in the Kiewa Valley was characterised as follows:

- Upland zone: The Near Riparian domain was mostly Eucalypt Open Forests (48% of domain area) with Eucalypt Tall Open Forests (22%) and Eucalypt Woodlands (18%). One of the two other MVGs present was more than 5% of the domain.

- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (62% of domain area), with Eucalypt Open Forests (20%) and Eucalypt Tall Open Forests (17%) with one other MVG present.

- Lowland zone: The Near Riparian domain was almost entirely Eucalypt Woodlands (99% of domain area), with one other MVG present.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced in all domains, but particularly in the lower zones where the effect on Eucalypt Woodlands, formerly the most extensive MVG, is severe. All MVGs are reduced.

- Upland zone: In the Near Riparian domain, the three MVGs are reduced but are still the most extensive, Eucalypt Open Forests (32% of the domain area), Eucalypt Woodlands (15%) and Eucalypt Tall Open Forests (11%). About 31% is cleared or non-native vegetation. Eucalypt Tall Open Forests is the most proportionally depleted MVG, from 22% under Reference Conditions to 11%, while Eucalypt Open Forest has been the most depleted in absolute area.

- Slopes zone: In the Near Riparian domain, the MVGs are all reduced with Eucalypt Woodlands now 9% of domain area, and Eucalypt Open Forests 7%. About 82% is cleared or non-native vegetation. All the MVGs are reduced relative to Reference Conditions.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are reduced (now 13% of domain area). About 80% is cleared or non-native vegetation. The mapping is ambiguous for 7% of the domain.

Unlike the other themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up-to-date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping is 2004, whereas the LiDAR was flown May-June 2010. This means that the Structure Sub-indicator and the abundance, richness and nativeness metrics are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees present. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

Most of the metrics are based on vegetation mapping, which is not current and can be of variable quality. The condition of the Near Riparian domain, and hence of the zones and of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Kiewa Valley is notable for the extremely low scores for abundance and nativeness of MVGs in the Slopes and Lowland zones, and the contrast in overall condition between these lower zones and the Upland zone.

Of the three zones, the condition of the riverine vegetation is best in the Upland zone, rated near reference overall, with moderate scores for abundance and nativeness and near reference scores for richness and structure. Condition is worst in the Lowland zone, rated Extremely Poor, with very low scores for abundance and nativeness, and richness. Condition in the Slopes zone, which is the zone with the greatest influence on the valley score, is also Extremely Poor.

Condition in the Near Riparian domain changes down the valley. In the Upland zone, metrics for abundance, nativeness, richness and structure have moderate to near reference scores but at lower zones, the scores for abundance and nativeness indicate severe clearing. The MVG lost from the Near Riparian domain in the Lowland zone is Callitris Forests and Woodlands.

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Table KWA 7: Kiewa Valley SRA Vegetation Condition Index, indicators, metrics and derived variables.
LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	40	99	12	3
Indicator	Abundance and diversity	48	89	31	16
Metric	LF stability				
Sub-ind.	NRLF richness				
Metric	NR richness	0.89	1	1	0.50
Metric	LF richness				
Sub-ind.	NRLF abundance				
Metric	NR abundance	0.34	0.68	0.18	0.13
Metric	LF abundance				
Indicator	Quality and integrity	48	86	28	29
Sub-ind.	NRLF nativeness				
Metric	NR nativeness	0.34	0.68	0.18	0.13
Metric	LF nativeness				
Sub-ind.	NR structure	77 (72–81)	81 (76–86)	71 (62–79)	80 (73–86)
Sub-ind.	LF fragmentation				

Table KWA 8: The most abundant MVGs in the Near Riparian domain in the Kiewa Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Valley		
	Upland	Slopes	Lowland
MVG			
2. Eucalypt Tall Open Forests	22	17	
3. Eucalypt Open Forests	48	20	
5. Eucalypt Woodlands	18	62	99
21. Other Grasslands, Herblands, Sedgelands and Rushlands	11		

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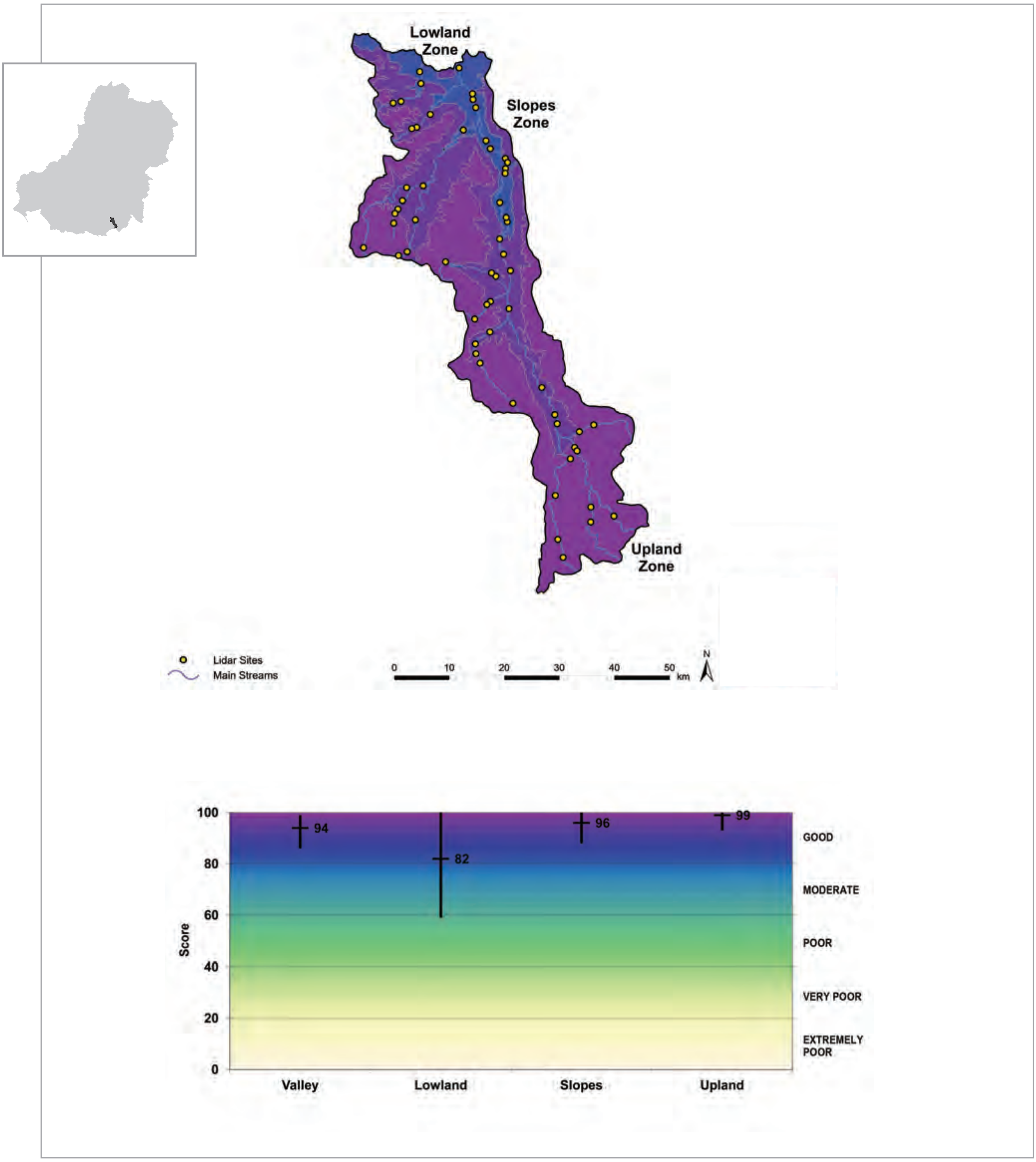

Figure KWA 5: Kiewa Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Kiewa Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 94. The condition of Physical Form in the zones was: Upland, Slopes and Lowland Good. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics was rated as Moderate. Floodplain Dynamics was rated as Good. Overall, the valley's physical form was characterised by elevated sediment loads since European settlement and associated sedimentation within the Lowland zone floodplain; while channel, bed and Bank Dynamics are generally close to or in Reference Condition.

The SRA Physical Form assessment considers physical form and processes along 395 km of stream across the valley. It is based on LiDAR data collected at 60 sites along river channels, as well as modelling of all 21 SedNet-defined river reaches within the valley. The Physical Form assessment considered four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure KWA 5 shows values of the Physical Form Index (SR–PI) for the Kiewa Valley and Table KWA 9 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a near Reference Condition for the Kiewa Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 94 (CL 86–99), indicating Good Physical Form condition
- the Channel Form indicator = 88 (CL 82–93), showing near Reference Condition
- the Bed Dynamics indicator = 79 (CL 72–85), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 98 (CL 97–99), showing near Reference Condition
- the Floodplain indicator = 82 (CL 68–99), showing near Reference Condition.

Upland zone

There were 16 LiDAR survey sites and 3 SedNet river segments in the Upland zone of the Kiewa Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upland zone. At these sites Channel Sediment Ratio was generally increased (most sites having large increases). Sinuosity was modified from reference in more than half of the Upland zone. At these sites Sinuosity was generally reduced. Channel Depth, Channel Width Variability, Meander Wavelength and Bank Variability were modified from reference for less than half of the Upland zone. At these sites Channel Depth and Channel Width Variability were generally reduced, results show both increases and decreases in Meander Wavelength across the zone and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width and Channel Sediment Deposition were largely unmodified from Reference Condition in the Upland zone. These results are generally consistent with field observations (Rutherfurd pers. comm.). Note that the headwater tributaries of the Kiewa River are in the alpine bogs and fens of the Bogong High Plains. The morphology of these streams has been transformed by alpine grazing, with considerable incision and widening (Lawrence *et. al*. 2007).

Slopes zone

There were 28 LiDAR survey sites and 10 SedNet river segments in the Slopes zone of the Kiewa Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width and Bank Variability were modified from reference in more than half of the Slopes zone. At these sites Channel Width was generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Depth, Channel Width Variability, Sinuosity and Meander Wavelength were modified from reference for less than half of the Slopes zone. At these sites results show both increases and decreases in Channel Depth and Meander Wavelength across the zone, Channel Width Variability and Sinuosity were generally reduced. Channel Sediment Deposition was largely unmodified from reference in the Slopes zone. These results are generally consistent with field observations (Rutherfurd pers. comm.), although there is some evidence of sedimentation in larger tributaries of the Kiewa River.

Lowland zone

There were 16 LiDAR survey sites and 8 SedNet river segments in the Lowland zone of the Kiewa Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 30% of the zone for the post-European period. Bank Variability was modified from reference in more than half of the Lowland zone. At these sites Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability was modified from reference for approximately half of the Lowland zone. At these sites Channel Width Variability was generally reduced. Sinuosity was modified from reference for less than half of the Lowland zone. At these sites results show both increases and decreases in Sinuosity across the zone. Channel Width, Channel Depth, Meander Wavelength and Channel Sediment Deposition were largely unmodified from reference in the Lowland zone. Field observations and comparisons of aerial photographs indicate increased width and erosion rates in larger streams in the Lowland zone (Rutherfurd pers. comm.).

Channel Form

There was little change from Reference Condition in Channel Form in the Upland zone. There was widespread evidence of channel straightening and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale. Adjustments to Channel Planform in the Upland zone will be constrained by bedrock. Local knowledge is required to interpret any departures from reference planform in bedrock channels. These results are consistent with field observations. Much of the Upland zone is forested.

There was little change from Reference Condition in Channel Form in the Slopes zone. There was widespread evidence of channel enlargement and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale. The observations of channel enlargement and simplification are consistent with field observations (Rutherfurd pers. comm.). In the Slopes zone, the Kiewa River and its tributaries are reported to have experienced increased rates of bank erosion (widening and meander migration) due to clearing and disturbance.

There was little change from Reference Condition in Channel Form in the Lowland zone. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Upland, Slopes and Lowland zones. Bank variability exceeded Reference Conditions at 40%–60% of sites. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result.

There was little change from Reference Condition in Bed Dynamics in the Upland zone mostly as a result of widespread elevated sediment load (in 100% of the SedNet river segments). There was minor change from Reference Condition in Bed Dynamics in the Slopes and Lowland zones mostly as a result of widespread elevated sediment load (in 100% of the SedNet river segments). Field observations suggest substantial increases in coarse sediment load in the Slopes and Lowland zones (Rutherfurd pers. comm.).

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was little change from Reference Condition in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (in 100% of SedNet river segments). There was considerable change from reference in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (in 100% of SedNet river segments).

Table KWA 9: Kiewa Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Index	Physical Form Condition (SR–PI)	94 (86–99)	99 (93–100)	96 (88–100)	82 (59–100)
Indicator	Channel Form (volume and flow events)	88 (82–93)	86 (73–95)	87 (77–95)	94 (86–99)
Sub-ind.	Cross-section Form	90 (84–94)	89 (76–98)	86 (77–93)	98 (96–99)
Metric	Channel Depth (mean)	1.07 (1.01–1.17)	1.05 (0.95–1.20)	1.11 (0.99–1.25)	1.03 (0.99–1.09)
Metric	Channel Width (mean)	1.17 (1.05–1.34)	1.21 (0.99–1.64)	1.22 (1.07–1.41)	1.01 (1.00–1.01)
Sub-ind.	Cross-section Form (variability)	94 (89–97)	96 (92–99)	93 (84–99)	90 (80–98)
Metric	Channel Width (CV)	0.95 (0.91–0.97)	0.96 (0.91–0.98)	0.95 (0.90–0.99)	0.92 (0.86–0.97)
Sub-ind.	Channel Planform	88 (81–93)	85 (72–95)	89 (79–96)	92 (83–97)
Metric	Sinuosity	1.00 (0.98–1.02)	0.98 (0.96–0.99)	1.01 (0.99–1.04)	1.03 (0.98–1.08)
Metric	Meander Wavelength	1.02 (0.97–1.08)	1.03 (0.93–1.17)	1.01 (0.94–1.07)	1.01 (0.98–1.05)
Indicator	Bed Dynamics	79 (72–85)	88 (70–97)	78 (73–86)	65 (48–81)
Metric	Channel Sediment Ratio	10 (8–13)	6 (4–11)	11 (8–15)	15 (8–25)
Metric	Channel Sediment Depth	0.0007 (0–0.002)	0 (0–0)	0 (0–0)	0.003 (0–0.009)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone		
			Upland	Slopes	Lowland
Indicator	Bank Dynamics	98 (97–99)	97 (93–100)	99 (98–99)	100 (99–100)
Metric	Bank Variability (longitudinal)	1.09 (1.05–1.14)	1.11 (1.02–1.24)	1.10 (1.05–1.14)	1.06 (1.02–1.10)
Indicator	Floodplain	82 (68–99)	100 (100–100)	82 (57–100)	54 (26–98)
Metric	Floodplain Sediment Deposition	1.07 (0.52–1.63)	0.32 (0.24–0.42)	1.03 (0.22–1.91)	2.00 (0.70–3.00)

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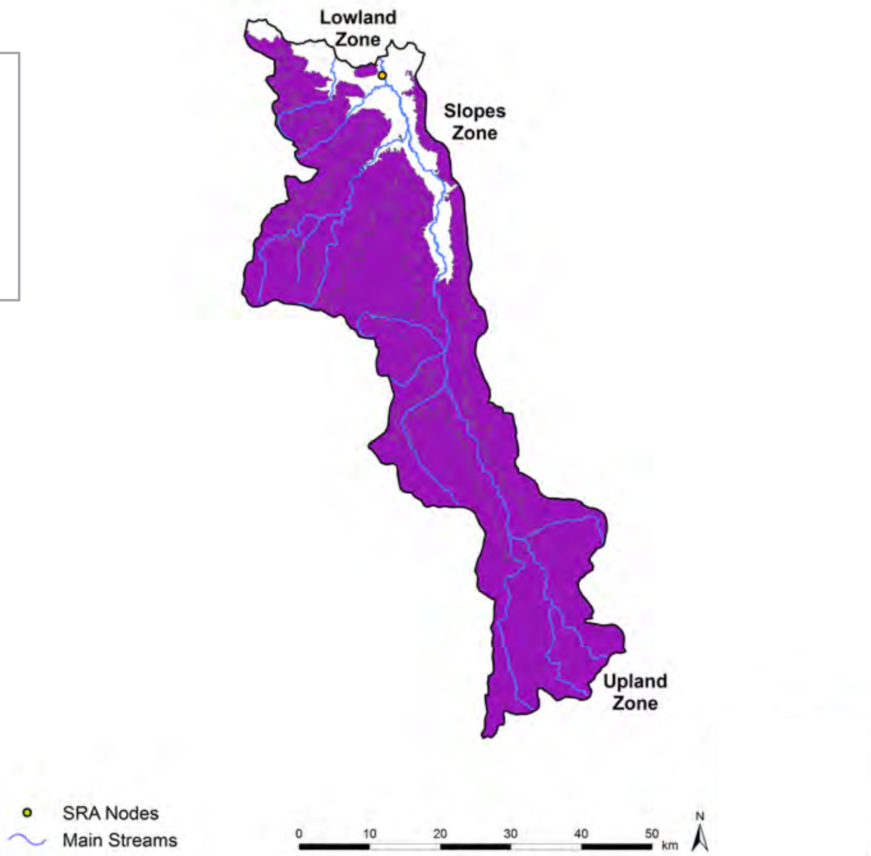

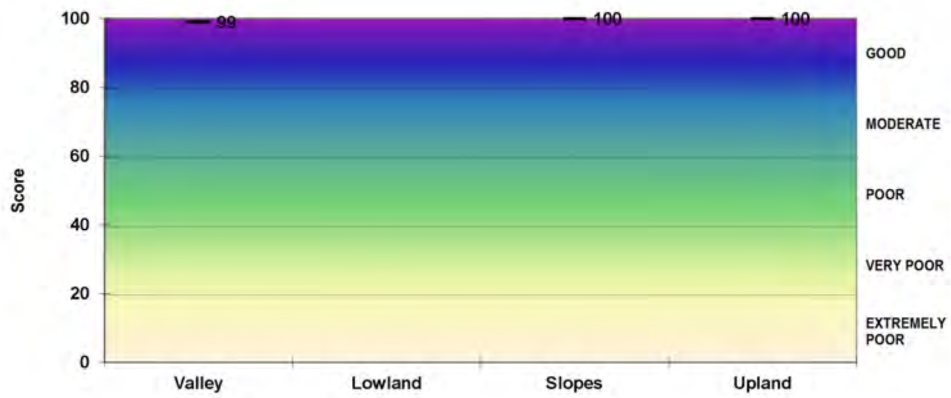

Figure KWA 6: Kiewa Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars. Note: Lowland area has a 'null' score due to no mainstem nodes being in the network, and no headwaters being present.

The Hydrology of the Kiewa Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 99. The Slopes and Upland zones were in Good condition. The headwater streams of the Kiewa Valley were rated in Good condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased. Throughout some of the headwater streams high flows were increased and the magnitude of low flows was increased. Flow alteration in the Kiewa River and larger tributaries are not assessed because they are not represented in basin-wide water resource modelling.

The Kiewa River rises on the Bogong High Plains on the Great Dividing Range as the Kiewa River West Branch, rising near Mt Hotham, and the Kiewa River East Branch, rising above Falls Creek township. The West Branch is the larger, carrying about six times the flow of the East Branch. They join near Mount Beauty and flow northward to join the Murray downstream of Lake Hume. Tributaries to the Kiewa Lowland zone include Yackandandah, Middle, House and Huon creeks. The valley is narrow and steep for much of its length, but the river develops a broad floodplain in the lowermost 20% of its length. Storages on the Kiewa are primarily for power generation, limiting their effects on the long-term pattern and volume of flow. Rocky Valley Dam (28.4 GL), on the East Branch, is the main storage, with a number of small associated (<1 GL) pondages that experience short-term water-level fluctuations and may create similar changes in flow immediately downstream.

In the Kiewa Valley, hydrological condition is assessed using metrics of hydrological alteration available for 319 km of headwater streams. No mainstem river reaches could be assessed for the Kiewa Valley, as the Kiewa River and larger tributaries are not represented in Basin-wide water resource modelling. There are 319 km of headwater stream (Upland zone: 110 km; Slopes zone: 149 km; Lowland zone: 60 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Kiewa Valley there is 121 km of these mid-size tributaries (16 km in the Upland zone; 62 km in the Slopes zone; 43 km in the Lowland zone) which is 0.4 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for approximately the last 40 years for the headwater streams. Importantly, these models have used the ‘current’ levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The ‘current’ water resource development refers to development levels represented for Basin planning in 2010.

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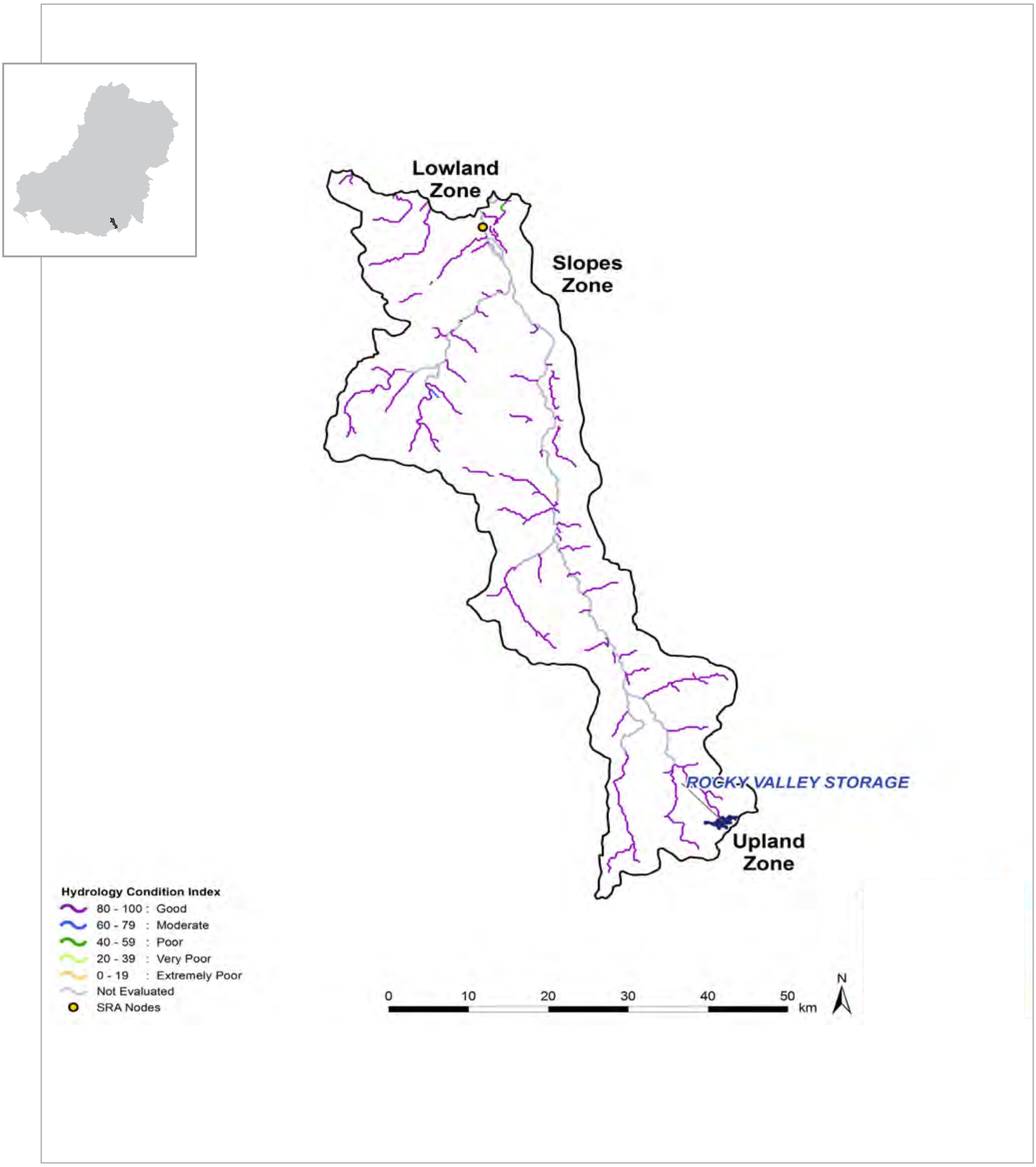

Figure KWA 7: Kiewa Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures KWA 6 and KWA 7 show values of the Hydrology Condition Index (SR–HI) for the Kiewa Valley and its river network, and Table KWA 10 and KWA 11 show the Index, sub-index, indicator and metric values. Analyses showed near Reference Condition for the Kiewa Valley, with:

- The Hydrology Condition Index for the whole valley = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for the Upland and Slopes zones = 100 and 100, indicating Good hydrological condition.
- The Hydrology Condition Index for headwater streams (valley-wide) = 99, indicating Good hydrological condition.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). In addition, results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to reference.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 3% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 32% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone and some in the Slopes zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to Reference Condition. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

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In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 3% of the headwater river length (associated with both increased and reduced flows) and a significant alteration from reference in 31% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone and some in the Slopes zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to Reference Condition. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 4% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 40% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Upland zone and some in the Slopes zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 4% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone.

Summary: mainstem rivers

Flow alteration in the Kiewa River and larger tributaries are not assessed because they are not represented in Basin-wide water resource modelling.

Summary: headwater streams

The headwater streams of the Kiewa Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events or Flow Gross Volume, relative to Reference Condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased. Throughout some of the headwater streams high flows were increased and the magnitude of low flows was increased relative to Reference Condition.

Table KWA 10: Kiewa Valley SRA Hydrology Condition Index at valley and zone scales.
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Upland	Slopes	Lowland
Hydrology Condition SR–HI	99	100	100	

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Table KWA 11: Kiewa Valley SRA
Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.
(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Headwater streams	Headwater streams		
			Upland	Slopes	Lowland
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**99 (31–100)**	**100**	**100**	
Sub-index	In-Channel Flow Regime	99 (31–100)	100	100	
Indicator	In-Channel Flow Regime A (volume and flow events)	99 (48–100)	100	99	
Sub-ind.	Flow Gross Volume	98 (78–100)	98	98	
Metric.	Mean Annual Flow	1.07 (0.68–1.19)	1.06	1.07	
Metric	Flow Duration	1.04 (0.79–1.21)	1.03	1.05	
Sub-ind.	High Flow Events	97 (43–100)	99	96	
Metric	High Flow	1.15 (0.73–1.84)	1.08	1.18	
Metric	High Flow Spells				
Sub-ind.	Low and Zero Flow Events	94 (57–99)	95	96	
Metric	Zero Flows Proportion	0.99 (0.96–1.00)	1.00	0.99	
Metric	Low Flow	1.12 (0.25–1.74)	1.09	1.15	
Metric	Low Flow Spells				
Indicator	In-Channel Flow Regime B (seasonality & variability)	98 (20–100)	100	98	
Sub-ind.	Flow Seasonality	92 (65–100)	97	90	
Metric.	Flow Seasonal Amplitude	1.19 (0.89–1.65)	1.10	1.24	
Metric	Flow Seasonal Period	0.97 (0.80–1.00)	0.99	0.98	
Sub-ind.	Flow Variability	95 (0–100)	100	96	
Metric	Flow Variation	0.95 (0.48–1.00)	1.00	0.96	
Sub-index	Over Bank Flow Regime	Not assessed			
Indicator	Over Bank Floods Low				
Metric	OB Flow Duration (ARI 1)				
Metric	OB Flow Spells (ARI 1)				
Indicator	Over Bank Floods High				
Metric	OB Flow Duration (ARI 8)				
Metric	OB Flow Spells (ARI 8)				

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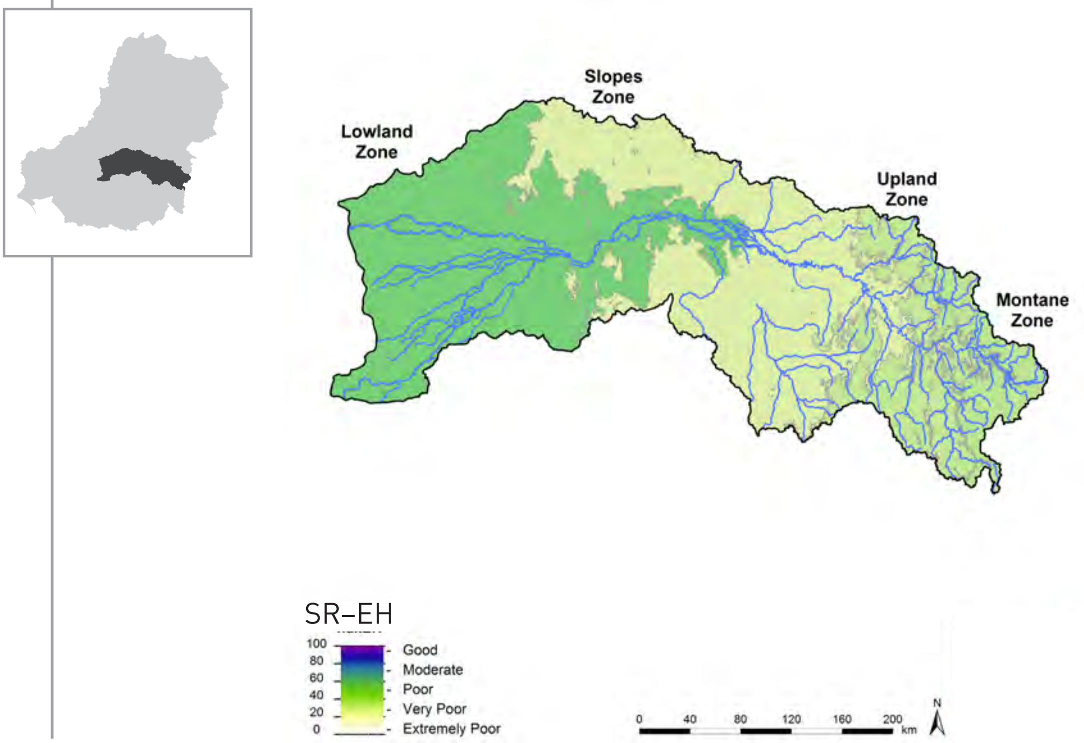

Figure LCH 1: Lachlan Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure LCH 1 shows the Ecosystem Health ratings for the Lachlan Valley and Tables LCH 1 and LCH 2 also show the Index values and ratings for each theme. Ecosystem Health shows a large difference from Reference Condition for the Lachlan Valley as a whole. The river system's Fish, Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Moderate and Poor conditions respectively, while Physical Form and Hydrology were in Good and Moderate condition respectively.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Lachlan Valley river system. River Ecosystem Health was rated as Very Poor (Lowland zone: Poor; Slopes zone: Very Poor; Upland zone: Very Poor; Montane zone: Very Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

Ecosystem Health

The Lachlan Valley ranked lowest amongst the 23 SRA valleys in terms of Ecosystem Health (see Table 5.2). It was in the lower 50% of valleys for all condition indices except for Physical Form for which it was equal eighth highest (with the Castlereagh and Murrumbidgee valleys). Of the biotic indices, it ranked 12th for the condition of Vegetation, equal 16th (with the Avoca) for Macroinvertebrates, and equal 21st (with the Broken) for Fish.

The Lachlan Valley river ecosystem was in Very Poor health. River Ecosystem Health for the zones was as follows: Montane, Upland and Slopes Very Poor; Lowland Poor. The Fish community was in Extremely Poor condition, many expected species were absent. The species count, biomass and abundance were dominated by alien species; and recruitment levels among the remaining native species were very low. The Macroinvertebrate community was in Moderate condition, with minor to moderate declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Poor condition overall, with reduced abundance and nativeness in the Near Riparian domain, but little change in the Lowland Floodplain. The Physical Form of the river system was in Good condition overall with channel form and bank dynamics in Good condition and bed dynamics in Moderate condition. There were high levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition, with mainstem river reaches characterised by substantial alteration relative to Reference Condition in low and zero flow events; and minor alteration in high over bank floods and flow seasonality.

Fish and macroinvertebrate sampling took place during continuing severe drought conditions. There was a significant decline in the condition of the fish community in the valley since SRA1 sampling and also in the Expectedness indicator, implying further loss of native species from SRA2 samples. Only one of the nine expected native species was captured in the Montane zone (with no evidence of recruitment) and even alien species appeared in low numbers. Macroinvertebrate communities appeared to be in better condition in all zones, with no significant decline since the previous sampling cycle.

The Lachlan supports extensive irrigated agriculture and flows are managed through in-stream storages in the upper catchment, off-stream storages, and weirs in-channel to support water diversions. As might be expected under these circumstances, Hydrological Condition was poorest in the Lowland zone and good in the upper catchment.

Whilst changes to the in-channel flow regime are significant in the Lowland, some components of the ecosystem, notably the fish community, are declining in condition throughout the valley. It is likely that this represents a response to extreme drought conditions in all zones, which even under Reference Condition might have resulted in loss of habitat diversity and disruption of in-channel connectivity (the existence of weir pools, and management efforts to supply water for human use, may actually provide refuge habitats for fish in lowland reaches during extended drought). Comparative response of these fish communities to more benign climatic conditions will be informative.

Fish Theme

The Fish Condition Index SR–FI = 7, indicating Extremely Poor condition (Lowland zone: Extremely Poor; Slopes zone: Extremely Poor; Upland zone: Extremely Poor; Montane zone: Extremely Poor). The Expectedness indicator = 9, indicating Extremely Poor condition and an extreme difference from Reference Condition. The Nativeness indicator = 41, indicating Poor condition and a large difference from Reference Condition. The Recruitment indicator = 21, indicating Very Poor condition and a very large difference from Reference Condition.

The valley had lost much of its native species richness and alien species contributed over 71% of fish biomass. Of the 18 native species expected to occur in the valley under Reference Condition, only six were captured. Native fish recruitment was also Extremely Poor in the Montane and Upland zones, and Very Poor in the Slopes and Lowland zones.

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Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 67, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate; Upland zone: Moderate; Montane zone: Moderate). The simOE metric = 46 indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Moderate or Good condition was high across all zones (66% overall), including eight of the 35 rated sites in Good condition.

Family richness generally was high, but was reduced compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 57, indicating Poor condition (Lowland zone: Good; Slopes zone: Very Poor; Upland zone: Very Poor; Montane zone: Very Poor). The Vegetation Abundance and Diversity indicator = 67, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 64, indicating Moderate condition and a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is little affected by clearing. The abundance, nativeness and degree of fragmentation of major vegetation groups in the sampled floodplain area was near Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 87, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good; Montane zone: Good). The Channel Form indicator = 84 and the Bank Dynamics indicator = 95, both indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 69, and the Floodplain Form indicator = 77, both indicating Moderate condition and showing a minor difference from Reference Condition.

Overall, the valley's riverine physical form was characterised by evidence of adjustments in channel size and channel simplification and in particular channel enlargement in the Slopes zone. Sediment loads to the Floodplain have also been elevated since European settlement.

Hydrology Theme

The Hydrology Condition Index SR–HI = 64, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Good; Montane zone: Good). The In-Channel Flow Regime indicator = 36, indicating Very Poor condition and a major difference from Reference Condition for the flow regime within the channels. The Over Bank Flow Regime sub-index = 95, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

The mainstem river reaches were generally characterised by substantial alteration in Low and Zero Flow Events relative to Reference Condition, minor alteration in High Over Bank Floods and Flow Seasonality and little or no alteration in Low Over Bank Floods, Flow Variability, High Flow Events and Flow Gross Volume. Headwater streams showed little or no alteration in any of these indicators.

Table LCH 1: Lachlan Valley Ecosystem Health and condition assessments.

Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	MONTANE	UPLAND	SLOPES	LOWLAND
		Very Poor	Very Poor	Very Poor	Very Poor	Poor
THEME		VALLEY	ZONE			
			MONTANE	UPLAND	SLOPES	LOWLAND
Fish	SCORE RATING	7 (5–10) Ext' Poor	9 (4–10) Ext' Poor	4 (1–8) Ext' Poor	2 (0–11) Ext' Poor	12 (7–16) Ext' Poor
Macro-invertebrates	SCORE RATING	67 (64–70) Moderate	71 (65–81) Moderate	78 (68–88) Moderate	66 (59–73) Moderate	62 (58–66) Moderate
Vegetation	SCORE RATING	57 Poor	27 Very Poor	34 Very Poor	22 Very Poor	100 Good

Table LCH 2: Lachlan Valley Physical Form and Hydrology condition assessments.

Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE			
			MONTANE	UPLAND	SLOPES	LOWLAND
Physical Form	SCORE RATING	87 (79–91) Good	93 (91–95) Good	85 (74–89) Good	80 (60–89) Good	91 (84–99) Good
Hydrology	SCORE RATING	64 Moderate	98 Good	99 Good	62 Moderate	46 Poor

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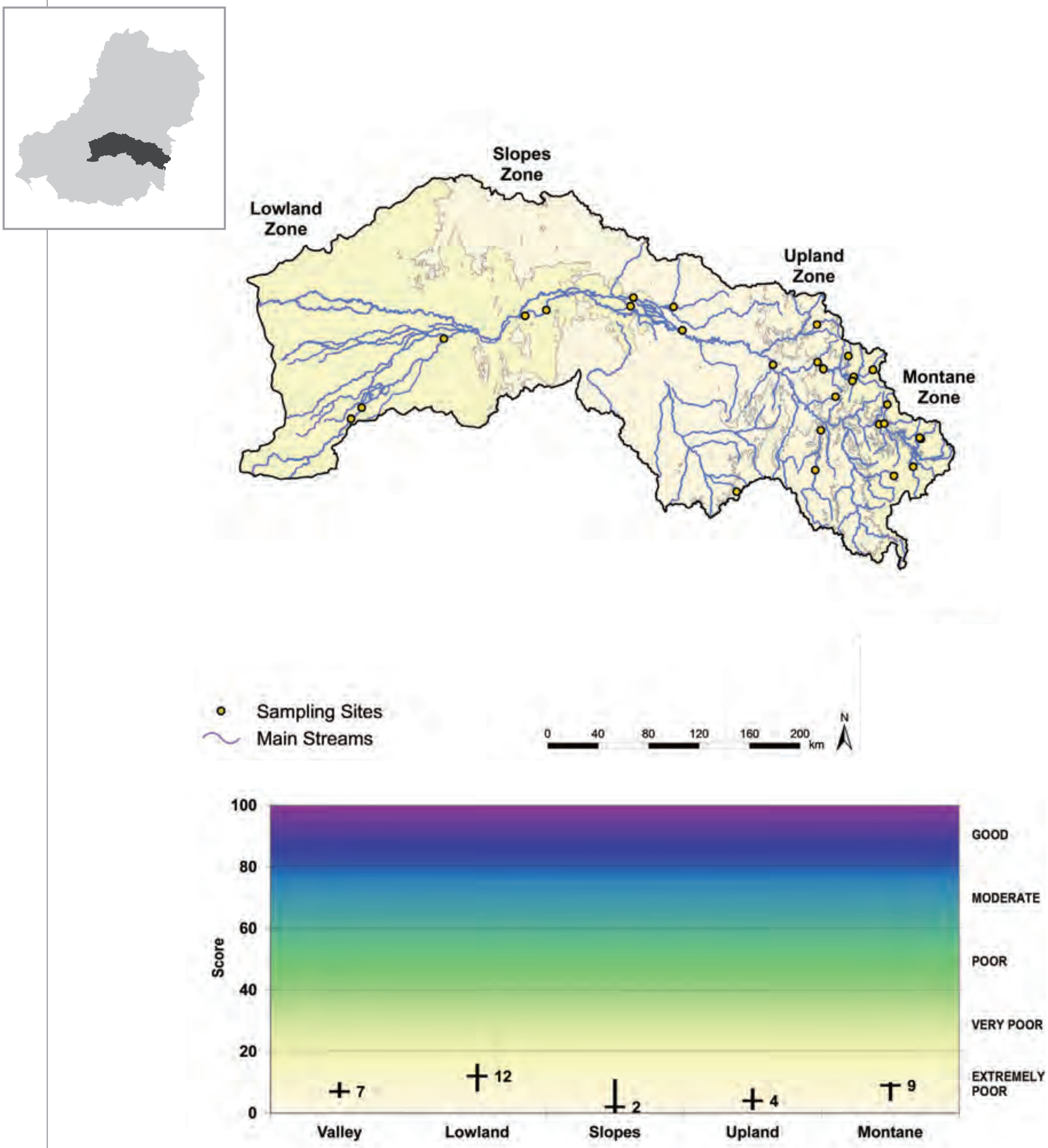

Figure LCH 2: Lachlan Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores (see key).

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Lachlan Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 7. The condition of the fish community in the Montane, Upland, Slopes and Lowland zones was Extremely Poor. The fish community was characterised by an Extremely Poor score for expected native fish species, a Poor score for nativeness and a Very Poor score for native fish recruitment. The Montane zone in particular had only one native species present, lacking almost 89% of the predicted native species. The valley had lost much of its native species richness and alien species contributed over 71% of the biomass in samples. Native fish recruitment was Extremely Poor in the Montane and Upland zones, and Very Poor in the Slopes and Lowland zones.

Twenty-eight sites were surveyed across the Lachlan Valley in January–April 2009, yielding 1,474 fish. Analyses showed an extreme difference from Reference Condition for the Lachlan Valley, with:

- SRA Fish Index (SR–FI) = 7 (CL 5–10), indicating Extremely Poor condition of the fish community.
- The Expectedness indicator = 9 (CL 6–11), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Only 33% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 41 (CL 31–52), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 21 (CL 13–29), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for 2 of the 6 native species observed in the valley.

Figure LCH 2 shows sampling sites, zones and corresponding SR–FI values, and Table LCH 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Lachlan Valley was the second lowest of all valleys in the Basin, and close to that for the Mitta Mitta and Broken valleys. The fish community was in Extremely Poor condition in all four zones with SR–FI values of 9, 4, 2, and 12 for the Montane, Upland, Slopes, and Lowland zones respectively.

Expectedness was rated as Extremely Poor at the valley scale and in each of the zones. The Lachlan River Slopes and Montane zones were the two lowest ranked zones of all 68 zones sampled in the Basin. Of the 18 native species that were expected to occur in some part of the Lachlan Valley under Reference Condition, only six were captured at any of the 28 sampling sites. The percentage of expected species caught in the Montane, Upland, Slopes, and Lowland zones was 11%, 31%, 17%, and 29% respectively.

Nativeness was Very Poor in the Slopes zone and Poor in the Upland and Lowland zones. By contrast, the Montane zone scored a moderate rating for Nativeness, not so much for the quality of its native fish community but because there were also very few alien fish (2.4 per site) and mostly of low biomass.

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The Lachlan had the fifth lowest biomass of fish per site of the 23 SRA valleys (4.3 kg/site). Of this, 71% was contributed by alien species, which were numerically inferior to the native fish by a factor of nearly 2:1. Most native fish caught were small-bodied species. The 15 golden perch caught weighed an average of 1.2 kg but the 24 Murray cod averaged 632g in weight reflecting the presence of seven recruits amongst them. No other native species weighed more than 60 g per fish. Alien species caught in the Lachlan Valley, with the potential to grow to a considerable size included common carp, brown trout, rainbow trout, and redfin perch. However, common carp weighed an average of 413 g, due in part to the presence of 66 recruits in the total of 178 individuals. Brown trout, rainbow trout and redfin perch averaged only 117 g, 83 g, and 17 g respectively.

Table LCH 4 shows native species abundances in the Lachlan Valley compared with Reference Condition. Golden perch was found in each of the three zones in which it was expected to occur and Murray cod was caught in the lower two zones. Freshwater catfish was predicted to occur in all four zones but was not caught throughout the valley. Macquarie perch, river blackfish, silver perch, and trout cod were predicted to be present in three of the four zones but were not caught in any samples.

Recruitment was Very Poor in the Lachlan Valley and rated as Extremely Poor in the Montane and Upland zones. There was no native recruitment in the Montane zone and only one of the four native species populations in the Upland zone included recruits. Bony herring, golden perch, and mountain galaxias showed no evidence of recruiting; nor did goldfish amongst the alien species. Common carp populations (in the three zones in which the species was caught) were made up of 37% recruits from nine of the 15 sites in which the species occurred.

In general, the fish community of the Lachlan had reduced numbers of expected native species. Numbers and biomass of fish, including alien species, were low relative to other parts of the Murray–Darling Basin.

Table LCH 3: Lachlan Valley: SRA Fish Condition Index, indicators, metrics and derived variables.
Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower– upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Fish Condition (SR–FI)	7 (5–10)	9 (4–10)	4 (1–8)	2 (0–11)	12 (7–16)
Indicator	Expectedness	9 (6–11)	2 (1–3)	10 (8–12)	1 (1–2)	16 (10–21)
Metric	O/E	0.20 (0.16–0.24)	0.22 (0.15–0.26)	0.18 (0.14–0.22)	0.09 (0.03–0.14)	0.29 (0.21–0.37)
Metric	O/P (zone level)	0.24 (0.24–0.24)	0.11 (0.11–0.11)	0.31 (0.31–0.31)	0.17 (0.17–0.17)	0.29 (0.29–0.29)

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Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Indicator	Nativeness	41 (31–52)	71 (48–92)	44 (20–64)	20 (3–45)	50 (35–65)
Metric	Proportion biomass native	0.31 (0.18–0.45)	0.55 (0.24–0.80)	0.33 (0.05–0.61)	0.18 (0.02–0.46)	0.36 (0.15–0.56)
Metric	Proportion abundance native	0.49 (0.36–0.62)	0.74 (0.46–0.98)	0.38 (0.14–0.69)	0.36 (0.09–0.65)	0.58 (0.41–0.76)
Metric	Proportion species native	0.44 (0.35–0.54)	0.60 (0.31–0.86)	0.53 (0.37–0.71)	0.30 (0.07–0.57)	0.48 (0.39–0.54)
Indicator	Recruitment	21 (13–29)	0 (0–0)	3 (0–11)	23 (5–45)	32 (18–40)
Metric	Proportion of sites with native recruits	0.31 (0.20–0.37)	0 (0–0)	0.10 (0–0.20)	0.27 (0.07–0.47)	0.50 (0.27–0.50)
Metric	Proportion of native taxa with recruits	0.46 (0.36–0.62)	0 (0–0)	0.25 (0–0.50)	0.67 (0.33–1.00)	0.50 (0.50–0.67)
Metric	Proportion of abundance as recruits	0.34 (0.25–0.51)	0 (0–0)	0.25 (0–0.50)	0.50 (0.33–1.00)	0.32 (0.26–0.44)
Variables						
	Number of sites sampled	28	7	7	7	7
	Total number of species	12	5	9	6	7
	Number of native species	6	1	4	3	4
	Number of predicted species	18	9	13	18	14
	Number of alien species	6	4	5	3	3
	Mean number of fish per site	53	55	55	43	58
	Biomass/site all species (g)	4307	219	4159	3035	9816
	Mean native biomass/fish (g)	36	2	13	24	88
	Mean alien biomass/fish (g)	171	50	103	126	502

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Table LCH 4: Lachlan Valley: number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Sites sampled	28	7	7	7	7
Native species					
Australian smelt	0		0	0	0
Bony herring	5			0	5
Flathead gudgeon	1		1	0	0
Freshwater catfish	0	0	0	0	0
Golden perch	15		2	1	12
Gudgeon	541	0	98	159	284
Macquarie perch	0	0	0	0	
Mountain galaxias	386	369	17	0	
Murray cod	24	0	0	2	22
Murray jollytail	0			0	0
Murray–Darling rainbowfish	0			0	0
Olive perchlet	0			0	0

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Fish species	Valley	Zone			
		Montane	Upland	Slopes	Lowland
River blackfish	0	0	0	0	
Silver perch	0		0	0	0
Southern purple-spotted gudgeon	0	0	0	0	0
Southern pygmy perch	0	0	0	0	0
Trout cod	0	0	0	0	
Unspecked hardyhead	0			0	0
Alien species					
Brown trout	1	1			
Common carp	178		72	63	43
Gambusia	275	6	179	69	21
Goldfish	35		14	5	16
Rainbow trout	10	9	1		
Redfin perch	3	1	2		

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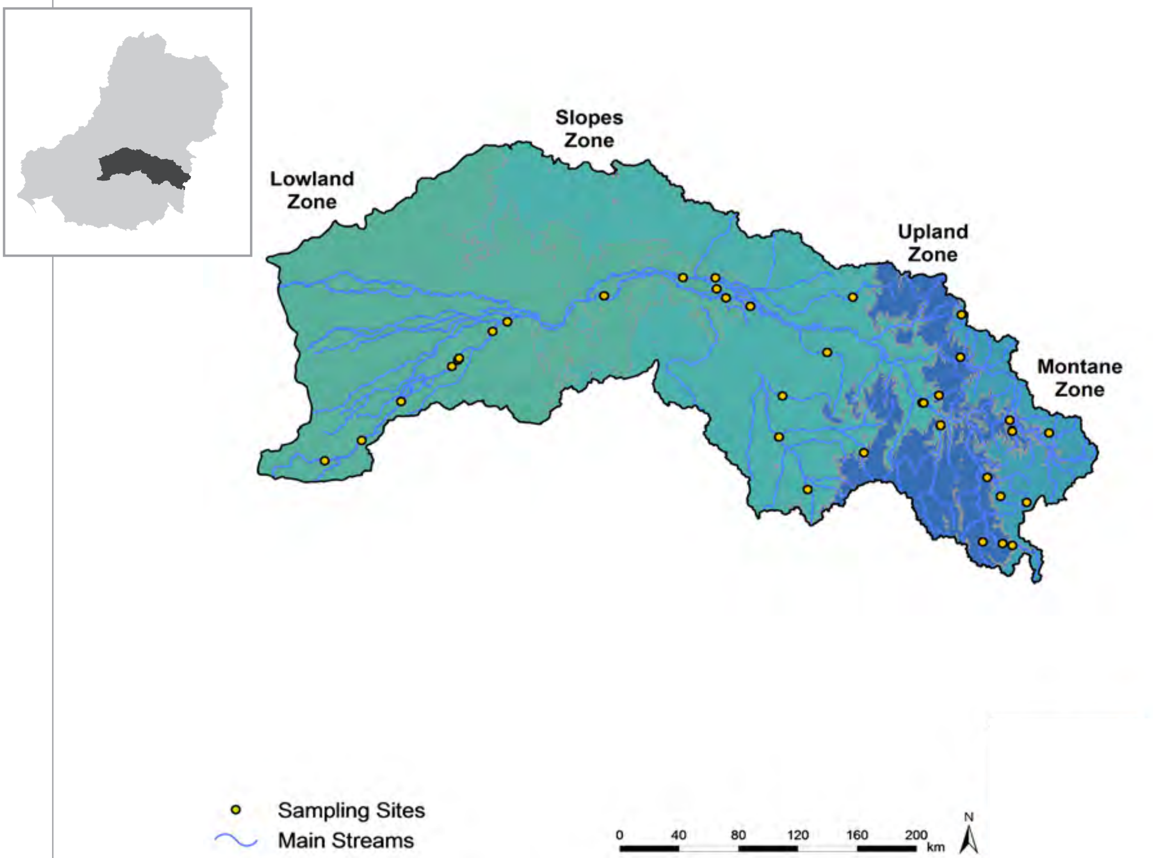

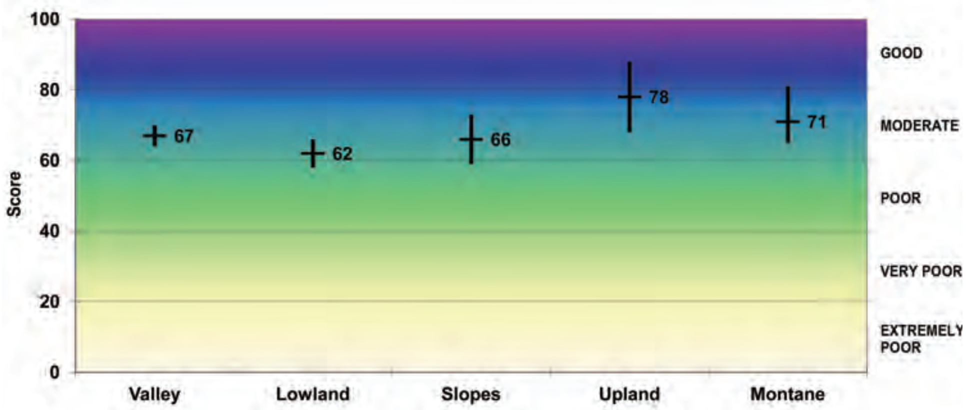

Figure LCH 3: Lachlan Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.

Graph shows mean SR–MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Lachlan Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 67. The condition of the macroinvertebrate community in the zones was as follows: Montane Moderate; Upland Moderate; Slopes Moderate; Lowland Moderate.

The proportion of sites in Moderate or Good condition was high across all zones (66%), with seven sites (20%) in Good condition. Family richness generally was high, but was reduced compared to Reference Condition.

Thirty-five sites were surveyed across the Lachlan Valley in September–October 2008 yielding 6,923 macroinvertebrates in 63 families (67% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 67 (CL 64–70), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 46 (CL 45–48) indicating a moderate difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate or Good condition was high across all zones (66% overall), including seven of the 35 rated sites (20%) in Good condition (four of which were in the Upland zone).
- The number of families found was lowest in the Slopes zone (39 families) and highest in the Upland and Montane zones (47 and 46), and the Montane zone had the highest average number of families per site (37).

Figure LCH 3 shows sampling sites, zones and SR–MI values, and Table LCH 5 shows Index and metric values. The SR–MI score for the Lachlan Valley indicated Moderate condition of macroinvertebrate communities, rating 17th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of all four zones showed moderate differences from Reference Condition (SR–MI = 62–78), with the Lowland zone rating poorest (SR–MI = 62) with most (54%) of its sites falling just below Moderate condition (and thus rated as Poor). A wide confidence interval (20 points) for the Upland zone SR–MI value indicates more spatial variability there. Most sites (66%) had no or a moderate difference from Reference Condition. Expectedness (simOE) was generally moderate and only varied by up to 13 points among sites.

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Table LCH 6 shows that most sites in both zones had Moderate to Good condition SR–MI values, with seven sites rated in Good condition. Only one site had a low simOE score (<40 points). Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

Family richness generally was reduced compared to Reference Condition. Diversity was high (average 27 families per site), with the Montane zone being most diverse at site scale (average 37 families per site). The valley contained 67% of the families found across the Basin (Table LCH.10), with the Slopes and Lowland zones having the lowest representation of Basin-wide fauna (41 and 43% respectively). Most (73–75%) of the fauna of the valley was found in each of the Montane and Upland zones.

Table LCH 5: Lachlan Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	67 (64–70)	71 (65–81)	78 (68–88)	66 (59–73)	62 (58–66)
Metric	SimOE	46 (45–48)	48 (45–52)	52 (47–56)	46 (43–49)	44 (43–46)

Table LCH 6: Lachlan Valley: Distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Sites					
Number of sites sampled	35	4	7	11	13
Number of sites with index values*	35	4	7	11	13
N sites by SR–MI condition band					
Good (80–100)	7	1	4	2	
Moderate (60–80)	16	3	2	5	6
Poor (40–60)	12		1	4	7
Very or Extremely Poor (0–40)					
Families					
Number of families sampled	63	46	47	39	40
No. families/site (min–max)	27 (10–43)	37 (29–43)	30 (21–40)	19 (10–29)	29 (22–33)
Percent of families in Basin	67	49	50	41	43
Percent of families in valley	100	73	75	62	63

*simOE values could occasionally not be derived for every sample site.

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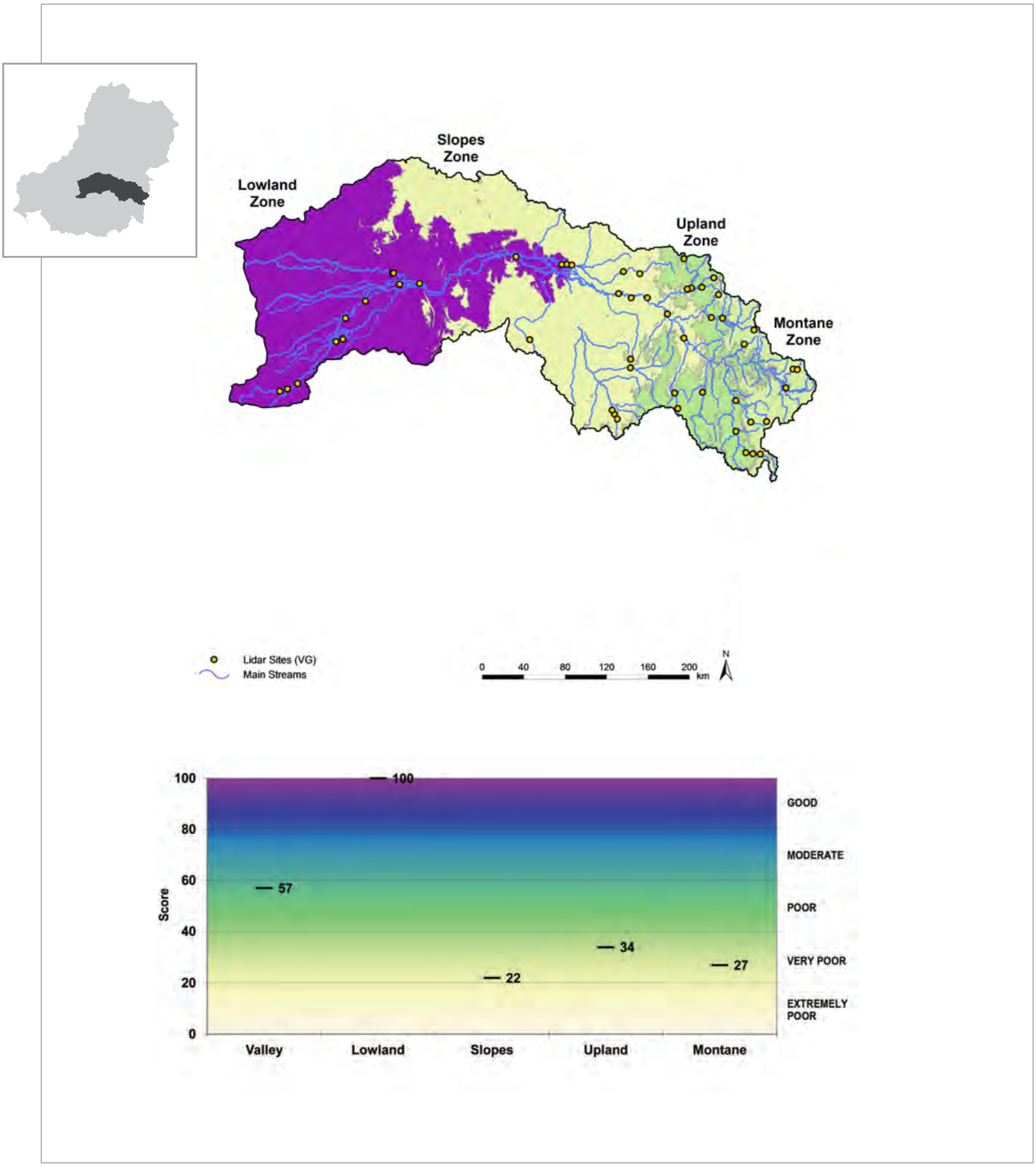

Figure LCH 4: Lachlan Valley zone: map with LiDAR sites and zones coloured by SRA Vegetation Index scores (see key).

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Lachlan Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 57. Overall condition for the four zones in this valley was: Montane Very Poor; Upland Very Poor; Slopes Very Poor; Lowland Good.

The Abundance and Diversity indicator score was 67 for the valley, indicating a Moderate rating overall. In the four zones it was: Montane Poor; Upland Poor; Slopes Very Poor; Lowland Good.

The Quality and Integrity indicator score was 64 for the valley, indicating a Moderate rating overall. In the four zones it was: Montane Poor; Upland Poor; Slopes Very Poor; Lowland Good.

The SRA Vegetation assessment for the Lachlan Valley considers riverine vegetation in two spatial domains: Near Riparian, along 8,075 km of stream, and Lowland Floodplain, for 3,443 km^2 of flooding land which is part of the floodplain in the Lowland zone. Much (42%) of the stream length is in the Lowland zone, and the length of stream assessed per zone is as follows: Montane 708 km; Upland 1,426 km; Slopes 2,543 km; and Lowland 3,398 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 52 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream network amongst the four zones as follows: Montane six sites; Upland 12 sites; Slopes 19 sites; and Lowland 15 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure LCH 4 shows values of the Vegetation Index (SR–VI) for the Lachlan Valley and Table LCH 7 shows the Index, indicator and sub-indicator values. Tables LCH 8 and LCH 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed a large difference from Reference Condition for the Lachlan Valley with:

- SRA Vegetation Index (SR–VI) = 57, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 67, indicating a moderate difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain areas.
- The Vegetation Quality and Integrity indicator = 64, indicating a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near reference.

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with MVGs showing a large difference from Reference Condition in the Montane and Uplands zones, a very large difference from reference in the Slopes zone, and near reference for the Lowland zone. The moderate rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of major vegetation groups as given in NVIS 3.0. Valley-wide abundance shows a large difference from reference in the Near Riparian domain, and near reference in the Lowland Floodplain domain. MVG richness is near Reference Condition in both Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 92% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, and shows a large difference from reference in the Montane and Upland zones, a very large difference from reference in the Slopes zone and is near reference in the Lowland zone. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table LCH 8 as well as other native but non-specific MVGs. Valley-wide Nativeness shows a large difference from reference in the Near Riparian domain, and is near reference in the Lowland Floodplain domain. The degree of MVG Fragmentation in the Lowland Floodplain domain is near reference.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall. The metrics show the loss of one MVG from the Near Riparian domain in the Montane zone, but no loss of any MVG from the Near Riparian domain in the Upland, Slopes and Lowland zones; and no loss of any MVG from the Lowland Floodplain domain, when mapped at this scale.

Abundance

- The Abundance of MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show differences between zones and domains. Abundance in the Near Riparian domain shows a very large difference from reference in the Montane zone, a large difference in the Upland zone, a very large difference in the Slopes zone, and near reference in the Lowland zone; and in the Lowland Floodplain, abundance is near reference.

Stability

- Floodplain areas in the Lowland Floodplain domain are in Good condition, with little evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Good condition overall, and the metrics show differences between zones and domains. Nativeness in the Near Riparian domain shows a very large difference from reference in the Montane zone, a large difference in the Upland zone, a very large difference in the Slopes zone, and is near reference in the Lowland zone; and in the Lowland Floodplain domain, nativeness is near reference.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall, with differences between zones. Structure is near reference in the Montane zone, and is moderately different from reference in the Upland and Slopes zones, but Poor in the Lowland zone. Structure refers only to the height of the upper canopy of individual patches of woody vegetation types near the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of MVGs is in Good condition, with MVGs being near reference.

Under Reference Conditions, the riverine vegetation in the Lachlan Valley was characterised as follows:

- Montane zone: The Near Riparian domain was mostly Eucalypt Open Forests (63% of domain area) with Eucalypt Woodlands (30%), with three other MVGs, none as much as 5%.
- Upland zone: The Near Riparian domain was mostly Eucalypt Woodlands (60% of the domain) with Eucalypt Open Forests (37%): one other MVG was also present but this was not as much as 5% of the domain.
- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (84% of the domain) and Eucalypt Open Forests (12%); with five other MVGs, none covering as much as 5% of the domain.
- Lowland zone: The Near Riparian domain was a mix of Eucalypt Woodlands (35% of the domain), Eucalypt Open Forests (22%) and Other Shrublands (27%). Two of the other six MVGs present covered at least 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was a mix of Other Shrublands (32% of the domain) and Eucalypt Woodlands (27%), with nine other MVGs of which three were more than 5% of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been substantially reduced in all domains. The effect on individual MVGs is quite variable and varies between zones.

- Montane zone: In the Near Riparian domain, Eucalypt Open Forests are reduced (15% of the domain area) and Eucalypt Woodlands to 18% but is now the most extensive MVG. About 62% is cleared or non-native vegetation. All MVGs are affected and two MVGs most proportionally affected are Grasslands, Herblands, Sedgelands and Rushlands (reduced to 0% of its reference area) and Eucalypt Tall Open Forests (reduced to 10%), while the two most affected in absolute area loss are Eucalypt Open Forest and Eucalypt Woodlands.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands and Eucalypt Open Forests are considerably reduced and now cover 22% and 14% of the domain. About 58% is cleared or non-native vegetation. The effect on MVGs is variable, with two showing little effect: the greatest proportional changes are for Eucalypt Woodlands and Eucalypt Open Forests, reduced to 37% and 39% of their reference area.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands and Eucalypt Open Forests are considerably reduced and now cover 17% and 9% of the domain. About 65% is cleared or non-native vegetation. The effect is variable across MVGs, with five being unaffected, and Eucalypt Woodlands showing the greatest proportional reduction, to 21% of its reference area.

- Lowland zone: In the Near Riparian domain, although Eucalypt Woodlands is reduced, the characteristic mix of Eucalypt Woodlands (26% of the domain area), Eucalypt Open Forests (22%) and Other Shrublands (27%) is still present. About 10% is cleared or non-native vegetation with a variable effect on MVGs. Several are unaffected, and the most proportionally affected is Callitris Forests and Woodlands, reduced to 16% of its reference area, while Eucalypt Woodlands shows the greatest absolute area reduction.

- Lowland zone: Eucalypt Woodlands are reduced in area relative to Reference Condition, but the mix of MVGs is retained. About 7% is cleared or non-native vegetation. The most proportional decline is Callitris Forests and Woodlands, from 1.4% under Reference Conditions to 0.7%, while the reduction in area of Other Shrublands is also significant.

Unlike the other themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping may range from 1997 to 2004, whereas the LiDAR was flown in January–February 2010. This means that the Structure sub-indicator and three metrics (abundance, richness and nativeness) are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

Most of the metrics are based on vegetation mapping, which is not current and can be variable quality. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the zones and of valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Lachlan Valley is notable for the Poor condition of the Slopes zone, and the change in the condition of the Near Riparian domain down the valley.

Riverine vegetation in the Lowland zone is rated as near reference and is in better condition than in the other three zones, which are all in Very Poor condition. The Lowland zone has near reference scores for all metrics except the Structure sub-indicator which rates as moderate and is variable, indicative of patchy clearing. The Lowland zone is the zone with most influence on the zone score. Within the Lowland zone, the Near Riparian and Lowland Floodplain domains are in similar condition, with all mapping metrics in near Reference Condition. These two domains assess differing parts of the Lowland zone: the Lowland Floodplain domain is land that floods beside major channels and between major distributaries, whereas the Near Riparian domain is centred on all channels, and covers a smaller area.

The condition of riverine vegetation in the Near Riparian domain in the other three zones is in marked contrast to the Near Riparian domain in the Lowland zone. Nativeness and abundance scores are Poor to Very Poor, indicative of substantial clearing. In the Montane zone, one MVG (Other Grasslands, Herblands, Sedgelands and Rushlands) has been completely lost.

Table LCH 7: Lachlan Valley: SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only |zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Vegetation Condition (SR–VI)	57	27	34	22	100
Indicator	Abundance and diversity	67	42	50	38	100
Metric	LF stability	0.92				0.92
Sub-ind.	NRLF richness	100				100
Metric	NR richness	0.98	0.80	1	1	1
Metric	LF richness	1				1
Sub-ind.	NRLF abundance	100				100
Metric	NR abundance	0.58	0.35	0.40	0.30	0.90
Metric	LF abundance	0.92				0.92
Indicator	Quality and integrity	64	46	50	39	92
Sub-ind.	NRLF nativeness	100				100
Metric	NR nativeness	0.58	0.37	0.42	0.31	0.90
Metric	LF nativeness	0.92				0.92
Sub-ind.	NR structure	72 (64–79)	91 (85–96)	75 (60–85)	79 (72–85)	61 (44–76)
Sub-ind.	LF fragmentation	97				97

Table LCH 8: The most abundant MVGs in the Near Riparian domain in the Lachlan Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

Major Vegetation Groups	Zone			
	Montane	Upland	Slopes	Lowland
MVG				
3. Eucalypt Open Forests	63	37	12	22
5. Eucalypt Woodlands	30	60	84	35
17. Other Shrublands				27
19. Tussock Grasslands	4	4		7
22. Chenopod Shrublands, Samphire Shrublands and Forblands				6

Table LCH 9: Most abundant MVGs in the Lowland Floodplain domain in the Lachlan Valley.

Showing percentage of domain area under Reference Condition and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
3. Eucalypt Open Forests	13	1	1
5. Eucalypt Woodlands	27	0.81	0.94
17. Other Shrublands	32	1	1
19. Tussock Grasslands	10	1	1
22. Chenopod Shrublands, Samphire Shrublands and Forblands	11	0.91	1.06

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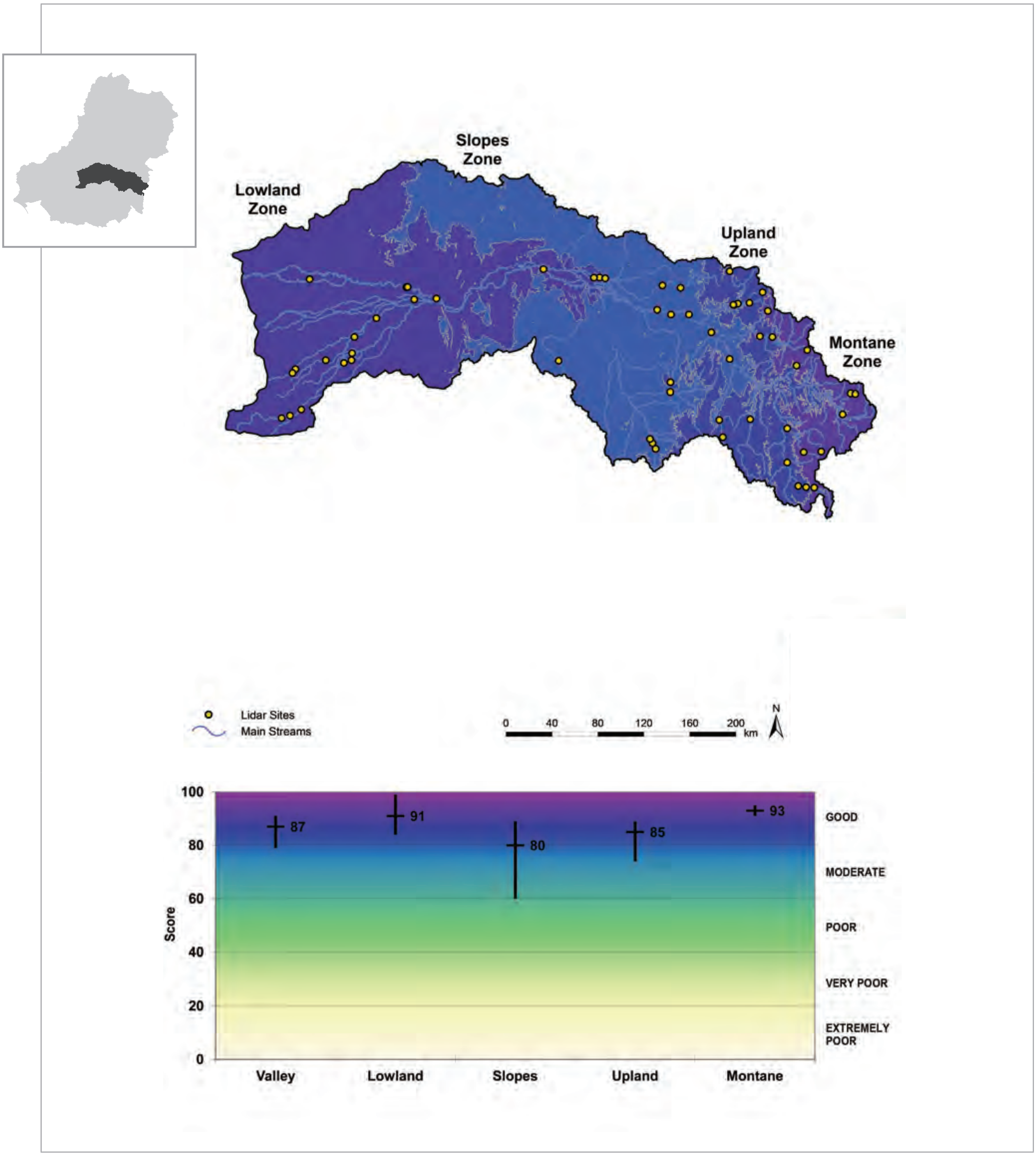

Figure LCH 5: Lachlan Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores (see key).

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Lachlan Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 87. The condition of Physical Form in the zones was: Montane, Upland, Slopes and Lowland Good. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics and Floodplain Dynamics were rated as Moderate. Overall, the valley's riverine physical form was characterised by evidence of adjustments in channel size and channel simplification and in particular channel enlargement in the Slopes zone. Sediment loads to the floodplain have also been elevated since European settlement.

The SRA Physical Form assessment considers physical form and processes along 8,075 km of stream across the valley. It is based on LiDAR data collected at 57 sites along river channels, as well as modelling of all 726 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment integrates four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure LCH 5 shows values of the Physical Form Index (SR–PI) for the Lachlan Valley and Table LCH 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a near Reference Condition for the Lachlan Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 87 (CL 79–91), indicating Good Physical Form condition
- the Channel Form indicator = 84 (CL 78–89), showing near Reference Condition
- the Bed Dynamics indicator = 69 (CL 68–71), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 95 (CL 91–97), showing near Reference Condition
- the Floodplain indicator = 77 (CL 73–81), showing a moderate difference from Reference Condition.

Montane zone

There were six LiDAR survey sites and 35 SedNet river segments in the Montane zone of the Lachlan Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Montane zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Depth was modified from reference for approximately half of the Montane zone. At these sites Channel Depth was generally reduced. Channel Width, Channel Width Variability, Sinuosity, Meander Wavelength, Bank Variability and Channel Sediment Deposition were largely unmodified from reference in the Montane zone.

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Upland zone

There were 12 LiDAR survey sites and 123 SedNet river segments in the Upland zone of the Lachlan Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width, Channel Depth and Channel Width Variability were modified from reference for approximately half of the Upland zone. At these sites Channel Width and Depth was generally increased (a few sites having large increases in Channel Width) and Channel Width Variability was generally reduced. Meander Wavelength and Bank Variability were modified from reference for less than half of the Upland zone. At these sites Meander Wavelength was generally increased (a few sites having large increases) and Bank Variability was generally reduced indicating enhanced bank stability. Sinuosity and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

Slopes zone

There were 19 LiDAR survey sites and 327 SedNet river segments in the Slopes zone of the Lachlan Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Depth was modified from reference in more than half of the Slopes zone. At these sites Channel Depth was generally increased (many sites having large increases). Channel Width, Channel Width Variability and Bank Variability were modified from reference for approximately half of the Slopes zone. At these sites Channel Width was generally increased and both Channel Width Variability and Bank Variability were generally reduced. Sinuosity, Meander Wavelength and Channel Sediment Deposition were modified from reference for less than half of the Slopes zone. At these sites Sinuosity and Meander Wavelength were generally increased (a few sites having large increases in Meander Wavelength) and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period.

Lowland zone

There were 20 LiDAR survey sites and 241 SedNet river segments in the Lowland zone of the Lachlan Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Depth was modified from Reference Condition in more than half of the Lowland zone. At these sites results show both increases and decreases in Channel Depth across the zone. Channel Width, Channel Width Variability and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites Channel Width and Channel Width Variability were generally reduced and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Sinuosity and Bank Variability were modified from reference for less than half of the Lowland zone. At these sites Sinuosity was generally increased (many sites having large increases) and Bank Variability was generally reduced indicating enhanced bank stability. Meander Wavelength was largely unmodified from reference in the Lowland zone.

Channel Form

There was little change from Reference Condition in Channel Form in the Montane zone. There was widespread evidence of changes in channel size but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Upland zone. There was widespread evidence of channel enlargement and channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Slopes zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 70% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

There was little change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was changes in channel size. There was evidence of both channel enlargement and contraction across this zone. An enlarged channel was indicated at 40% of sites as a result of channel widening and bed degradation. Channel contraction was indicated at 50% of sites as a result of channel narrowing and bed aggradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale.

Channel and Floodplain Dynamics

There was no change from Reference Condition in Bank Dynamics in the Montane zone. There was little change from Reference Condition in Bank Dynamics in the Upland, Slopes and Lowland zones.

There was minor change from Reference Condition in Bed Dynamics in the Montane, Upland, Slopes and Lowland zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There is also widespread sedimentation in the Lowland zone (50% of the SedNet river segments). In the Lowland zone, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. Local knowledge is required to resolve these conflicting results.

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was minor change from Reference Condition in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (100% of SedNet river segments). There was little change from reference in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

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Table LCH 10: Lachlan Valley: SRA Physical Form Condition Index, indicators, metrics and derived variables.

(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Index	Physical Form Condition (SR-PI)	87 (79–91)	93 (91–95)	85 (74–89)	80 (60–89)	91 (84–99)
Indicator	Channel Form (volume and flow events)	84 (78–89)	97 (92–100)	85 (74–96)	84 (71–94)	80 (72–90)
Sub-ind.	Cross-section Form	81 (76–85)	90 (77–98)	86 (77–93)	77 (67–87)	79 (71–88)
Metric	Channel Depth (mean)	1.14 (1.05–1.25)	0.91 (0.78–1.00)	1.14 |(1.01–1.27)	1.32 (1.14–1.51)	1.06 (0.88–1.25)
Metric	Channel Width (mean)	1.03 (0.99–1.08)	1.00 (0.89–1.12)	1.17 (1.07–1.33)	1.05 (0.99–1.14)	0.95 (0.91–0.99)
Sub-ind.	Cross-section Form (variability)	86 (78–91)	99 (98–100)	84 (68–95)	85 (68–95)	84 (74–93)
Metric	Channel Width (CV)	0.90 (0.86–0.93)	0.98 (0.95–1.00)	0.90 (0.80–0.97)	0.89 (0.80–0.95)	0.89 (0.82–0.94)
Sub-ind.	Channel Planform	92 (87–96)	99 (98–99)	92 (80–99)	93 (84–97)	90 (81–96)
Metric	Sinuosity	1.07 (1.03–1.12)	1.00 (1.00–1.00)	1.04 (1.00–1.11)	1.03 (1.01–1.06)	1.13 (1.03–1.24)
Metric	Meander Wavelength	1.02 (1.00–1.05)	0.98 (0.95–1.00)	1.04 (1.00–1.10)	1.02 (0.98–1.06)	1.03 (1.00–1.08)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone			
			Montane	Upland	Slopes	Lowland
Indicator	Bed Dynamics	69 (68–71)	70 (68–72)	63 (59–67)	63 (61–66)	76 (74–79)
Metric	Channel Sediment Ratio	67 (59–76)	52 (41–62)	99 (84–113)	84 (69–99)	43 (27–59)
Metric	Channel Sediment Depth	0.002 (0.001–0.003)	0.0004 (0–0.001)	0.003 (0.001–0.007)	0.003 (0.002–0.004)	0.001 (0.001–0.001)
Indicator	Bank Dynamics	95 (91–97)	100 (100–100)	99 (99–100)	85 (76–93)	99 (97–100)
Metric	Bank Variability (longitudinal)	0.95 (0.93–(0.97)	1.00 (1.00–1.00)	0.99 (0.97–1.02)	0.89 (0.82–0.94)	0.98 (0.96–1.00)
Indicator	Floodplain	77 (73–81)	82 (75–88)	65 (56–72)	75 (69–81)	82 (76–89)
Metric	Floodplain Sediment Deposition	3.00 (1.87–4.00)	1.46 (1.19–1.76)	2.00 (1.89–3.00)	4.00 (2.00–7.00)	1.75 (1.06–3.00)

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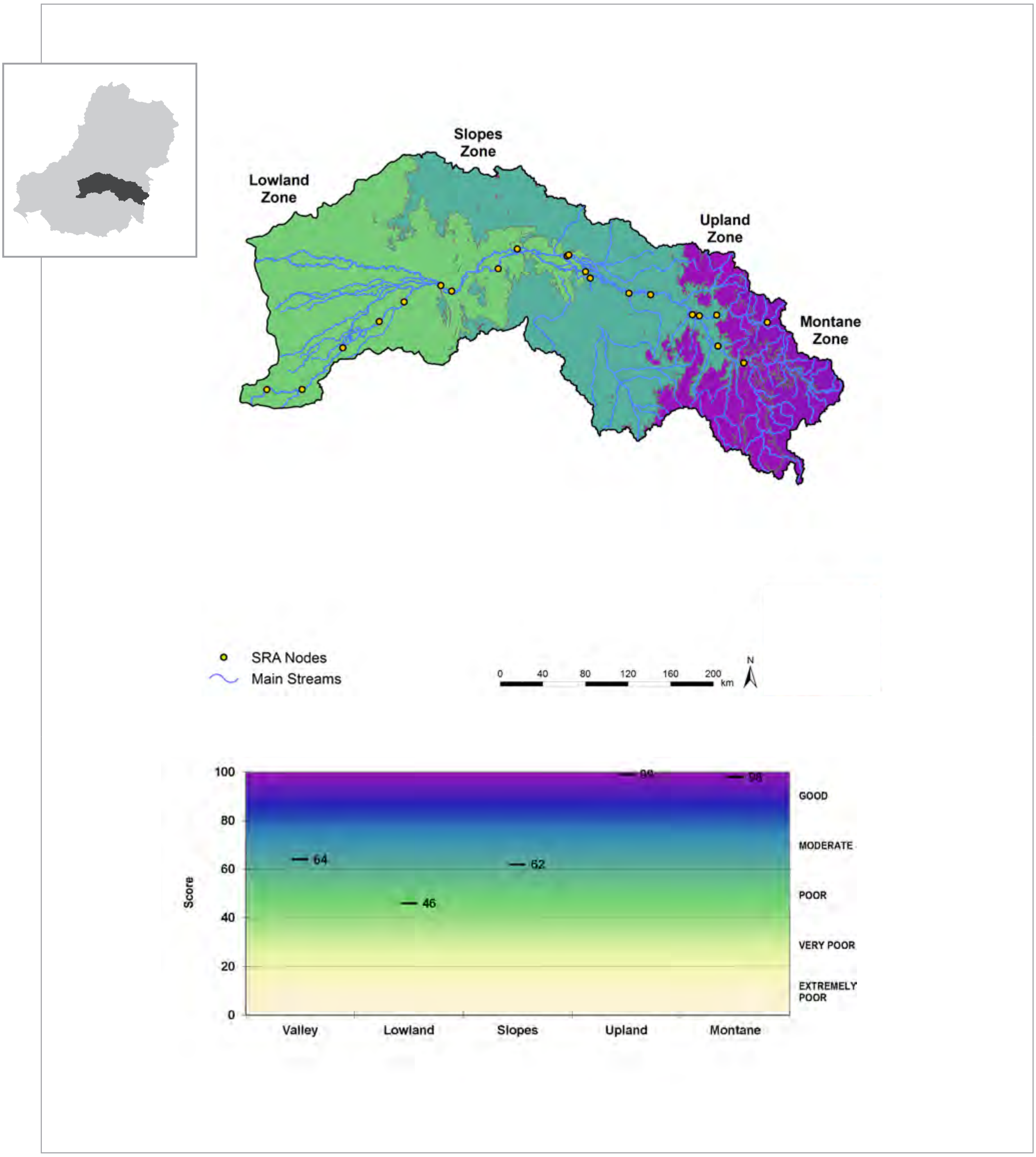

Figure LCH 6: Lachlan Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Lachlan Valley river system was in Moderate condition, with an aggregate Hydrology Index (SR–HI) score of 64. The Upland and Montane zones were in Good condition, the Slopes zone in Moderate condition and the Lowland zone in Poor condition.

The mainstem river system was in Poor condition. Throughout most of the mainstem river system the duration and frequency of high flow spells and low flow spells were reduced, the magnitude of low flows was increased, timing of seasonal flow variations was altered, inter-flood durations for low and high over bank flows were increased, and the duration of high over bank flows was altered. Throughout much of the mainstem river system high flows and the amplitude of seasonal flow variations was reduced. Throughout some of the mainstem river system monthly flow variation was altered.

The headwater streams were generally characterised by little or no alteration in flow variability, flow seasonality, low and zero flow events, high flow events and flow gross volume.

The Lachlan River rises in the foothills of the Great Dividing Range near Gunning and arcs westward, fed by foothill tributaries, terminating in the Great Cumbung Swamp. The main instream storage is Wyangala Dam (1,218 GL), at the junction of the Lachlan and Abercrombie rivers. In addition there is Carcoar Dam (36 GL) on the Belubula River, two offstream storages (Lake Brewster: 153 GL; Lake Cargelligo: 36 GL) and numerous on-farm storages. There is significant irrigation development between Forbes and Condobolin, and in the vicinity of Hillston.

In the Lachlan Valley, hydrological condition is assessed using metrics of hydrological alteration available for 11,085 km of mainstem rivers and headwater streams. There are 1,139 km of mainstem river extending across the Lowland, Slopes and Upland zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily water resource modelling. In the Lachlan Valley there is 9,946 km of headwater stream (Montane zone: 1,037 km; Upland zone: 2,097 km; Slopes zone: 5,468 km; Lowland zone: 1,345 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Lachlan Valley there is 6,884 km of these mid-size tributaries (171 km in the Montane zone; 753 km in the Upland zone; 2,630 km in the Slopes zone; 3,329 km in the Lowland zone) which is 0.6 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

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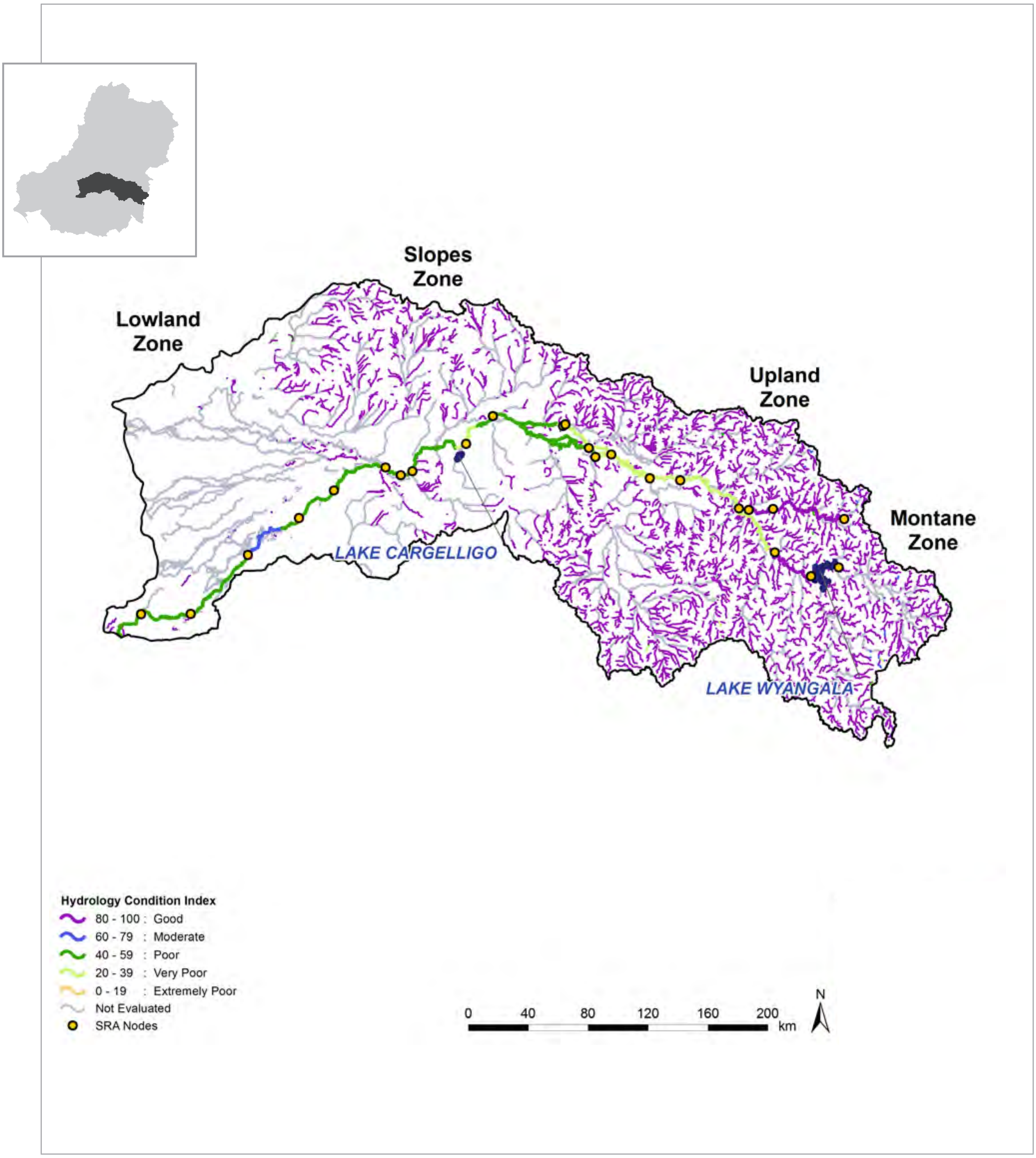

Figure LCH 7: Lachlan Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures LCH 6 and LCH 7 show values of the Hydrology Condition Index (SR–HI) for the Lachlan Valley and its river network, and Table LCH 11 and LCH 12 show the Index, sub-index, indicator and metric values. Analyses showed a moderate difference from Reference Condition for the Lachlan Valley, with:

- The Hydrology Condition Index for the whole valley = 64, indicating Moderate hydrological condition.
- The Hydrology Condition Index for the Montane, Upland, Slopes and Lowland zones = 98, 99, 62 and 46 indicating Good, Good, Moderate and Poor hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 49, indicating Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 36, indicating Very Poor condition and a very large difference from Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 95, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a significant alteration from reference in 18% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. In addition, results for the Flow Duration metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows).

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to reference.

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In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 2% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 52% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. Results for the High Flow Spells metric showed a significant alteration from reference in 85% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 2% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 12% of the headwater river length (associated with both increased and reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, some in the Upland zone, some in the Slopes zone and a small proportion in the Lowland zone.

Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to reference. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a very large difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 69% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 12% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed a significant alteration from reference in 13% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 82% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a significant alteration from reference in 26% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Montane zone, some in the Upland zone, some in the Slopes zone and a small proportion in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to reference. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to reference.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a moderate difference from Reference Condition. Results for the Seasonal Amplitude metric showed a significant alteration from reference in 75% of the mainstem river length (mostly associated with a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 5% of the mainstem river length and a significant alteration from reference in 80% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 2% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 19% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, some in the Upland zone, some in the Slopes zone and a small proportion in the Lowland zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 35% of the mainstem river length (associated with both increased and reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and most in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 2% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with some in the Montane zone, some in the Upland zone and some in the Slopes zone.

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Low Over Bank Floods

The Low Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 1-year flood in the reference regime. It is calculated from a combination of the Low Over Bank Flood Duration metric and the Low Over Bank Flood Spells metric. The Low Over Bank Flood Duration metric quantifies change in the duration of flooding of low-level floodplain areas relative to reference. The Low Over Bank Flood Spells metric quantifies change in the duration of time between low-level floodplain inundation events relative to reference. The Low Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly rather than daily timestep.

In the mainstem rivers, the Low Over Bank Floods indicator showed near Reference Condition. Results for the Low Over Bank Flow Duration metric showed a significant alteration from reference in 85% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 5% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 10% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

High Over Bank Floods

The High Over Bank Floods indicator is a measure of alteration in flooding corresponding to the 8-year flood in the reference regime. It is calculated from a combination of the High Over Bank Flood Duration metric and the High Over Bank Flood Spells metric. The High Over Bank Flood Duration metric quantifies change in the duration of flooding of high-level floodplain areas relative to reference. The High Over Bank Flood Spells metric quantifies change in the duration of time between high-level floodplain inundation events relative to reference. The High Over Bank Floods indicator could not be assessed for headwater streams in this SRA assessment or mainstem rivers in valleys where water resource models use a monthly rather than daily timestep.

In the mainstem rivers, the High Over Bank Floods indicator showed a moderate difference from Reference Condition. Results for the High Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 31% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 54% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone. Results for the High Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 22% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 54% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Lachlan Valley was generally characterised by substantial alteration in Low and Zero Flow Events, moderate alteration in High Over Bank Floods and Flow Seasonality and little or no alteration in Low Over Bank Floods, Flow Variability, High Flow Events or Flow Gross Volume relative to Reference Condition. Throughout most of the mainstem river system the duration and frequency of high flow spells was reduced; the magnitude of low flows were increased; and the frequency of low flow spells were reduced. The timing of seasonal flow variations was altered, inter-flood durations for low and high over bank flows were increased and the duration of high over bank flows was altered. Throughout much of the mainstem river system high flows were reduced and the amplitude of seasonal flow variations was reduced. Throughout some of the mainstem river system monthly flow variation was altered.

Summary: headwater streams

The headwater streams of the Lachlan Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume relative to Reference Condition. Throughout some of the headwater streams the magnitude of low flows was reduced.

Table LCH 11: Lachlan Valley: SRA Hydrology Condition Index at zone and zone scales.
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	64	98	99	62	46

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Table LCH 12: Lachlan Valley: SRA Hydrology Condition Index, sub-indices, indicators and metrics at zone and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**49 (21–100)**	**100 (30–100)**
Sub-index	In-Channel Flow Regime	36 (11–100)	100 (30–100)
Indicator	In-Channel Flow Regime A (volume and flow events)	45 (32–100)	100 (58–100)
Sub-ind.	Flow Gross Volume	93 (59–100)	99 (82–100)
Metric.	Mean Annual Flow	0.89 (0.52–1.12)	1.03 (0.72–1.23)
Metric	Flow Duration	1.08 (0.95–1.14)	0.98 (0.85–1.26)
Sub-ind.	High Flow Events	88 (69–99)	98 (32–100)
Metric	High Flow	0.78 (0.50–1.09)	1.00 (0.58–1.90)
Metric	High Flow Spells	0.71 (0.50–1.00)	
Sub-ind.	Low and Zero Flow Events	37 (19–98)	97 (60–99)
Metric	Zero Flows Proportion	1.07 (0.90–1.45)	0.99 (0.96–1.00)
Metric	Low Flow	1.68 (1.00–2.00)	0.90 (0.27–1.47)
Metric	Low Flow Spells	1.82 (1.00–2.00)	
Indicator	In-Channel Flow Regime B (seasonality & variability)	74 (25–100)	98 (20–100)
Sub-ind.	Flow Seasonality	63 (37–100)	95 (64–100)
Metric.	Flow Seasonal Amplitude	0.70 (0.56–1.00)	1.09 (0.89–1.67)
Metric	Flow Seasonal Period	0.70 (0.45–1.00)	0.96 (0.73–1.00)
Sub-ind.	Flow Variability	81 (25–100)	90 (1–100)
Metric	Flow Variation	0.97 (0.64–1.40)	0.91 (0.53–1.00)
Sub-index	Over Bank Flow Regime	95 (63–100)	
Indicator	Over Bank Floods Low	90 (68–99)	
Metric	OB Flow Duration (ARI 1)	0.71 (0.55–1.00)	
Metric	OB Flow Spells (ARI 1)	0.99 (0.54–1.51)	
Indicator	Over Bank Floods High	75 (37–98)	
Metric	OB Flow Duration (ARI 8)	0.61 (0.48–0.71)	
Metric	OB Flow Spells (ARI 8)	1.18 (0.39–1.46)	

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
	100	**46**	**46**	**98**	**99**	**100**
	100	44	26	98	99	100
	100	**52**	**37**	**99**	**100**	**100**
	100	100	89	96	99	99
	1.00	0.97	0.84	1.09	1.04	1.02
	1.00	1.10	1.08	1.01	0.99	0.98
	99	95	83	92	98	98
	1.00	0.92	0.68	1.24	1.07	0.94
	1.00	0.79	0.64			
	98	43	29	95	97	96
	1.00	1.00	1.11	0.98	0.99	0.99
	1.00	1.61	1.72	0.91	0.91	0.87
	1.00	1.71	1.95			
	100	75	71	95	98	99
	100	65	59	89	94	96
	1.00	0.72	0.66	1.23	1.11	1.08
	1.00	0.72	0.67	0.93	0.95	0.96
	100	83	78	87	89	90
	1.00	0.88	1.03	0.89	0.90	0.90
	100	97	94			
	99	89	89			
	1.00	0.75	0.67			
	1.00	1.06	0.95			
	98	65	79			
			0.61			
			1.18			

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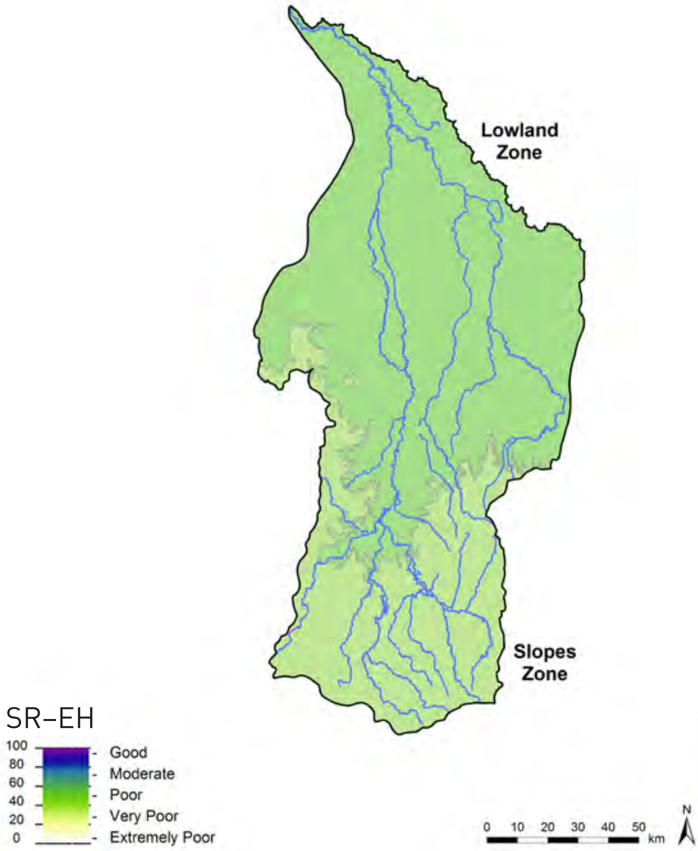

Figure LOD 1: Loddon Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.

Figure LOD 1 shows the Ecosystem Health ratings for the Loddon Valley and Tables LOD 1 and LOD 2 also show the Index values and ratings for each theme. Ecosystem Health shows a large difference from Reference Condition for the Loddon Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Very Poor, Moderate and Extremely Poor condition respectively, while Physical Form and Hydrology were both in Moderate condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation Themes were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Loddon Valley river system. The River Ecosystem Health was rated as Very Poor (Lowland zone: Very Poor; Slopes zone: Very Poor).

Key features of the condition of biophysical components, represented as Themes, are described below.

The Loddon Valley river ecosystem was in Very Poor health. River Ecosystem Health for the zones was as follows: Slopes and Lowland Very Poor. The Fish community was in Very Poor condition. Many expected species were absent. Alien species comprised 55–75% of total fish species count; biomass, abundance and recruitment levels among the remaining native species were very low. The Macroinvertebrate community was in Moderate condition, with moderate to large declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Extremely Poor condition overall; with reduced abundance, stability, structure and nativeness in the Near Riparian and Lowland Foodplain domains; and moderately increased fragmentation in the Lowland Floodplain. The Physical Form of the river system was in Moderate condition with channel form and bank dynamics in Good condition and bed dynamics in Poor condition, but with moderate to high levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition, with mainstem river reaches characterised by substantial alteration in flow seasonality and minor alteration in flow variability and low and zero flow events relative to Reference Condition.

Ecosystem Health

The Loddon Valley was ranked 19th of the 23 SRA valleys in terms of Ecosystem Health (see Table 5.2), among the six lowest-rated valleys. It was rated as in the lower 50% of valleys for all condition indices, including lowest for all valleys in terms of Vegetation condition.

The Loddon supports irrigated agriculture. There are in-stream storages in the Slopes zone (total capacity 228 GL), weirs to facilitate water diversion, and flow can be augmented by inter-valley transfer from the Murray and Goulburn systems entering the Loddon at Kerang and Loddon Weirs in the Lowland zone.

The vegetation of the Loddon Valley is considerably modified, with reduced abundance and diversity in both near-riparian and floodplain plant communities. The deviation of Physical Form from Reference Condition marked by elevated sediment loads and simplification of channel structure may be a consequence of these vegetation changes.

The Loddon Valley has experienced extreme drought throughout the SRA program to date and at the time of sampling for fish (late 2007) and macroinvertebrates (late 2009) drought conditions had prevailed unchanged for 7–9 years. There was little difference between the two zones in terms of macroinvertebrate condition. Taxonomic richness for macroinvertebrates and fish was reduced in comparison to Reference Condition. Fish condition in the Slopes zone was worse than that in the Floodplain zone. In particular only four of the expected 15 native species were caught and large-bodied native species were absent. This may reflect the relative absence of refugial habitats for these species.

Fish Theme

The Fish Condition Index SR–FI = 26, indicating Very Poor condition (Lowland zone: Very Poor; Slopes zone: Extremely Poor). The Expectedness indicator = 40, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 62, indicating Moderate condition, and a moderate difference from Reference Condition. The Recruitment indicator = 27, indicating Very Poor condition, and a very large difference from Reference Condition.

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The valley had lost much of its native species richness, while alien species contributed over 75% of the biomass in samples. Native fish recruitment was Very Poor in both zones.

Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 65, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate). The simOE metric = 46 (CL 43–48) indicating a large difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in Moderate condition was high across both zones (73% overall), and four of the 33 rated sites (12%) were in Good condition.

Family richness generally was very low, and was also low compared to Reference Condition.

Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 11, indicating Extremely Poor condition (Lowland zone: Extremely Poor; Slopes zone: Extremely Poor). The Vegetation Abundance and Diversity indicator = 30, indicating Very Poor condition and a very large difference from Reference Condition for the abundance and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 26, indicating Very Poor condition and a very large difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain is considerably affected by clearing. The abundance and the degree of fragmentation of major vegetation groups in the sampled floodplain area show a large difference from Reference Condition.

Physical Form Theme

The Physical Form Condition Index SR–PI = 78, indicating Moderate condition (Lowland zone: Good; Slopes zone: Moderate). The Channel Form indicator = 81 and the Bank Dynamics indicator = 94, both indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 44, indicating Poor condition and showing a moderate difference from Reference Condition. The Floodplain Form indicator = 66, indicating Moderate condition and showing a minor difference from Reference Condition.

Overall, the valley's riverine Physical Form is characterised by elevated sediment loads since European settlement and associated sedimentation within the river channel and floodplain. There was also evidence of channel enlargement and channel simplification.

Hydrology Theme

The Hydrology Condition Index SR–HI = 60, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Good). The In-Channel Flow Regime indicator = 46, indicating Poor condition and a moderate difference from Reference Condition for the flow regime within the channels.

The mainstem river reaches were generally characterised by substantial alteration in Flow Seasonality relative to Reference Condition, minor alteration in Flow Variability and Low and Zero Flow Events and little or no alteration in High Flow Events and Flow Gross Volume. The headwater streams were generally characterised by little or no alteration in any of these indicators.

Table LOD 1: Loddon Valley Ecosystem Health and condition assessments.
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

Ecosystem Health	HEALTH RATING	VALLEY	SLOPES	LOWLAND
		Very Poor	Very Poor	Very Poor

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Fish	SCORE RATING	26 (19–31) Very poor	10 (2–19) Ext' poor	35 (25–41) Very poor
Macro-invertebrates	SCORE RATING	65 (59–69) Moderate	68 (60–74) Moderate	63 (54–69) Moderate
Vegetation	SCORE RATING	11 Ext' Poor	13 Ext' Poor	10 Ext' Poor

Table LOD 2: Loddon Valley Physical Form and Hydrology condition assessments.
Index values are means (lower–upper 95% confidence limits shown for Themes where calculated and Hydrology where stream reach max—min values are shown).

THEME		VALLEY	ZONE	
			SLOPES	LOWLAND
Physical Form	SCORE RATING	78 (68–85) Moderate	75 (61–88) Moderate	80 (66–89) Good
Hydrology	SCORE RATING	60 Moderate	96 Good	46 Poor

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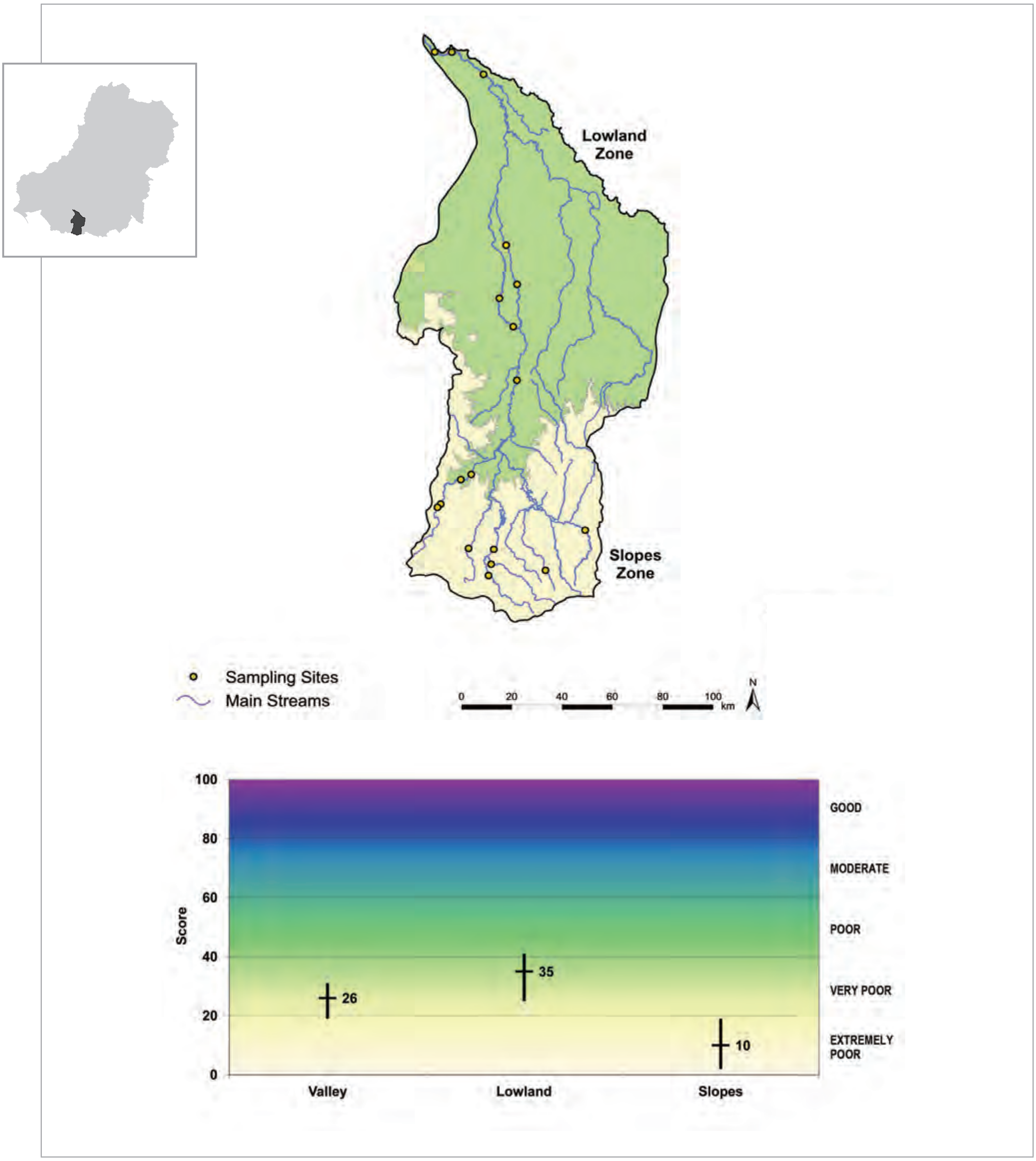

Figure LOD 2: Loddon Valley map with sampling sites and zones coloured by SR Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

The Fish community of the Loddon Valley river system was in Very Poor condition, with an aggregate Fish Index score (SR–FI) of 26. The condition of the Fish community in the zones was as follows: Slopes Extremely Poor; Lowland Very Poor. The fish community was characterised by a Poor score for expected native fish species, a Moderate score for nativeness and a Very Poor score for native fish recruitment. The Slopes zone in particular had few fish and lacked 73% of the predicted native species. The valley had lost much of its native species richness and alien species contributed over 75% of the biomass in samples. Native fish recruitment was Very Poor in both zones.

Eighteen sites were surveyed across the Loddon Valley in November 2007, yielding 916 fish. Analyses showed a very large difference from Reference Condition for the Loddon Valley, with:

- SRA Fish Index (SR–FI) = 26 (CL 19–31), indicating Very Poor condition of the fish community.
- The Expectedness indicator = 40 (CL 34–47), indicating Poor condition, and a large difference from Reference Condition. Only 59% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 62 (CL 51–74), indicating Moderate condition, and a moderate difference from Reference Condition.
- The Recruitment indicator = 27 (CL 14–32), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for seven of the 13 native species observed in the valley.

Figure LOD 2 shows sampling sites, zones and corresponding SR–FI values, and Table LOD 3 shows Index values, indicators, metrics and derived variables.

SR–FI for the Loddon Valley was second lowest of all valleys, and close to that for the Mitta Mitta, Broken and Macquarie valleys. The Slopes zone community was in much worse condition (SR–FI = 10) than that in the Lowland zone (SR–FI = 35).

Expectedness differed between zones; the Slopes zone rated as Extremely Poor and the Lowland zone as Poor. This reflects the fact that only 27% of fish species predicted to be present under Reference Condition (RC–F) were caught during sampling in the Slopes zone, whereas the same metric for the Lowland zone was 62%.

Nativeness also varied between zones. Four alien species were caught in each zone and the difference in Nativeness scores mainly reflects the larger number and diversity of native fish caught in the Lowland zone.

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The Loddon Valley had the thirteenth highest number of native fish per site and the tenth highest native biomass per site of all Basin valleys. The mean number of fish caught per site was similar in both zones; 47.3 fish/site in the Slopes zone (23.6 native and 23.6 alien) and 53.8 fish/site in the Lowland zone (32.4 native and 21.4 alien). In terms of biomass, however, the two zones differed markedly. The Slopes zone yielded an average of 303g of fish per site (162 g native and 141 g alien), whereas 15.4 kg of fish were caught per site in the Lowland zone (3.8 kg native and 11.6 kg alien). The difference was driven mainly by the capture of 16 golden perch at 1.5 kg/fish, four Murray cod at 2.9 kg/fish and, amongst the alien species, 95 common carp averaging 1.1 kg. None of these species appeared in samples from the Slopes zone.

Table LOD 4 shows native species abundances in the Loddon Valley compared with Reference Condition. Macquarie perch, Murray jollytail, southern pigmy perch, and trout cod were expected in both zones under Reference Condition but were not observed in any samples. Freshwater catfish, Murray cod and silver perch occurred in very low numbers.

Recruitment was Very Poor in both zones. In the Slopes zone, two of the four native species recorded were considered to be recruiting. In the Lowland zone, seven of the 13 native species showed evidence of recruitment. Bony herring, freshwater catfish, golden perch, Murray cod, river blackfish and silver perch, some of which were in very limited numbers, showed no evidence of recruitment. Tench was the only alien species not recruiting in the Loddon Valley. The other five alien species were recorded as recruiting in every zone in which they occurred.

In general, the fish community of the Loddon had reduced numbers of expected native species. Recruitment of native species was Very Poor.

Table LOD 3: Loddon Valley SRA Fish Condition Index, indicators, metrics and derived variables.
Lower and upper 95% confidence limits in parentheses. Values for Index and indicators are means (lower– upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Fish Condition (SR–FI)	26 (19–31)	10 (2–19)	35 (25–41)
Indicator	Expectedness	40 (34–47)	16 (5–29)	53 (47–61)
Metric	O/E	0.35 (0.26–0.46)	0.32 (0.12–0.52)	0.37 (0.27–0.49)
Metric	O/P (Zone level)	0.50 (0.50–0.50)	0.27 (0.27–0.27)	0.62 (0.62–0.62)
Indicator	Nativeness	62 (51–74)	48 (23–68)	70 (59–85)
Metric	Proportion biomass native	0.51 (0.33–0.69)	0.46 (0.20–0.75)	0.54 (0.31–0.77)
Metric	Proportion abundance native	0.57 (0.44–0.71)	0.41 (0.15–0.70)	0.66 (0.50–0.80)
Metric	Proportion species native	0.62 (0.51–0.74)	0.46 (0.19–0.72)	0.71 (0.60–0.82)
Indicator	Recruitment	27 (14–32)	24 (4–33)	29 (14–36)
Metric	Proportion of sites with native recruits	0.37 (0.23–0.42)	0.33 (0.13–0.50)	0.39 (0.23–0.44)
Metric	Proportion of native taxa with recruits	0.52 (0.41–0.61)	0.50 (0.33–0.50)	0.54 (0.42–0.70)
Metric	Proportion of abundance as recruits	0.41 (0.29–0.48)	0.38 (0.14–0.42)	0.42 (0.34–0.54)
Variables				
	Number of sites sampled	18	8	10
	Total number of species	19	8	17
	Number of native species	13	4	13
	Number of predicted species	22	15	21
	Number of alien species	6	4	4
	Mean number of fish per site	51	47	54
	Biomass/site all species (g)	8698	303	15413
	Mean native biomass/fish (g)	76	7	116
	Mean alien biomass/fish (g)	292	6	544

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Table LOD 4: Loddon Valley number of fish by zone.
Predicted species (RC–F list) shown by numbers (including zero); species not predicted shown by blanks.

Fish species	Valley	Zone	
		Slopes	Lowland
Sites sampled	18	8	10
Native species			
Australian smelt	83	1	82
Bony herring	7		7
Congolli	0		0
Dwarf flathead gudgeon	2		2
Flathead gudgeon	59	7	52
Freshwater catfish	1	0	1
Golden perch	16	0	16
Gudgeon	134	0	134
Macquarie perch	0	0	0
Mountain galaxias	0	0	
Murray cod	4	0	4
Murray hardyhead	0		0
Murray jollytail	0	0	0
Murray–Darling rainbowfish	6	0	6
Obscure galaxias complex	174	164	10

Fish species	Valley	Zone	
		Slopes	Lowland
River blackfish	21	17	4
Shortheaded lamprey	0		0
Silver perch	3	0	3
Southern purple-spotted gudgeon	0		0
Southern pygmy perch	0	0	0
Trout cod	0	0	0
Unspecked hardyhead	3		3
Alien species			
Brown trout	12	12	0
Common carp	95	0	95
Gambusia	185	167	18
Goldfish	72	0	72
Redfin perch	33	4	29
Tench	6	6	0

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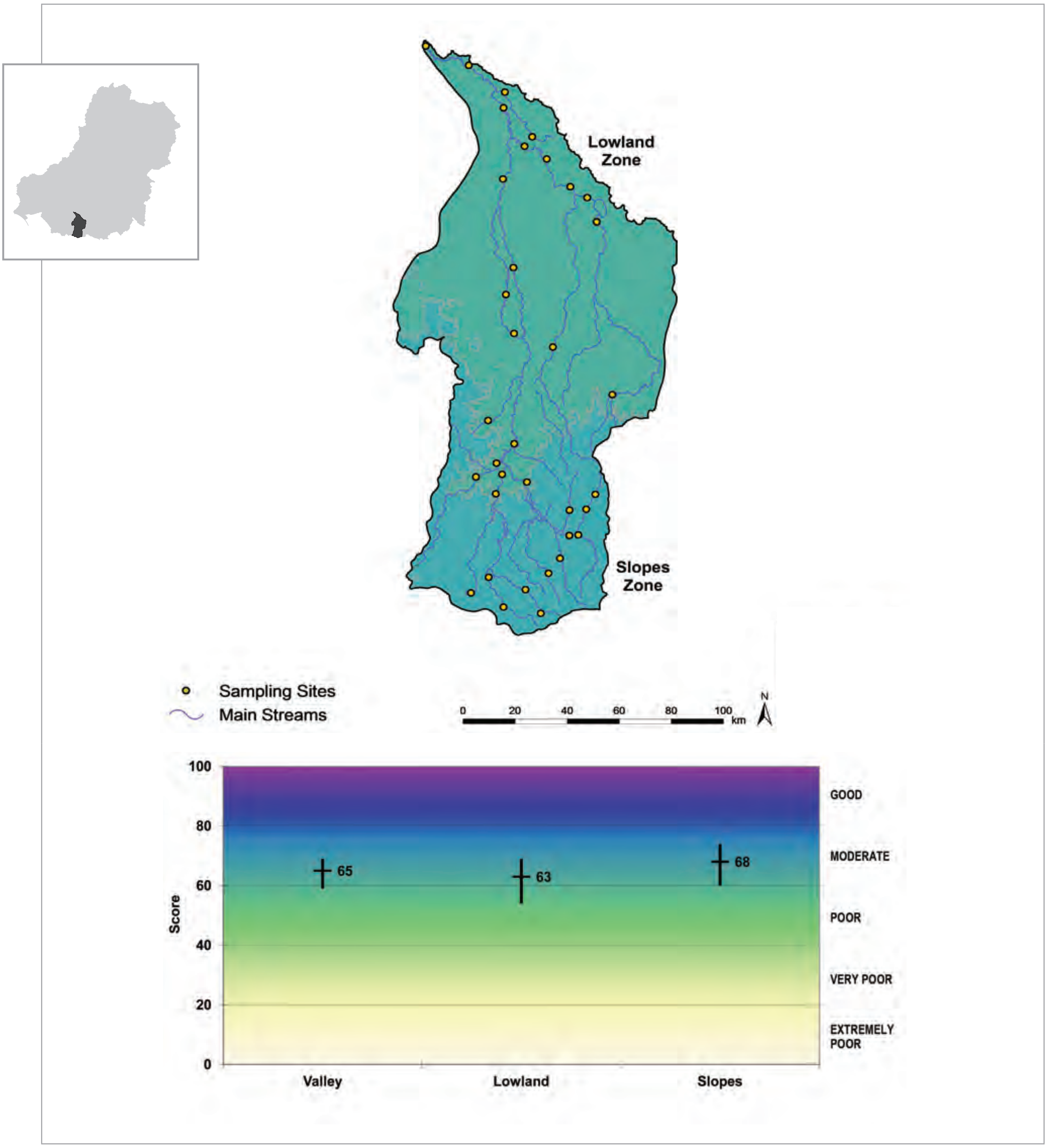

Figure LOD 3: Loddon Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.

Graph shows mean SR-MI scores as horizontal bars and 95% confidence limits as vertical bars.

The Macroinvertebrate community of the Loddon Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 65. The condition of the Macroinvertebrate community in the zones was as follows: Slopes zone: Moderate; Lowland zone: Moderate. The proportion of sites in Moderate condition was 57% overall across both zones; four of the 33 rated sites were in Good condition. Family richness generally was very low, and was also low compared to Reference Condition.

Thirty-five sites were surveyed across the Loddon Valley in October 2009 yielding 8,401 macroinvertebrates in 53 families (56% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 65 (CL 59–69), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 46 (CL 43–48) indicating a moderate to large difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of sites in Moderate condition was 57% overall, and four of the 33 rated sites (12%) were in Good condition (two in each zone).
- The number of families found was lowest in the Slopes zone (39 families) and highest in the Lowland zone (43 families), though both zones had the same average number of families per site (15).

Figure LOD 3 shows sampling sites, zones and SR–MI values, and Table LOD 5 shows Index and metric values. The SR–MI score for the Loddon Valley indicated Moderate condition of macroinvertebrate communities, rating 19th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the zones showed moderate differences from Reference Condition (SR–MI = 68 and 63). Similar confidence intervals (14 and 15 points) indicate similar spatial more variability across the zones. Most sites showed either a moderate difference from Reference Condition. Expectedness (simOE) was Moderate for all but five sites which had low simOE values (< 40 points) and varied only by up to eight points among sites.

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Table LOD 6 shows that most sites in both zones had moderate SR–MI values, with four sites were rated in Good condition. The Lowland zone had four sites with a low simOE score (<40 points), while the Slopes zone had one. 88% of sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

Family richness generally was low compared to Reference Condition. Diversity was very low (average 15 families per site), with both zones being equally diverse at site scale (average 15 families per site). The valley contained 56% of the families found across the Basin (Table LOD 6), with the Lowland zone having a marginally lower representation of Basin-wide fauna. Most (74–81%) of the fauna of the valley was found in each of the zones.

Table LOD 5: Loddon Valley: Macroinvertebrate Condition Index and metric values, numbers of sample sites and derived variables.

Index and metric values are medians, shown with their lower–upper 95% confidence limits.

Indexes Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Macroinvertebrate Condition (SR–MI)	65 (59–69)	68 (60–74)	63 (54–69)
Metric	SimOE	46 (43–48)	47 (44–50)	45 (42–47)

Table LOD 6: Loddon Valley distribution of sample sites and values of derived variables.

Number of sites and families sampled	Valley	Zone	
		Slopes	Lowland
Sites			
Number of sites sampled	35	12	23
Number of sites with index values*	33	12	21
N sites by SR–MI condition band			
Good (80–100)	4	2	2
Moderate (60–80)	20	8	12
Poor (40–60)	5	1	4
Very or Extremely Poor (0–40)	4	1	3
Families			
Number of families sampled	53	39	43
No. families/site (min–max)	15 (3–31)	15 (6–26)	15 (3–31)
Percent of families in Basin	56	41	46
Percent of families in valley	100	74	81

*simOE values could occasionally not be derived for every sample site.

LODDON VALLEY

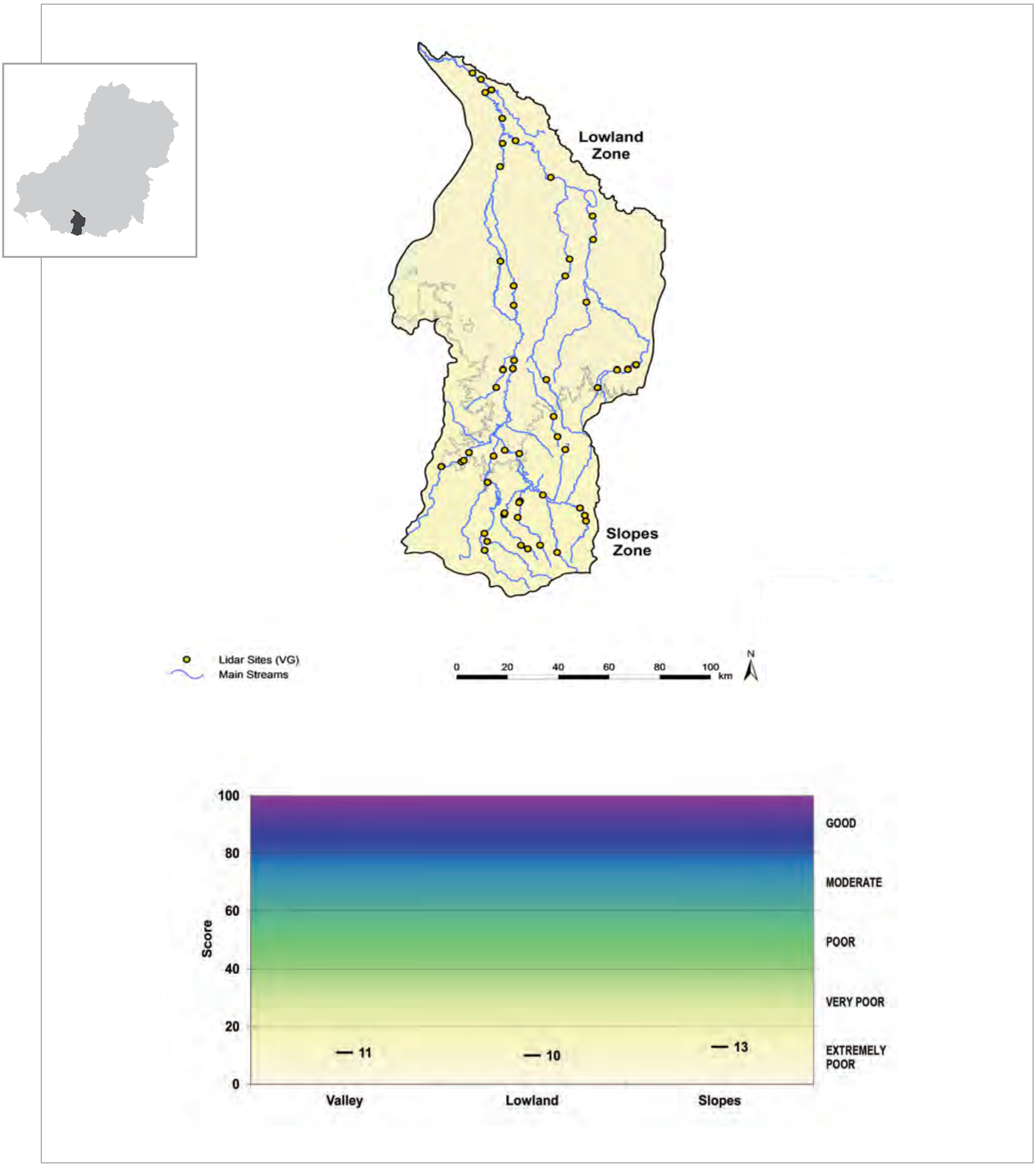

Figure LOD 4: Loddon Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

The Riverine Vegetation of the Loddon Valley river system was in Extremely Poor condition, with an aggregate Vegetation Index score (SR–VI) of 11. Overall condition for the two zones in this valley was: Slopes Extremely Poor; Lowland Extremely Poor.

The Abundance and Diversity indicator score was 30 for the valley, indicating a Very Poor rating overall. In the two zones it was: Slopes Very Poor; Lowland Very Poor.

The Quality and Integrity indicator score was 26 for the valley, indicating a Very Poor rating overall. In the two zones it was: Slopes Very Poor; Lowland Very Poor.

The SRA Vegetation assessment for the Loddon Valley considers riverine vegetation in two spatial domains: Near Riparian, along 1,707 km of stream, and Lowland Floodplain, for 307 km^2 of flooding land which is part of the floodplain in the Lowland zone. Most (65%) of the stream length is in the Lowland zone, and stream length per zone is as follows: Slopes, 590 km; and Lowland, 1,117 km. The assessment of the Near Riparian domain is based on national vegetation mapping of Major Vegetation Groups (MVGs) covering a 400 m wide strip centred on all streams in the network, and on LiDAR data from 53 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream network amongst the two zones as follows: Slopes, 19 sites; and Lowland, 34 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure LOD 4 shows values of the Vegetation Index (SR–VI) for the Loddon Valley and Table LOD 7 shows the Index, indicator and sub-indicator values. Tables LOD 8 and LOD 9 show key MVG variables and metrics for the valley, the zones and the Lowland Floodplain domain.

Analyses showed an extreme difference from Reference Condition for the Loddon Valley with:

- SRA Vegetation Index (SR–VI) = 11, indicating Extremely Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 30, indicating a very large difference from Reference Condition for the abundance, richness and stability of major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Vegetation Quality and Integrity indicator = 26, indicating a very large difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian and Lowland Floodplain domains.
- The Lowland Floodplain domain is considerably affected by clearing. The abundance and the degree of fragmentation of major vegetation groups in the sampled area are largely different from Reference Condition.

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The Abundance and Diversity of valley riverine vegetation is in Very Poor condition overall, with MVGs showing a very large difference from Reference Condition in both the Slopes and Lowland zones. The Very Poor rating for the Abundance and Diversity indicator is largely due to the extent (abundance) of major vegetation groups as given in NVIS 3.0. Valley-wide abundance shows a very large difference from Reference Condition for the Near Riparian domain, and a large difference from Reference Condition for the Lowland Floodplain domain. MVG richness is near Reference Condition in both Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 48% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Very Poor condition overall, and shows a very large difference from Reference Condition in both the Slopes and the Lowland zones. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where the presence of native vegetation is indicated by the MVGs listed in Table LOD 8 as well as other native but nonspecific MVGs. Valley-wide Nativeness shows a very large difference from Reference Condition in the Near Riparian domain, and a large difference from Reference Condition in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain domain shows a moderate difference from Reference Condition.

The sub-indicators and metrics for the Abundance and Diversity indicator show the following:

Richness

- The Richness of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain, is in Good condition overall, and the metrics show no loss of any MVG in any of the zones from the Near Riparian domain, and the Lowland Floodplain domain is near Reference Condition, when mapped at this scale.

Abundance

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Extremely Poor condition overall, and the metrics show differences between the domains. Abundance in the Near Riparian domain shows a very large difference from Reference Condition in both Slopes and Lowland zones; and in the Lowland Floodplain domain, it shows a large difference.

Stability

- Floodplain areas in the Lowland Floodplain domain are in Poor condition, with considerable evidence of turnover or change when vegetation is mapped at this scale.

The sub-indicators and metrics for the Quality and Integrity indicator show the following:

Nativeness

- The Nativeness of the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Extremely Poor condition overall, and the metrics show differences between domains. Nativeness in the Near Riparian domain shows a very large difference from Reference Condition in both Slopes and Lowland zones; and in the Lowland Floodplain domain, it shows a large difference.

Structure

- Near Riparian Structure, which assesses the canopy height for woody plant communities in the Near Riparian domain sampled by LiDAR, is in Moderate condition overall. The two zones are similar, with both Slopes and Lowland zones having a Structure that is moderately different from Reference Condition. Structure refers only to height of the upper canopy of individual patches of woody vegetation types 50 metres or more away from the channel.

Fragmentation

- Fragmentation is a sub-indicator for the Lowland Floodplain domain that integrates two metrics: the number of patches, and mean patch area for all MVGs present in pre–1750 mapping. The Fragmentation sub-indicator shows that the integrity of MVGs is in Moderate condition. All MVGs show some fragmentation, and none have patch number with mean patch area close to Reference Condition.

Under Reference Conditions, the riverine vegetation in the Loddon Valley was characterised as follows:

- Slopes zone: The Near Riparian domain was mostly Eucalypt Woodlands (71% of domain area). The other two MVGs present were each more than 5% of the domain.
- Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (64%). Two out of the other five MVGs present were more than 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (39%) and Other Shrublands (30%). Two out of the other five MVGs present were over 5% of the area.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the extent of the riverine vegetation in the valley has been considerably reduced in all zones and domains. Nearly all MVGs are affected quite substantially, Eucalypt Open Forests much less so.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are reduced to 12% of the domain area but are still the most extensive MVG. About 70% is cleared or non-native vegetation, and the effect on MVGs is quite variable. Other Forests and Woodlands, and Eucalypt Woodlands are reduced to 13% and 17% of their reference area, whereas the area of Mallee Woodlands and Shrublands is unchanged.
- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are reduced to 14% of the domain area. About 76% is cleared or non-native vegetation. All MVGs are reduced to less than 30% of their reference distribution, except for Eucalypt Open Forests which is 67% of its reference area.
- Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands (25% of the domain area) is still the most extensive MVG although reduced. About 50% of the domain is cleared or non-native vegetation. The effect on MVGs ranges from complete reduction (Mallee Woodlands and Shrublands), to substantial reduction for three MVGs reduced to 20% or less of their reference area: in contrast, Eucalypt Open Forests is 90% of its reference area.

LODDON VALLEY

Unlike the other themes, the Vegetation Theme relies substantially on information that, although contemporary, is not completely up to date. The two techniques used, NVIS mapping and LiDAR sampling, differ in currency and resolution, and refer to different parts of the Near Riparian domain: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping is 2004, whereas the LiDAR was flown in March 2010. This means that the Structure sub-indicator which is based on LiDAR data and three mapping metrics (abundance, richness and nativeness) are off-set slightly in time and space. The Structure sub-indicator assesses how close tree heights are to Reference Condition, without considering the number, density or extent of trees. In each of the mapping polygons being assessed, the trees may be only a remnant clump or scattered isolates.

Most metrics are based on vegetation mapping. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the two zones and of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Loddon Valley is notable for the very low abundance of MVGs and low nativeness in the Near Riparian domain, throughout the valley, and for the Lowland Floodplain domain, with higher scores for abundance, stability, nativeness, fragmentation and structure, being in better condition.

The condition of riverine vegetation in the Slopes zone is marginally better than in the Lowland zone, but both are in Extremely Poor condition: the Lowland zone, with more stream length, has a stronger influence on the valley score. The abundance and nativeness metrics have very low scores, indicating substantial clearing in the Near Riparian domain, and the variability in the Structure sub-indicators suggests this is variable or patchy.

In the Lowland zone, the Lowland Floodplain domain is in better condition than the Near Riparian domain with higher scores for abundance and nativeness and a degree of fragmentation that is moderately different from Reference Condition. Despite the complete loss of one MVG from the Lowland Floodplain domain, Mallee Woodlands and Shrublands, richness is near reference. The two domains refer to differing although slightly overlapping parts of the landscape: the Lowland Floodplain is land that floods near the main river channels, whereas the Near Riparian domain is centred on all channels in the valley, and covers a larger area.

Table LOD 7: Loddon Valley: SRA Vegetation Condition Index, indicators, metrics and derived variables.

LF = Lowland Floodplain domain; NR = Near Riparian domain. Valley-scale values for Index, indicators and metrics are stream length weighted means (with upper and lower 95% confidence limits shown for Structure). Valley-scale scores for metrics and sub-indicators have been generated for this table. Only zone-scale values are used as inputs when deriving valley-scale Index values (see Appendix). The NRLF sub-indicator is only reported when both Near Riparian and Lowland Floodplain domains are assessed.

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Vegetation Condition (SR–VI)	11	13	10
Indicator	Abundance and diversity	30	33	28
Metric	LF stability	0.48		0.48
Sub-ind.	NRLF richness	100		100
Metric	NR richness	1	1	1
Metric	LF richness	0.88		0.88
Sub-ind.	NRLF abundance	19		19
Metric	NR abundance	0.22	0.23	0.21
Metric	LF abundance	0.50		0.50
Indicator	Quality and integrity	26	27	26
Sub-ind.	NRLF nativeness	19		19
Metric	NR nativeness	0.22	0.23	0.21
Metric	LF nativeness	0.50		0.50
Sub-ind.	NR structure	66 (57–74)	61 (45–75)	68 (58–77)
Sub-ind.	LF fragmentation	60		60

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Table LOD 8: The most abundant MVGs in the Near Riparian domain in the Loddon Valley.
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

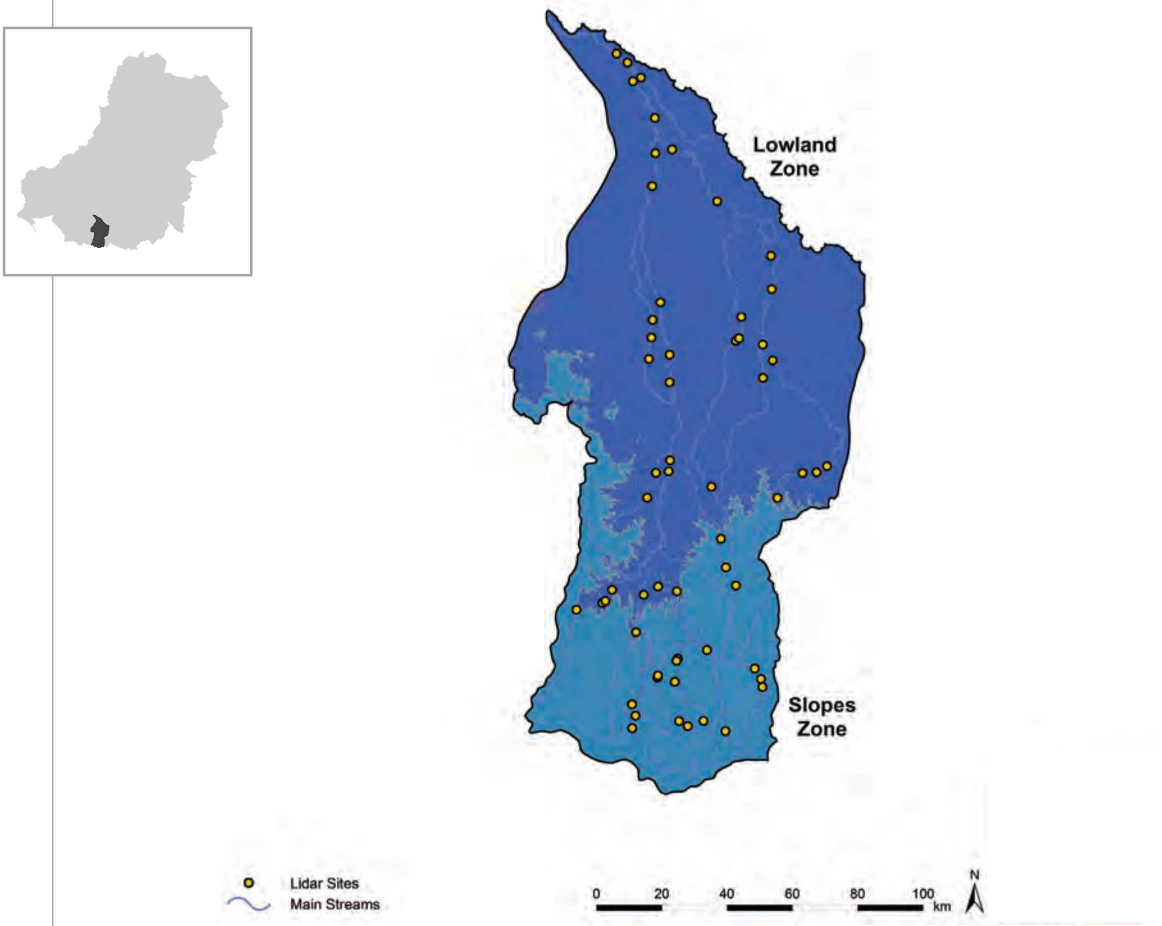
Major Vegetation Groups	Zone	
	Slopes	Lowland
MVG		
3. Eucalypt Open Forests	15	
5. Eucalypt Woodlands	71	64
10. Other Forests and Woodlands	6	
17. Other Shrublands		8
19. Tussock Grasslands		16

Table LOD 9: Most abundant MVGs in the Lowland Floodplain domain of the Loddon Valley.

Showing percentage of domain area under Reference Condition in the Loddon Valley, and metrics for the number of patches, and mean patch area: restricted to MVGs that are at least 5% of the domain area. N patches = the ratio of the current to reference number of patches for the MVG.

Major Vegetation Groups	% domain	N patches	Mean patch area
MVG			
3. Eucalypt Open Forests	6	1.12	0.79
5. Eucalypt Woodlands	39	1.05	0.61
17. Other Shrublands	30	1.13	0.40
19. Tussock Grasslands	14	0.52	0.29

LODDON VALLEY



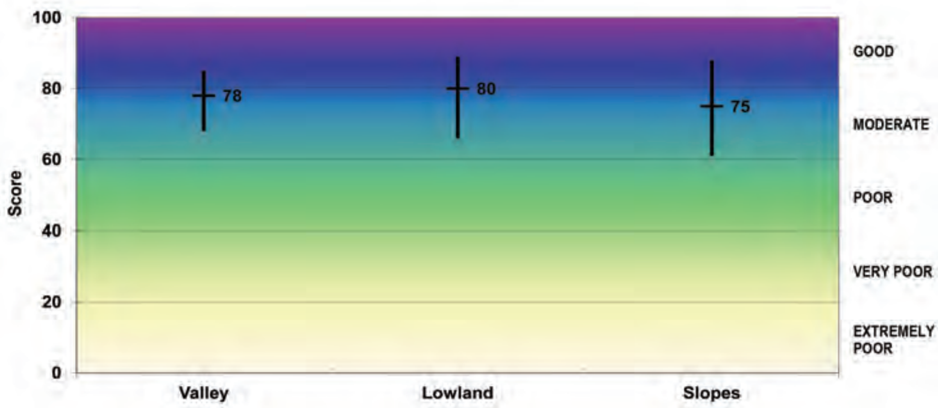


Figure LOD 5: Loddon Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

Graph shows mean SR–PI scores as horizontal bars and 95% confidence limits as vertical bars.

The Physical Form of the Loddon Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 78. The condition of Physical Form in the zones was: Slopes Moderate and Lowland Good. The valley's river Channel Form and Bank Dynamics were rated as Good. Bed Dynamics was rated as Poor. Floodplain Dynamics was rated as Moderate. Overall, the valley's riverine physical form is characterised by elevated sediment loads since European settlement and associated sedimentation within the river channel and floodplain. There was also evidence of channel enlargement and channel simplification.

The SRA Physical Form assessment considers physical form and processes along 1,707 km of stream across the valley. It is based on LiDAR data collected at 59 sites along river channels, as well as modelling of all 119 river reaches within the valley that have been defined within the SedNet model for the Basin. The Physical Form assessment integrates four indicators: Channel Form, Bank Dynamics, Bed Dynamics and Floodplain (see Section 3).

Figure LOD 5 shows values of the Physical Form Index (SR–PI) for the Loddon Valley and Table LOD 10 shows the Index, indicator, sub-indicator and metric values.

Analyses showed a moderate difference from Reference Condition for the Loddon Valley with:

- the SRA Physical Form Condition Index (SR–PI) = 78 (CL 68–85), indicating Moderate Physical Form condition
- the Channel Form indicator = 81 (CL 74–87), showing near Reference Condition
- the Bed Dynamics indicator = 44 (CL 37–51), showing a large difference from Reference Condition
- the Bank Dynamics indicator = 94 (CL 90–98), showing near Reference Condition
- the Floodplain indicator = 66 (CL 58–75), showing a moderate difference from Reference Condition.

Slopes zone

There were 19 LiDAR survey sites and 36 SedNet river segments in the Slopes zone of the Loddon Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Slopes zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width and Meander Wavelength were modified from Reference Condition for approximately half of the Slopes zone. At these sites Channel Width and Meander Wavelength were generally increased (many sites having large increases in Meander Wavelength). Channel Depth, Channel Width Variability, Sinuosity, Bank Variability and Channel Sediment Deposition were modified from reference for less than half of the Slopes zone. At these sites Channel Depth, Sinuosity and Bank Variability were generally increased (a few sites having large increases in Sinuosity), Channel Width Variability was generally reduced and there was a large increase in Channel Sediment Deposition across 30% of the zone for the post-European period. Although the general pattern in the observations made here are supported by previous field observations, the magnitude of channel disturbance in the Slopes zone seems to be underestimated. Studies by Abernethy *et al*. (2003) suggest ubiquitous gullying across the Slopes zone (also shown in maps by Milton 1971), with more than half of the channel length being aggraded by sediment from these gullies. Impacts of gold mining and salinity exacerbated channel erosion and sedimentation (Davis 1996). The slopes of the Loddon River can be considered amongst the most degraded stream channels of the Victorian valleys of the Basin.

Lowland zone

There were 40 LiDAR survey sites and 83 SedNet river segments in the Lowland zone of the Loddon Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Channel Sediment Ratio was generally increased (many sites having large increases) and there was a moderate increase in Floodplain Sediment Deposition across 30% of the zone for the post-European period. Channel Depth was modified from Reference Condition in more than half of the Lowland zone. At these sites Channel Depth was generally increased (a few sites having large increases). Channel Width, Channel Width Variability, Bank Variability and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites results show both increases and decreases in Channel Width across the zone, Channel Width Variability and Bank Variability were generally reduced and there was a large increase in Channel Sediment Deposition across 40% of the zone for the post-European period. Sinuosity and Meander Wavelength were modified from reference for less than half of the Lowland zone. At these sites Sinuosity was generally reduced and Meander Wavelength was generally increased (many sites having large increases). These results are generally consistent with previous field observations (Rutherfurd, pers. comm.). The dramatic channel changes in the Slopes zone have not translated to degraded channels downstream. Instead, previous field observations indicate that the lower Loddon and its anabranches and tributaries are only slightly affected by accelerated erosion and deposition.

Channel Form

There was little change from Reference Condition in Channel Form in the Slopes zone. The more serious impact was channel simplification. Channel simplification was indicated at 60% of sites mostly as a result of channel straightening. There was widespread evidence of channel enlargement and channel straightening but small deviations from reference had little influence on scores when aggregated at the zone scale. These results are generally not consistent with field observations (Abernethy *et al*. 2003, Milton 1971, Rutherfurd pers. comm.). Major channel changes appear to be almost ubiquitous in the upper catchment and slopes of the Loddon River.

There was minor change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was channel enlargement. An enlarged channel was indicated at 70% of sites as a result of channel widening and bed degradation. There was widespread evidence of channel simplification but small deviations from reference had little influence on scores when aggregated at the zone scale. These results appear consistent with previous field observations (Rutherfurd pers. comm.) and may require further validation.

Channel and Floodplain Dynamics

There was little change from Reference Condition in Bank Dynamics in the Slopes and Lowland zones. At 40% of sites across the Lowland zone, Bank Variability was less than Reference Conditions indicating altered Bank Dynamics. Bank erosion throughout the Loddon River was noted in the Loddon River Health (LRH) survey (North Central CMA 2000), with the Lowland zone reaches from Laanecoorie Reservoir to Loddon Weir exhibiting the most prevalent bank erosion. While bank erosion may have been a serious problem in the past, the sites visited during the field inspection by the Loddon River Environmental Flows Scientific Panel (2002) were reported as appearing reasonably stable. Abernethy *et al*. (2005) also reported that rates of bank erosion in the Loddon River were relatively low because of good riparian cover.

Previous geomorphic studies suggest that in the Loddon Valley channel instability varies spatially, and has generally lessened over time. The SRA assessment result is generally consistent with this pattern.

Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They reflect overall post-European changes and do not necessarily reflect recent or current sediment dynamics.

There was considerable change from Reference Condition in Bed Dynamics in the Slopes and Lowland zones as a result of widespread sedimentation (40%-60% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). Indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. This is probably due to erosion taking place in the upstream portion of the Slopes zone streams, with deposition in downstream reaches of the same zone.

There was minor change from Reference Condition in Floodplain Sedimentation in the Slopes and Lowland zones as a result of widespread sedimentation (in 90% of SedNet river segments).

This SRA assessment result of widespread sediment deposition is consistent with large quantities of sediment released from the upper catchment in association with (i) extensive gold mining in the upland areas which was most active in the 1850s, and (ii) the development of extensive gullying associated with clearing for agriculture of upland areas with erodible sodic duplex soils (Ford *et al*. 1993, SKM 2002, North Central CMA 2006). There is evidence of sand slugs appearing during the 1950s (SKM 2004b). The gully network is thought to have stabilised by the 1960s at which time land practice improvements and soil conservation works were noted (SKM 2004b). While the rates of sediment delivery continue to decline, slugs of sand in the tributary network continue to move along the system (Abernethy *et al*. 2005). Abernethy *et al*. (2005) estimated that half of the sediment liberated by 150 years of catchment disturbance remains stored in channels as sand accumulations. Approximately 50% of stream length was predicted by SKM (2004b) to be impacted by sand slug deposition or similar instream accumulation of sediment.

LODDON VALLEY

Table LOD 10: Loddon Valley SRA Physical Form Condition Index, indicators, metrics and derived variables.
(Lower–upper 95% confidence limits shown for those metrics which are derived at site level).

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Index	Physical Form Condition (SR–PI)	78 (68–85)	75 (61–88)	80 (66–89)
Indicator	Channel Form (volume and flow events)	81 (74–87)	84 (72–94)	79 (72–87)
Sub-ind.	Cross-section Form	83 (79–87)	97 (93–98)	77 (70–83)
Metric	Channel Depth (mean)	1.19 (1.12–1.26)	1.06 (1.02–1.11)	1.26 (1.15–1.36)
Metric	Channel Width (mean)	1.04 (0.98–1.11)	1.07 (1.02–1.14)	1.02 (0.94–1.14)
Sub-ind.	Cross-section Form (variability)	88 (83–94)	95 (87–100)	85 (77–92)
Metric	Channel Width (CV)	0.91 (0.89–0.95)	0.98 (0.93–1.03)	0.88 (0.83–0.93)
Sub-ind.	Channel Planform	84 (77–91)	77 (63–90)	87 (80–95)
Metric	Sinuosity	1.00 (0.99–1.03)	1.03 (1.00–1.07)	1.00 (0.98–1.02)
Metric	Meander Wavelength	1.10 (1.05–1.15)	1.14 (1.05–1.24)	1.07 (1.02–1.12)
Indicator	Bed Dynamics	44 (37–51)	50 (39–62)	41 (32–50)
Metric	Channel Sediment Ratio	281 (219–341)	275 (158–396)	284 (219–349)
Metric	Channel Sediment Depth	0.007 (0.005–0.01)	0.006 (0.002–0.01)	0.007 (0.005–0.01)

Continued/...

Indexes Indicators Metrics	Description	Valley	Zone	
			Slopes	Lowland
Indicator	Bank Dynamics	94 (90–98)	100 (99–100)	91 (85–97)
Metric	Bank Variability (longitudinal)	0.97 (0.94–1.00)	1.01 (0.99–1.05)	0.95 (0.91–0.99)
Indicator	Floodplain	66 (58–75)	74 (61–88)	62 (52–73)
Metric	Floodplain Sediment Deposition	2.00 (1.70–3.00)	3.00 (1.26–4.00)	2.00 (1.56–3.00)

LODDON VALLEY

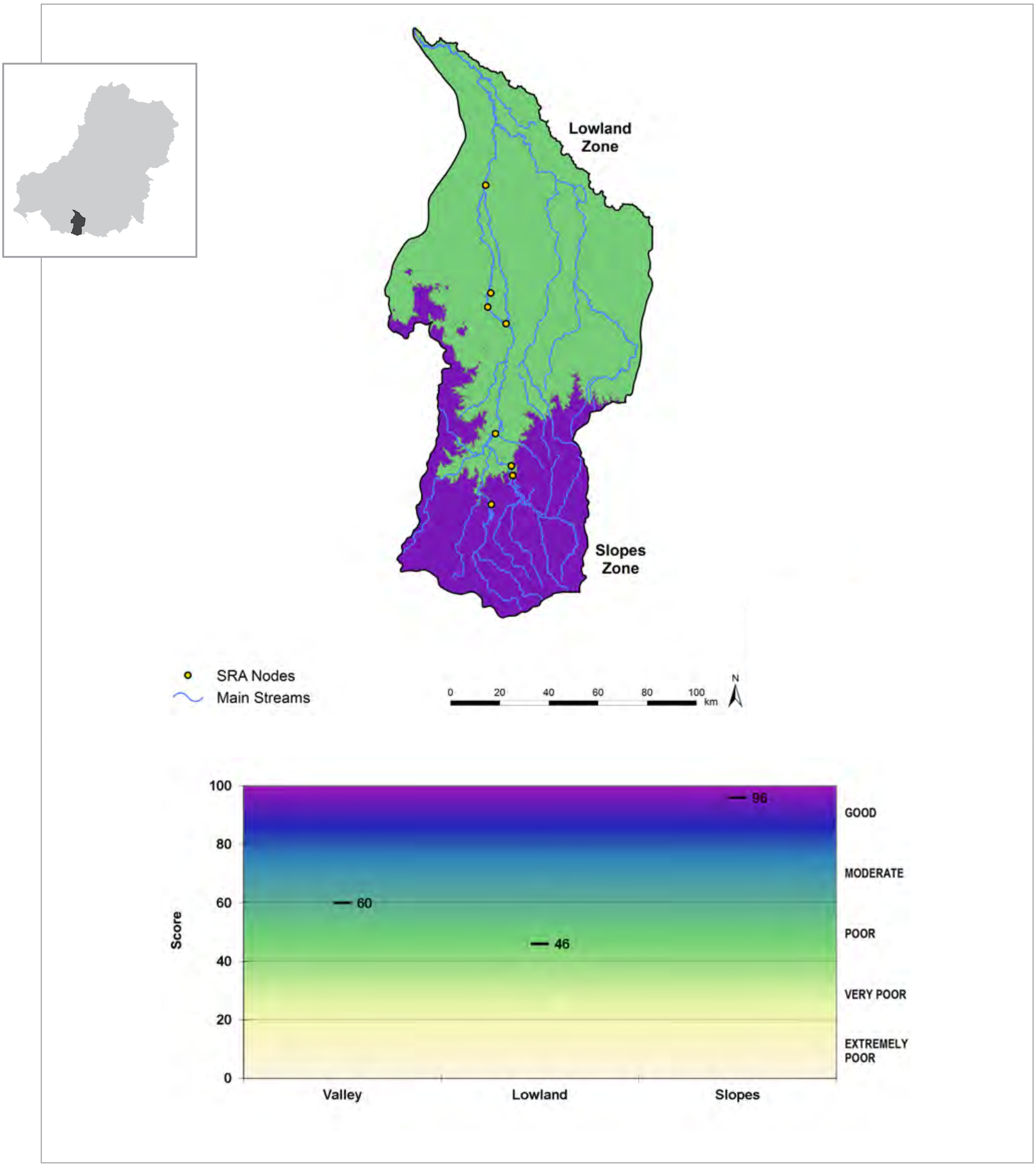


Figure LOD 6: Loddon Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

The Hydrology of the Loddon Valley river system was in Moderate condition, with an aggregate Hydrology Index (SR–HI) score of 60. The Slopes zone was in Good condition. The Lowland zone was in Poor condition. The mainstem river system of the Loddon Valley was rated in Poor condition. Flow seasonality was altered throughout all of the mainstem river system with reduced amplitude and altered timing of seasonal flow variations relative to Reference Condition. Also, throughout most of the mainstem river system high flows were reduced and the magnitude of low flows was altered. The headwater streams of the Loddon Valley were rated in Good condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased relative to Reference Condition. Throughout some of the headwater streams the magnitude of low flows was reduced.

The Loddon River flows northward from the Great Dividing Range, through Central Victoria, to join the Murray near Kerang, downstream of Torrumbarry Weir. Instream storages in the upper catchment include Cairn Curran and Tullaroop Dams and Laanecoorie Reservoir (total 228 GL). The valley supports extensive irrigation, particularly irrigated pasture, supported by inter-valley transfers from the Murray and the Goulburn (via the Waranga Basin). These transfers enter the Loddon at Kerang Weir and Loddon Weir, respectively. Instream weirs (Serpentine, Loddon, Boags, Kerang) provide hydraulic heads for diversions.

In the Loddon Valley, hydrological condition is assessed using metrics of hydrological alteration available for 2,483 km of mainstem rivers and headwater streams. There are 310 km of mainstem river extending across the Lowland and Slopes zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by monthly water resource modelling. It is not possible to calculate the over bank flow metrics, the high flow spells metric or the low flow spells using monthly data. Consequently, these metrics have not been included in the analysis for this valley. In the Loddon Valley there is 2,173 km of headwater stream (Slopes zone: 754 km; Lowland zone: 1,420 km). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

Unfortunately it is still not possible to assess flow alteration in the mid-size tributaries, many of which are not explicitly represented in the water resource models. Private diversions and smaller impoundments can significantly alter flow regimes in these streams, but they could not be included in this assessment. In the Loddon Valley there is 1,472 km of these mid-size tributaries (289 km in the Slopes zone; 1,183 km in the Lowland zone) which is 0.6 times the stream length for which metrics are available.

In contrast to the other themes, the Hydrology Theme uses metrics calculated from model runs, for the period 1895 to 2009 for the mainstem rivers and approximately the last 40 years for the headwater streams. Importantly, these models have used the 'current' levels of water resource development, farm dam densities and tree cover for the entire period of simulation. The 'current' water resource development refers to development levels represented for Basin planning in 2010.

Figures LOD 6 and LOD 7 show values of the Hydrology Condition Index (SR–HI) for the Loddon Valley and its river network, and Table LOD 11 and LOD 12 show the Index, sub-index, indicator and metric values. Analyses showed a moderate difference from Reference Condition for the Loddon Valley, with:

- The Hydrology Condition Index for the whole valley = 60, indicating Moderate hydrological condition.

LODDON VALLEY

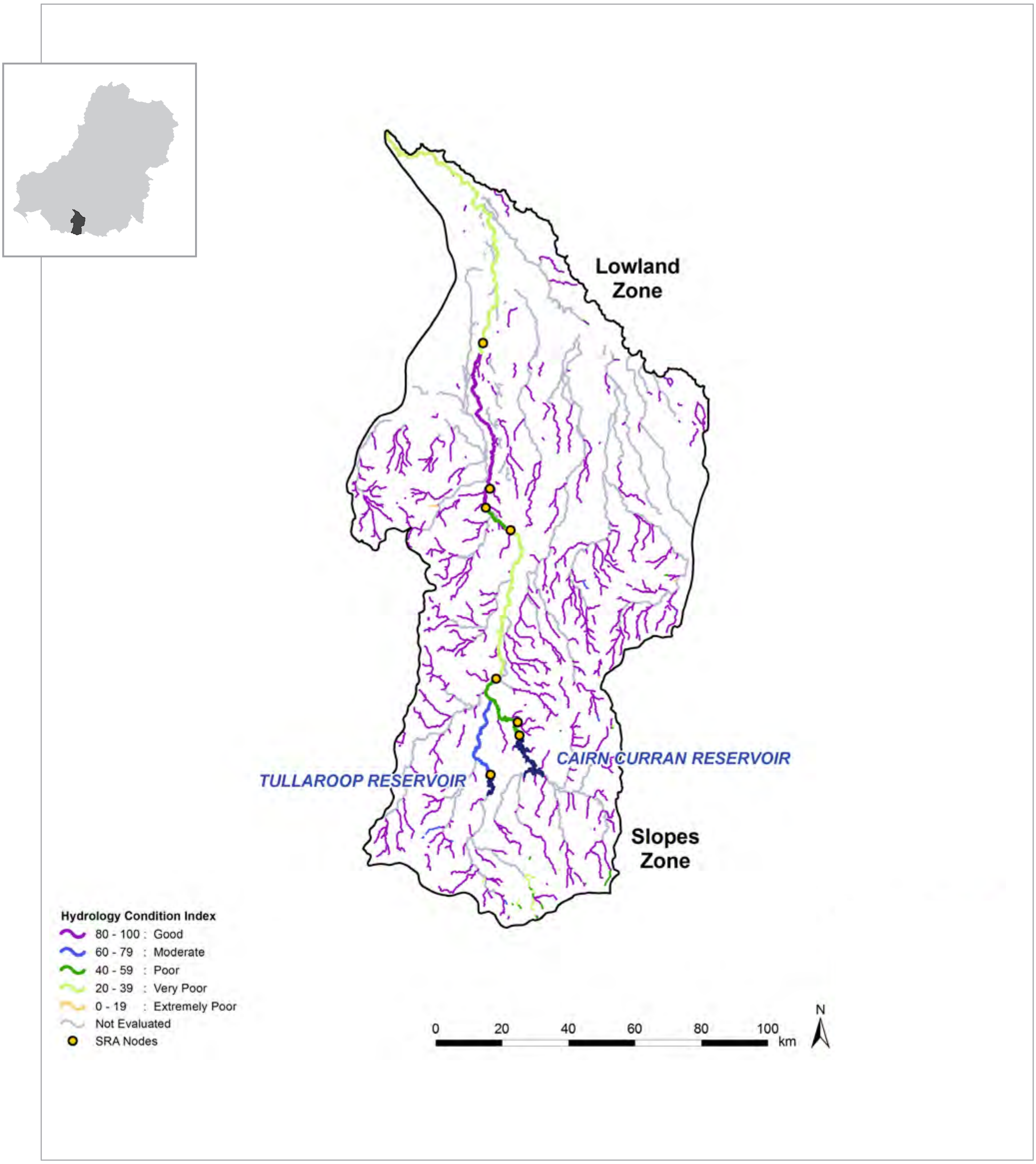


Figure LOD 7: Loddon Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

- The Hydrology Condition Index for the Slopes and Lowland zones = 96 and 46 indicating Moderate and Poor hydrological condition respectively.
- The Hydrology Condition Index for headwater streams (valley-wide) = 98, indicating Good hydrological condition.
- The Hydrology Condition Index for mainstem rivers (valley-wide) = 46, indicating Poor hydrological condition.
- The In-Channel Flow Regime indicator in the mainstem river reaches = 46, indicating Poor condition and a large difference from Reference Condition for the flow regime within the channels.

Flow Gross Volume

The Flow Gross Volume sub-indicator is a measure of alteration in the annual volume of streamflow. It is calculated from the Mean Annual Flow metric which quantifies change in annual flows relative to Reference Condition.

In the mainstem rivers, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed a significant alteration from reference in 37% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology were in the Lowland zone. In addition, results for the Flow Duration metric showed a significant alteration from reference in 10% of the mainstem river length (mostly associated with increased flows). These river reaches were in the Lowland zone.

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Mean Annual Flow metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows).

High Flow Events

The High Flow Events sub-indicator is a measure of alteration in high in-channel flows. It is calculated from a combination of the High Flow metric and the High Flow Spells metric. The High Flow metric quantifies change in high flows relative to high flows in the reference flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to the reference flow regime.

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 37% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 43% of the mainstem river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. The High Flow Spells metric could not be calculated for this valley.

In the headwater streams, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 2% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 20% of the headwater river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone.

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Low and Zero Flow Events

The Low and Zero Flow Events sub-indicator is a combined measure of alteration in low flows and cease-to-flow periods. It is calculated from a combination of the Low Flow metric, the Low Flow Spells metric and the Zero Flow metric. The Low Flow metric quantifies change in low flows relative to low flows in the reference flow regime. The Low Flow Spells metric quantifies change in the frequency of low flow events relative to the reference flow regime. The Zero Flow metric quantifies the proportion of time with cease-to-flow conditions relative to the reference regime.

In the mainstem rivers, the Low and Zero Flow Events sub-indicator showed a moderate difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 71% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from reference in 29% of the mainstem river length (mostly associated with increased flows). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. Results for the Zero Flows Proportion metric showed only small variations from reference throughout the mainstem river length (mostly associated with increased flows). The Low Flow Spells metric could not be calculated for this valley.

In the headwater streams, the Low and Zero Flow Events sub-indicator showed near Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 2% of the headwater river length (mostly associated with reduced flows) and a significant alteration from reference in 32% of the headwater river length (mostly associated with reduced flows). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Zero Flows Proportion metric showed no significant variations from reference.

Flow Seasonality

The Flow Seasonality sub-indicator is a measure of alteration in the seasonality of the flow regime. It is calculated from a combination of the Seasonal Amplitude metric and the Seasonal Period metric. The Seasonal Amplitude metric quantifies change in seasonal range of mean monthly relative to the reference flow regime. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to the reference flow regime.

In the mainstem rivers, the Flow Seasonality sub-indicator showed a very large difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 37% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 63% of the mainstem river length (mostly a reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 63% of the mainstem river length and a significant alteration from reference in 37% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 7% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in

46% of the headwater river length (mostly associated with an increased amplitude). These river reaches with altered hydrology are distributed across the valley, with some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

Flow Variability

The Flow Variability sub-indicator is a measure of alteration in the variability of the flow regime. It is calculated from Flow Variation metric, which quantifies change in monthly flow variation.

In the mainstem rivers, the Flow Variability sub-indicator showed a moderate difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 37% of the mainstem river length (mostly associated with increased variability). These river reaches with altered hydrology are distributed across the valley, with most in the Lowland zone.

In the headwater streams, the Flow Variability sub-indicator showed near Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 7% of the headwater river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes zone and some in the Lowland zone.

Summary: mainstem rivers

The mainstem river system of the Loddon Valley was generally characterised by substantial alteration in Flow Seasonality, minor alteration in Flow Variability and Low and Zero Flow Events and little or no alteration in High Flow Events and Flow Gross Volume, relative to Reference Condition. Flow seasonality was altered throughout all of the mainstem river system with reduced amplitude and altered timing of seasonal flow variations relative to Reference Condition. Also, throughout most of the mainstem river system high flows were reduced and the magnitude of low flows was altered.

Summary: headwater streams

The headwater streams of the Loddon Valley were generally characterised by little or no alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume relative to Reference Condition. Throughout much of the headwater streams the amplitude of seasonal flow variations was increased. Throughout some of the headwater streams the magnitude of low flows was reduced.

Table LOD 11: Loddon Valley SRA Hydrology Condition Index at valley and zone scales
Values derived by aggregation of mainstem river and headwater stream values.

Index	Valley	Zone			
		Montane	Upland	Slopes	Lowland
Hydrology Condition SR–HI	60			96	46

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Table LOD 12: Loddon Valley SRA Hydrology Condition Index, sub-indices, indicators and metrics at valley and zone scales for mainstem river and headwater stream reaches.

(Minimum and maximum values are shown in brackets).

Indexes Indicators Metrics	Description	Valley	
		Mainstem rivers	Headwater streams
Index	**Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)**	**46 (25–86)**	**98 (0–100)**
Sub-Index	In-Channel Flow Regime	46 (25–86)	98 (0–100)
Indicator	**In-Channel Flow Regime A (volume and flow events)**	**76 (39–100)**	**99 (1–100)**
Sub-ind.	Flow Gross Volume	94 (84–100)	99 (0–100)
Metric	Mean Annual Flow	0.89 (0.74–0.98)	1.04 (0.03–1.19)
Metric	Flow Duration	0.99 (0.81–1.25)	0.99 (0.45–1.10)
Sub-ind.	High Flow Events	83 (64–100)	97 (9–100)
Metric	High Flow	0.68 (0.44–0.99)	1.06 (0.10–1.90)
Metric	High Flow Spells		
Sub-ind.	Low and Zero Flow Events	68 (30–90)	96 (23–99)
Metric	Zero Flows Proportion	1.02 (0.99–1.18)	0.98 (0.96–1.00)
Metric	Low Flow	1.20 (0.45–1.93)	0.90 (0.01–1.46)
Metric	Low Flow Spells		
Indicator	**In-Channel Flow Regime B (seasonality & variability)**	**40 (15–65)**	**96 (18–100)**
Sub-ind.	Flow Seasonality	35 (31–43)	90 (62–100)
Metric	Flow Seasonal Amplitude	0.58 (0.37–0.77)	1.23 (0.89–1.73)
Metric	Flow Seasonal Period	0.44 (0.32–0.51)	0.96 (0.66–1.00)
Sub-ind.	Flow Variability	64 (30–92)	87 (0–100)
Metric	Flow Variation	1.11 (0.83–1.53)	0.89 (0–1.00)
Sub-Index	Over Bank Flow Regime	Not assessed	
Indicator	Over Bank Floods Low		
Metric	OB Flow Duration (ARI 1)		
Metric	OB Flow Spells (ARI 1)		
Indicator	**Over Bank Floods High**		
Metric	OB Flow Duration (ARI 8)		
Metric	OB Flow Spells (ARI 8)		

	Zone					
	Mainstem rivers			Headwater streams		
	Upland	Slopes	Lowland	Montane	Upland	Slopes
		68	**46**			**96**
		68	46			96
		100	**76**			**98**
		100	94			98
		0.98	0.89			1.05
		1.25	0.99			1.00
		100	83			95
		0.99	0.68			1.16
		85	68			94
		1.00	1.02			0.98
		1.43	1.20			0.90
		52	**40**			**92**
		33	35			88
		0.77	0.58			1.26
		0.32	0.44			0.94
		68	64			83
		0.88	1.11			0.87

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