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 3**

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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# Sustainable Rivers Audit 2

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

**Volume 3**

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

# About SRA report 2 (volume 3)

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 analysed 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 3 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 Macquarie to the Wimmera.

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; that 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 2 contains the assessment findings for Murray–Darling Basin valleys listed alphabetically from the Avoca to the Loddon.

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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# MACQUARIE VALLEY

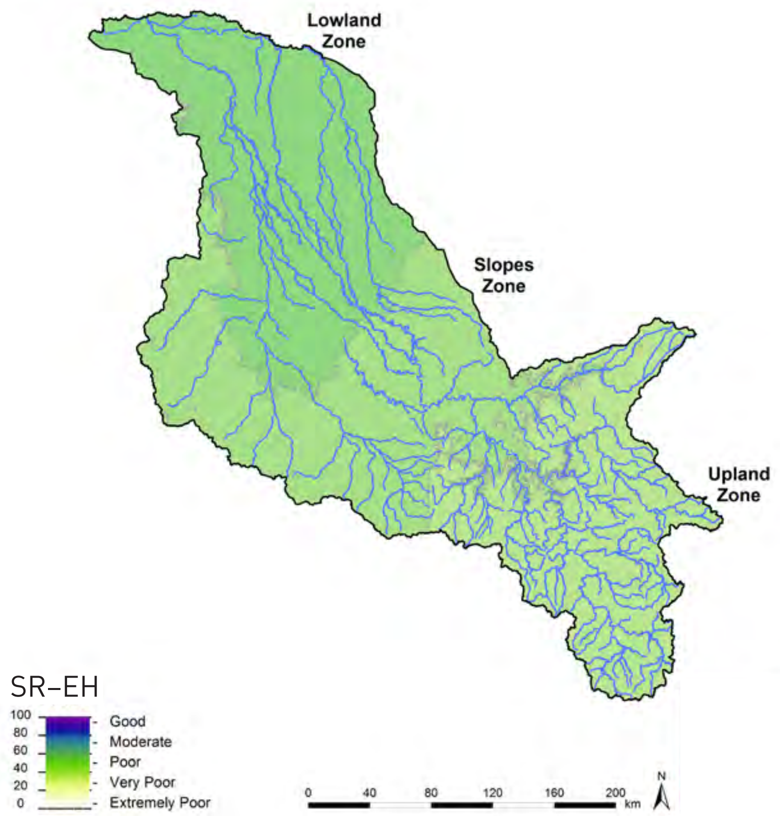



**Figure MCQ 1: Macquarie Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure MCQ 1 shows the Ecosystem Health ratings for the Macquarie Valley and Tables MCQ 1 and MCQ 2 also show the index values and ratings for each theme. Ecosystem health shows a large difference from Reference Condition for the Macquarie Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Moderate and Moderate 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 Macquarie Valley river system. The River Ecosystem Health was rated as Very Poor (Lowland zone: Poor; Slopes zone: Very Poor; Upland zone: Very Poor).

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

*The Macquarie Valley river ecosystem was in Very Poor health. River Ecosystem Health for the zones was as follows: Upland and Slopes Very Poor; Lowland Poor. The Fish community was in Extremely Poor condition. Many expected species were absent. Species count, abundance and biomass were dominated by aliens; recruitment levels among the remaining native species were very low. 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 Moderate condition overall, with reduced abundance, structure and nativeness in the Near Riparian and Lowland Floodplain domains, and very little increase in 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 to high levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition, with mainstem river reaches experiencing considerable change from Reference Condition in low and zero flow events; minor alteration in low and high over bank floods, flow variability and flow seasonality; and little or no alteration in high flow events and flow gross volume.*

### *Ecosystem Health*

The Macquarie Valley ranked third last amongst the SRA valleys in terms of Ecosystem Health, marginally higher that for the Broken and Lachlan valleys (see Table 5.2). All indices of condition, except for Riverine Vegetation, were ranked in the lower 50% of all Basin valleys. Riverine Vegetation condition was ranked eighth. The valley was ranked in the lowest quartile of all SRA valleys for condition of its fish and macroinvertebrate communities.

Flow in the Macquarie is regulated by several in-stream storages (total capacity 1,566 GL) in the upper catchment and the river system supports extensive irrigation. The Hydrology Condition Index reflects this situation with the Upland zone rated as Good and the Slopes and Lowland zones both rated as Poor. This pattern is not so clearly reflected for other Themes. In particular the condition of the fish community in the Upland zone was roughly equivalent to that in the Lowland with similar 'loss' of native species and widespread failure to recruit. It is possible that different factors are responsible for the depressed state of the fish community in the three zones (as with other biota). Further research is required.

### *Fish Theme*

The Fish Condition Index SR–FI = 8, indicating Extremely Poor condition (Lowland zone: Extremely Poor; Slopes zone: Extremely Poor; Upland zone: Extremely Poor). The Expectedness indicator = 17, indicating Extremely Poor condition, and an extreme difference from Reference Condition. The Nativeness indicator = 38, indicating Very Poor condition, and a very large difference from Reference Condition. The Recruitment indicator = 21, indicating Very Poor condition, and a very large difference from Reference Condition.

Much of the native species richness has been lost and alien species contributed over 70% of the biomass in samples. Native fish numbers were high but dominated by small to medium sized species. Native fish recruitment was Extremely Poor in the Upland zone and Very Poor in the Slopes and Lowland zones.

# MACQUARIE VALLEY

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 66, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Poor; Upland zone: Moderate). The simOE metric = 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 site communities in Moderate or Good condition was high across both zones (61% overall), with seven of the 34 rated sites (21%) rated 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 = 66, indicating Moderate condition (Lowland zone: Good; Slopes zone: Moderate; Upland zone: Very Poor). The Vegetation Abundance and Diversity indicator = 72, indicating Moderate condition and 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 = 67, indicating Moderate condition and a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in both 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 floodplain area is close to Reference Condition.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 79, indicating Moderate condition (Lowland zone: Good; Slopes zone: Moderate; Upland zone: Good). The Channel Form indicator = 73, the Bed Dynamics indicator = 68 and the Floodplain Form indicator = 65; all indicating Moderate condition and showing a minor difference from Reference Condition. The Bank Dynamics indicator = 97, indicating Good condition and near Reference Condition.

Overall, the valley's riverine physical form was characterised by channel simplification and adjustments in channel size. Elevated sediment loads since European settlement are associated with minor sedimentation within the river channel and moderate to high sedimentation on the floodplain.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 66, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Poor; Upland zone: Good). The In-Channel Flow Regime indicator = 51, indicating Poor condition and a moderate difference from Reference Condition for the flow regime within the channels. The Over Bank Flow Regime sub-index = 79, indicating Moderate condition and a moderate difference from Reference Condition for the wetting regime in riparian and floodplain areas.

The mainstem river reaches were generally characterised by considerable alteration from Reference Condition in Low and Zero Flow Events, minor alteration in High Over Bank Floods, Low Over Bank Floods, Flow Variability and Flow Seasonality 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 MCQ 1: Macquarie 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 | Very Poor | Very Poor | Poor |

| THEME | | VALLEY | ZONE | | |
|---|---|---|---|---|---|
| | | | UPLAND | SLOPES | LOWLAND |
| Fish | SCORE RATING | 8 (5–14) Ext' Poor | 6 (2–14) Ext' Poor | 14 (8–23) Ext' Poor | 6 (1–16) Ext' Poor |
| Macro-invertebrates | SCORE RATING | 66 (61–70) Moderate | 78 (70–85) Moderate | 55 (47–65) Poor | 63 (54–71) Moderate |
| Vegetation | SCORE RATING | 66 Moderate | 34 Very poor | 67 Moderate | 100 Good |

**Table MCQ 2: Macquarie 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 | 79 (72–83) Moderate | 82 (71–88) Good | 64 (54–75) Moderate | 89 (74–96) Good |
| Hydrology | SCORE RATING | 66 Moderate | 80 Good | 58 Poor | 56 Poor |

# MACQUARIE VALLEY

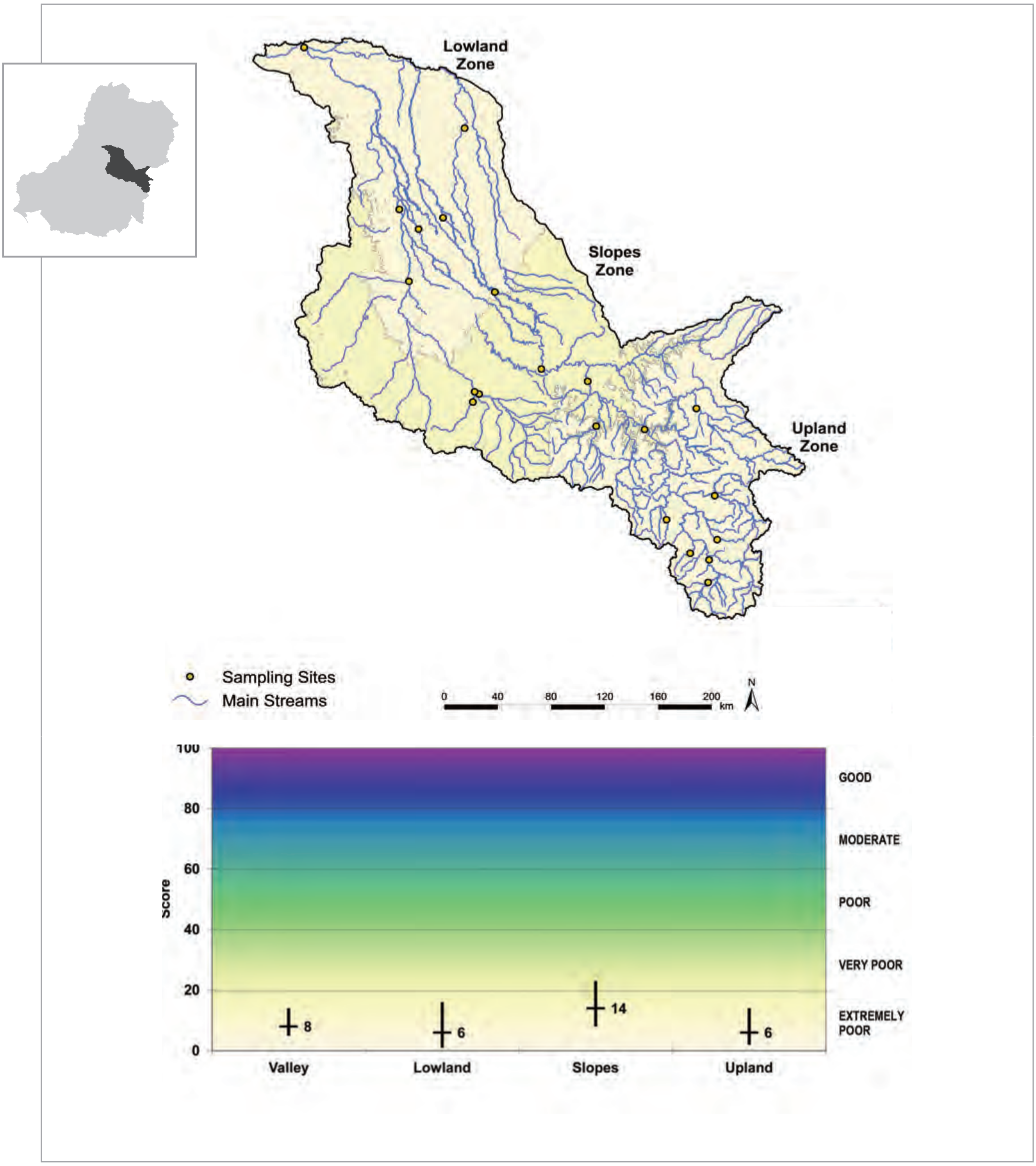



**Figure MCQ 2:** Macquarie Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

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

*The Fish community of the Macquarie Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 8. The condition of the fish community in the Upland, Slopes and Lowland zone 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. The valley had lost much of its native species richness and alien species contributed over 70% of the biomass in samples. Native fish recruitment was Extremely Poor in the Upland zone and Very Poor in the Slopes and Lowland zones.*

Twenty-one sites were surveyed across the Macquarie Valley in January–March 2009, yielding 5,591 fish. Analyses showed an extreme difference from Reference Condition for the Macquarie Valley, with:

- SRA Fish Index (SR–FI) = 8 (CL 5–14), indicating Extremely Poor condition of the fish community.
- The Expectedness indicator = 17 (CL 14–24), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Only 53% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 38 (CL 26–50), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 21 (CL 12–33), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for 6 of the 10 native species caught in the valley.

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

SR–FI for the Macquarie Valley was fourth lowest of all valleys, and close to that for the Broken River Valley. All three zones were assessed as being in Extremely Poor condition.

Expectedness was also rated as Extremely Poor, in all three zones. The Upland and Lowland zones had 38% of the expected native species present in samples, whilst the Slopes zone had 39%.

Nativeness was rated as Poor in the Upland and Slopes zones and Very Poor in the Lowland zone. 44% of the individuals were from alien species, but they made up 71% of the total fish biomass. The Macquarie had the third highest number of fish caught per site of all 23 Basin valleys (equal with the Gwydir Valley), but in terms of biomass it ranked sixteenth with slightly less than 6 kg of fish per site. The native fish assemblage was dominated by small-bodied species. The 96 common carp caught weighed an average of 887 g and contributed 96% of the total biomass of alien fish and 68% of the total fish biomass caught.

# MACQUARIE VALLEY

Table MCQ 4 shows native species abundances in the Macquarie Valley compared with Reference Condition. Mountain galaxias in the Upland zone and gudgeon in the lower two zones were the most numerous native fish. Gambusia was prevalent throughout the valley and was the most numerous alien species. Freshwater catfish, golden perch and Murray cod were present in low numbers. Trout cod, Macquarie perch, silver perch, and river blackfish were not found in samples, the latter two species expected to be present in all three zones.

Recruitment throughout the Macquarie Valley was rated as Very Poor, with six of the 10 native species caught showing evidence of recruitment at any site in the valley. In the Upland zone, recruitment was noted in only two of the six native species caught. In the Slopes and Lowland zones this statistic was four of seven and three of five respectively. All of the five alien species caught were recorded as recruiting in at least some part of the Macquarie Valley.

In general, the fish community of the Macquarie had substantially reduced numbers of expected native species. Native fish numbers were high (fourth highest of all Basin valleys) but the community was dominated by small to medium sized species.

**Table MCQ 3: Macquarie 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) | 8 (5–14) | 6 (2–14) | 14 (8–23) | 6 (1–16) |
| Indicator | Expectedness | 17 (14–24) | 18 (12–32) | 19 (14–29) | 16 (13–26) |
| Metric | O/E | 0.21 (0.13–0.30) | 0.23 (0.10–0.40) | 0.23 (0.13–0.35) | 0.19 (0.08–0.32) |
| Metric | O/P (Zone level) | 0.38 (0.38–0.38) | 0.38 (0.38–0.38) | 0.39 (0.39–0.39) | 0.38 (0.38–0.38) |
| Indicator | Nativeness | 38 (26–50) | 46 (16–69) | 55 (37–75) | 26 (9–44) |
| Metric | Proportion biomass native | 0.31 (0.19–0.44) | 0.36 (0.07–0.67) | 0.47 (0.18–0.79) | 0.21 (0.08–0.36) |
| Metric | Proportion abundance native | 0.46 (0.29–0.64) | 0.45 (0.17–0.76) | 0.52 (0.31–0.75) | 0.42 (0.16–0.73) |
| Metric | Proportion species native | 0.42 (0.29–0.53) | 0.48 (0.19–0.78) | 0.54 (0.38–0.72) | 0.33 (0.16–0.50) |

Continued/...

| Indexes Indicators Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Upland | Slopes | Lowland |
| Indicator | Recruitment | 21 (12–33) | 10 (4–20) | 29 (16–45) | 23 (6–44) |
| Metric | Proportion of sites with native recruits | 0.30 (0.18–0.40) | 0.20 (0.16–0.27) | 0.38 (0.22–0.48) | 0.30 (0.08–0.49) |
| Metric | Proportion of native taxa with recruits | 0.53 (0.39–0.72) | 0.33 (0.20–0.50) | 0.57 (0.33–0.80) | 0.60 (0.33–1.00) |
| Metric | Proportion of abundance as recruits | 0.44 (0.32–0.58) | 0.33 (0.20–0.50) | 0.46 (0.33–0.73) | 0.48 (0.27–0.67) |
| Variables | | | | | |
| | Number of sites sampled | 21 | 7 | 7 | 7 |
| | Total number of species | 15 | 11 | 10 | 8 |
| | Number of native species | 10 | 6 | 7 | 5 |
| | Number of predicted species | 19 | 16 | 18 | 13 |
| | Number of alien species | 5 | 5 | 3 | 3 |
| | Mean number of fish per site | 266 | 197 | 217 | 384 |
| | Biomass/site all species (g) | 5975 | 5313 | 6683 | 5929 |
| | Mean native biomass/fish (g) | 12 | 9 | 23 | 9 |
| | Mean alien biomass/fish (g) | 36 | 43 | 36 | 30 |

# MACQUARIE VALLEY

**Table MCQ 4: Macquarie 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 | 16 | 11 | 5 | 0 |
| Bony herring | 371 | | 17 | 354 |
| Dwarf flathead gudgeon | 0 | 0 | | |
| Flathead gudgeon | 46 | 2 | 44 | |
| Freshwater catfish | 1 | 0 | 0 | 1 |
| Golden perch | 7 | 1 | 4 | 2 |
| Gudgeon | 2040 | 12 | 519 | 1509 |
| Macquarie perch | 0 | 0 | 0 | |
| Mountain galaxias | 625 | 625 | 0 | |
| Murray cod | 8 | 3 | 5 | 0 |
| Murray jollytail | 0 | 0 | 0 | |
| Murray–Darling rainbowfish | 14 | 0 | 14 | 0 |
| Olive perchlet | 0 | | 0 | 0 |
| River blackfish | 0 | 0 | 0 | 0 |
| Silver perch | 0 | 0 | 0 | 0 |
| Southern purple-spotted gudgeon | 0 | 0 | 0 | 0 |
| Spangled perch | 0 | | 0 | 0 |
| Trout cod | 0 | 0 | 0 | |
| Unspecked hardyhead | 7 | 0 | 0 | 7 |

| Fish species | Valley | Zone | | |
|---|---|---|---|---|
| | | Upland | Slopes | Lowland |
| Alien species | | | | |
| Common carp | 96 | 23 | 23 | 50 |
| Gambusia | 2279 | 643 | 879 | 757 |
| Goldfish | 70 | 51 | 8 | 11 |
| Rainbow trout | 2 | 2 | | |
| Redfin perch | 9 | 9 | | |

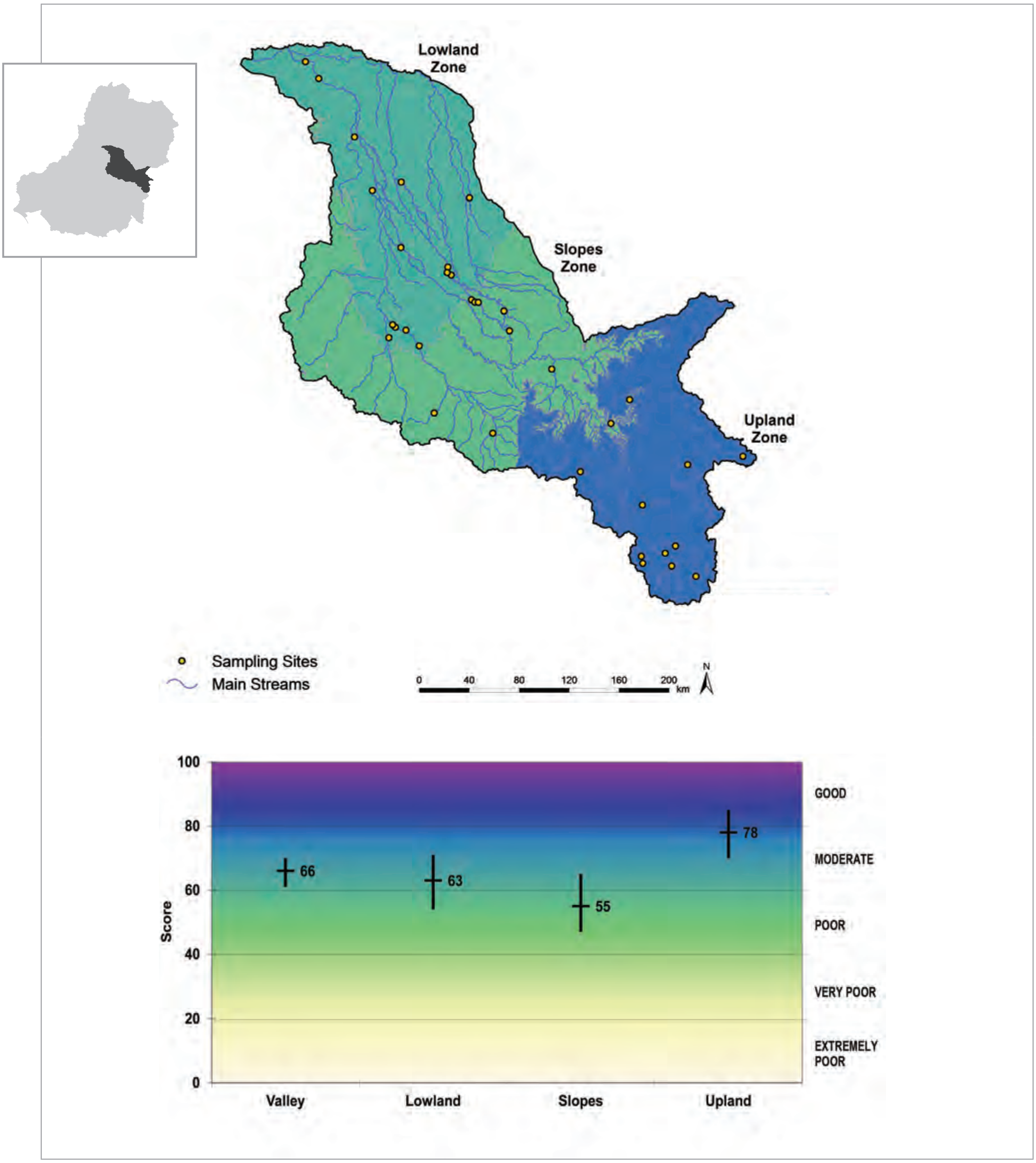



Figure MCQ 3: Macquarie Valley map with sampling sites and zones coloured by SR Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Macquarie Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 66. The condition of the macroinvertebrate community in the zones was as follows: Upland Moderate; Slopes Poor; Lowland Moderate. The proportion of sites in Moderate to Good condition was high (60%); and 7 of the 34 rated sites (21%) were in Good condition. Family richness generally was moderate, but was low compared to Reference Condition.*

Thirty-five sites were surveyed across the Macquarie Valley in September–November 2009 yielding 6,903 macroinvertebrates in 67 families (71% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 66 (CL 61–70), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 46 (CL 45–48) 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 site communities in Moderate or Good condition was high across both zones (60% overall), with seven of the 34 rated sites (21%) rated in Good condition.
- The number of families found was lowest in the Lowland zone (40 families) and highest in the Upland zone (55 families), with the Upland zone also having the highest average number of families per site (25).

Figure MCQ 3 shows sampling sites, zones and SR–MI values, and Table MCQ 5 shows index and metric values. The SR–MI score for the Macquarie Valley indicated Moderate condition of macroinvertebrate communities, rating 18th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Lowland and Upland zones showed moderate differences from Reference Condition (SR–MI = 63 and 78, respectively), while the Slopes zone showed a large difference from Reference Condition (SR–MI = 55). A wider confidence interval (17 points) for the Lowland zone SR–MI value indicates slightly more spatial variability there, though all sites in that zone showed moderate difference from Reference Condition and were in Moderate condition. Expectedness (simOE) was moderate for 24 sites, and varied by up to 24 points among sites.

# MACQUARIE VALLEY

Table MCQ 6 shows that most sites in all three zones had Poor to Moderate SR–MI values, though seven sites (21%) were rated in Good condition (five of which were in the Upland zone). Ten sites had a low simOE score (<40 points), including six of 10 sites sampled in the Slopes zone. All sites had reduced or substantially 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 21 families per site), with the Upland zone being most diverse at site scale (average 25 families per site). The valley contained 71% of the families found across the Basin (Table MCQ 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most of the fauna of the valley was found in the Upland and Slopes zones (82 and 67% respectively).

**Table MCQ 5: Macquarie 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) | 66 (61–70) | 78 (70–85) | 55 (47–65) | 63 (54–71) |
| Metric | SimOE | 46 (45–48) | 52 (48–55) | 42 (39–46) | 45 (42–48) |

Table MCQ 6: Macquarie 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 | 10 | 10 | 15 |
| Number of sites with index values* | 34 | 9 | 10 | 15 |
| N sites by SR–MI condition band | | | | |
| Good (80–100) | 7 | 5 | 1 | 1 |
| Moderate (60–80) | 14 | 3 | 2 | 9 |
| Poor (40–60) | 11 | 1 | 7 | 3 |
| Very or Extremely Poor (0–40) | 2 | | | 2 |
| Families | | | | |
| Number of families sampled | 67 | 55 | 45 | 40 |
| No. families/site (min-max) | 21 (11–39) | 25 (19–39) | 18 (11–30) | 20 (12–32) |
| Percent of families in Basin | 71 | 59 | 48 | 43 |
| Percent of families in valley | 100 | 82 | 67 | 60 |

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

# MACQUARIE VALLEY

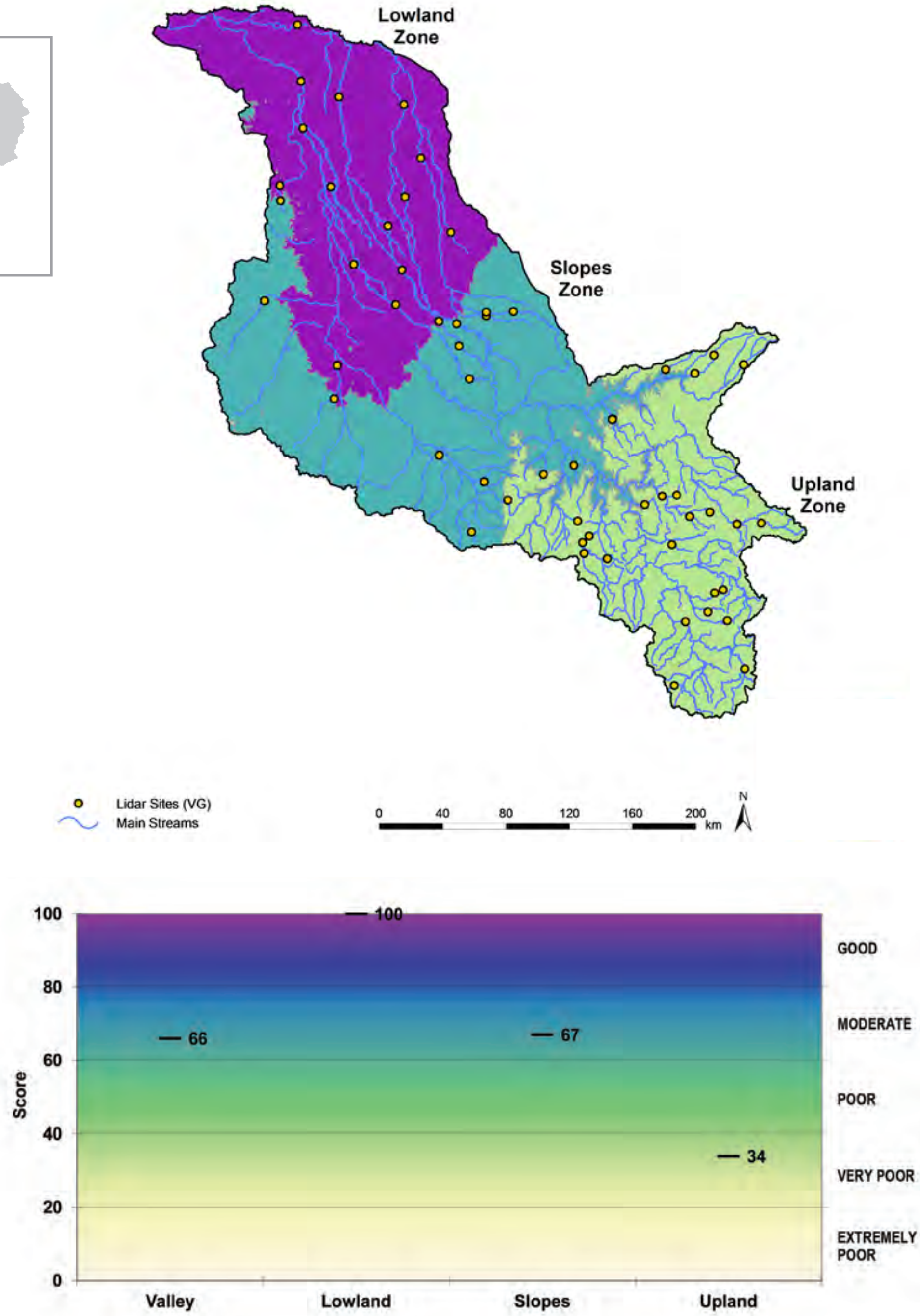



Figure MCQ 4: Macquarie Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR-VI) scores.

Graph shows mean SR-VI scores as horizontal bars.

*The Riverine Vegetation of the Macquarie Valley river system was in Moderate condition, with an aggregate Vegetation Index score (SR–VI) of 66. Overall condition for the three zones in this valley was: Upland Very Poor; Slopes Moderate; Lowland Good.*

*The Abundance and Diversity indicator score was 72 for the valley, indicating a Moderate rating overall. In the three zones it was: Upland Poor; Slopes Moderate; Lowland Good.*

*The Quality and Integrity indicator score was 67 for the valley, indicating a Moderate rating overall. In the three zones it was: Upland Poor; Slopes Moderate; Lowland Good.*

The SRA Vegetation assessment for the Macquarie Valley considers riverine vegetation in two spatial domains: Near Riparian (along 10,009 km of stream) and Lowland Floodplain for 3,819 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. The lengths of stream assessed are fairly similar among zones, as follows: Upland 3,692 km; Slopes 3,012 km; and Lowland 3,305 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 57 sites set back 50 m from the top of the channel bank. LiDAR sites are distributed along the stream network amongst the three zones as follows: Upland 23 sites; Slopes 17 sites; and Lowland 17 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure MCQ 4 shows values of the Vegetation Index (SR–VI) for the Macquarie Valley and Table MCQ 7 shows the index, indicator and sub-indicator values. Tables MCQ 8 and MCQ 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 Macquarie Valley with:

- SRA Vegetation Index (SR–VI) = 66, indicating Moderate condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 72, 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 = 67, 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 slightly affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with a large difference from reference in the Upland zone, 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 determined by 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 is near reference in the Lowland Floodplain domain. MVG richness is maintained in both the Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 91% 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 Upland zone, a moderate difference from Reference Condition 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 MCQ 8 as well as other native but non-specific MVGs. Valley-wide Nativeness in the Near Riparian domain is in Moderate condition, and is near reference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain domain is also near 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 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, with the metrics showing differences between zones and domains. Abundance in the Near Riparian domain shows a large difference from reference in the Upland and Slopes zones, and is near reference in the Lowland zone; and in the Lowland Floodplain domain, abundance is near Reference Condition.

***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, with the metrics showing differences between zones and domains. Nativeness in the Near Riparian domain shows a large difference from reference in the Upland and Slopes zones, and is near reference in the Lowland zone; nativeness 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 some differences between zones. Structure is near Reference Condition in the Upland zone, and is moderately different from reference in the Slopes and Lowland zones. 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 the number of patches and mean patch area being near reference for all MVGs present.

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

- Upland zone: The Near Riparian domain is mostly (58% of domain area) Eucalypt Woodlands with Eucalypt Open Forests (28%) and six other MVGs, of which only one is more than 5% of the domain.

- Slopes zone: The Near Riparian domain is mostly (58%) Eucalypt Woodlands with Eucalypt Open Forests (22%) and seven other MVGs, of which only one is more than 5% of the domain.

- Lowland zone: The Near Riparian domain is mostly (46%) Eucalypt Woodlands with Eucalypt Open Forests (20%) and nine other MVGs, of which three are more than 5% of the domain.

- Lowland zone: The Lowland floodplain domain is mostly Eucalypt Woodlands (38%) with Chenopod Shrublands, Samphire Shrublands and Forblands (24%) and eight other MVGs, of which only two are more than 5% of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley is reduced in the Upland and Slopes zones. The effect on individual MVGs is variable, with the formerly most extensive MVGs, Eucalypt Woodlands and Eucalypt Open Forests, being proportionately reduced but the other MVGs being little affected.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands and Eucalypt Open Forests are reduced (17% and 10% respectively of the domain area). About 58% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands and Eucalypt Open Forest are reduced to 29% and 35% of their reference area however the other five MVGs have areas equal to their reference values.

- Slopes zone: Although reduced, native vegetation in the Near Riparian domain is still mostly Eucalypt Woodlands (20% of domain area) or Eucalypt Open Forests (15%). About 43% of the domain is either cleared or non-native vegetation. The seven smallest MVGs are unaffected, with areas the same as reference, but Eucalypt Woodlands and Eucalypt Open Forests are down to 34% and 65% of their reference area.

- Lowland zone: The Near Riparian domain is still mostly Eucalypt Woodlands (43% of domain area) and Eucalypt Open Forests (20%). About 7% is either cleared or non-native vegetation, and MVGs are little changed. Eight MVGs have the same area as under Reference Condition and three have 90–95% of their reference area. However, Eucalypt Open Woodlands is now only 64% of its reference area.
- Lowland zone: The Lowland floodplain domain is little changed. About 9% is either cleared or non-native vegetation. Most MVGs are the same or very close to their reference area, except for Eucalypt Open Woodlands, which retains 53% of its reference area.

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 June–July 2010. Both techniques are used in the Near Riparian domain, therefore 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 mapping polygon being assessed, the trees may be only a remnant clump or scattered isolates.

Most of the metrics are based on vegetation mapping. 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 Macquarie Valley is in Moderate condition overall, and is notable for the near Reference Condition of the lowland zone. The two indicators, Abundance and Diversity, and Quality and Integrity, are also both rated as Moderate. Quality and Integrity indicator is slightly lower, brought down by a moderate rating for Structure.

Riverine vegetation in the Lowland zone is in better condition than in the Slopes and Upland zones, which are rated Moderate and Poor respectively. Nearly all metrics and sub-indicators are rated near reference, only Structure as moderate. Within the Lowland zone, the Near Riparian and Lowland Floodplain domains are in similar condition, with most metrics rated as near reference, except Structure. The two domains assess parts of the landscape: the Lowland Floodplain is area of land that floods low in the catchment, whereas the Near Riparian domain is centred on all channels in the network.

**Table MCQ 7: Macquarie 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) | 66 | 34 | 67 | 100 |
| Indicator | Abundance and diversity | 72 | 50 | 70 | 100 |
| Metric | LF stability | 0.91 | | | 0.91 |
| Sub-ind. | NRLF richness | 100 | | | 100 |
| Metric | NR richness | 1 | 1 | 1 | 1 |
| Metric | LF richness | 1 | | | 1 |
| Sub-ind. | NRLF abundance | 100 | | | 100 |
| Metric | NR abundance | 0.62 | 0.40 | 0.53 | 0.93 |
| Metric | LF abundance | 0.91 | | | 0.91 |
| Indicator | Quality and integrity | 67 | 49 | 62 | 92 |
| Sub-ind. | NRLF nativeness | 100 | | | 100 |
| Metric | NR nativeness | 0.62 | 0.40 | 0.53 | 0.93 |
| Metric | LF nativeness | 0.91 | | | 0.91 |
| Sub-ind. | NR structure | 71 (63–78) | 83 (70–92) | 70 (55–81) | 60 (44–75) |
| Sub-ind. | LF fragmentation | 95 | | | 95 |

# MACQUARIE VALLEY

**Table MCQ 8: The most abundant MVGs in the Near Riparian domain in the Macquarie 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 | 28 | 22 | 20 |
| 5. Eucalypt Woodlands | 58 | 58 | 46 |
| 6. Acacia Forests and Woodlands | | | 12 |
| 11. Eucalypt Open Woodlands | | | 9 |
| 19. Tussock Grasslands | 10 | 8 | |
| 22. Chenopod Shrublands, Samphire Shrublands and Forblands | | | 8 |

**Table MCQ 9: Most abundant MVGs in the Lowland Floodplain domain in the Macquarie 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 | 1.00 | 0.99 |
| 5. Eucalypt Woodlands | 38 | 0.97 | 1.01 |
| 11. Eucalypt Open Woodlands | 16 | 0.70 | 0.76 |
| 22. Chenopod Shrublands, Samphire Shrublands and Forblands | 24 | 0.96 | 1.03 |

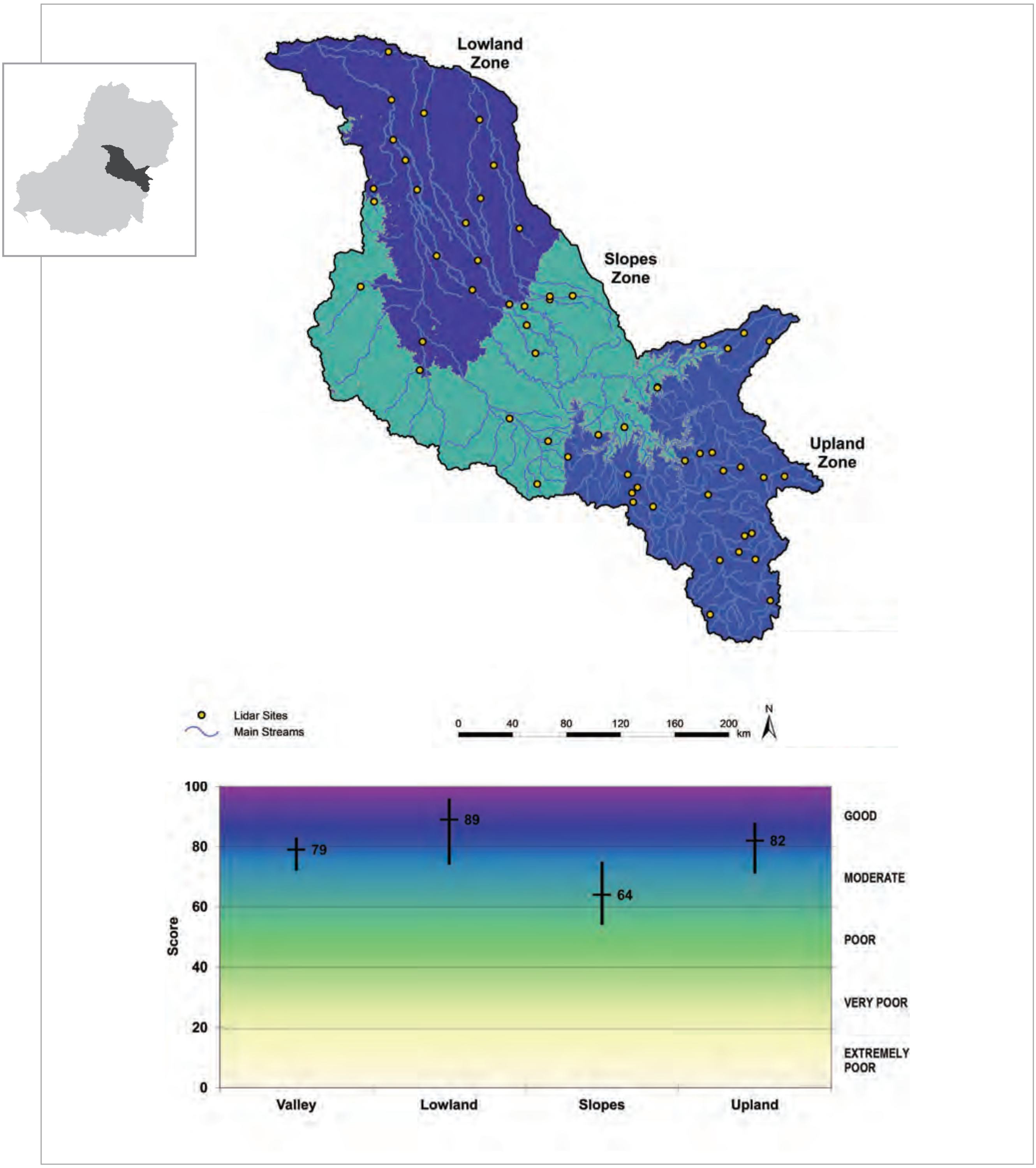



Figure MCQ 5: Macquarie Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR-PI) scores.

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

*The Physical Form of the Macquarie Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 79. The condition of Physical Form in the zones was: Upland Good; Slopes Moderate and Lowland Good. 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 riverine physical form was characterised by channel simplification and adjustments in channel size. Elevated sediment loads since European settlement are associated with minor sedimentation within the river channel and moderate to high sedimentation on the floodplain.*

The SRA Physical Form assessment considers physical form and processes along 10,009 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 625 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 MCQ 5 shows values of the Physical Form Index (SR–PI) for the Macquarie Valley and Table MCQ 10 shows the index, indicator, sub-indicator and metric values.

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

- the SRA Physical Form Condition Index (SR–PI) = 79 (CL 72–83), indicating Moderate physical Form condition
- the Channel Form indicator = 73 (CL 68–79), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 68 (CL 65–70), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 97 (CL 95–99), showing near Reference Condition
- the Floodplain indicator = 65 (CL 61–70), showing a moderate difference from Reference Condition.

***Upland zone***

There were 23 LiDAR survey sites and 135 SedNet river segments in the Upland zone of the Macquarie 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, Sinuosity and Meander Wavelength were modified from reference for approximately half of the Upland zone. At these sites Channel Width and

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

***Slopes zone***

There were 17 LiDAR survey sites and 250 SedNet river segments in the Slopes zone of the Macquarie 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 10% of the zone for the post-European period. Channel Width and Channel Depth were modified from reference in more than half of the Slopes zone. At these sites Channel Width was generally increased (many sites having large increases) and results show both increases and decreases in Channel Depth across the zone. Channel Width Variability, Meander Wavelength and Bank Variability were modified from reference for approximately half of the Slopes zone. At these sites Channel Width Variability was generally reduced, Meander Wavelength was generally increased (many sites having large increases) and results show both increases and decreases in Bank Variability across the zone. Sinuosity and Channel Sediment Deposition were modified from reference for less than half of the Slopes zone. At these sites Sinuosity was generally reduced and there was a large increase in Channel Sediment Deposition across 20% of the zone for the post-European period.

***Lowland zone***

There were 18 LiDAR survey sites and 240 SedNet river segments in the Lowland zone of the Macquarie Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from reference 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, Channel Depth, Sinuosity and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites Channel Width was generally increased, results show both increases and decreases in Channel Depth and Sinuosity 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 Variability, Meander Wavelength and Bank Variability were modified from reference for less than half of the Lowland zone. At these sites results show both increases and decreases in Channel Width Variability and Bank Variability across the zone and Meander Wavelength was generally increased (many sites having large increases).

***Channel Form:***

There was minor change from Reference Condition 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 Upland zone will be constrained by bedrock. Local knowledge is required to interpret any departures from reference planform in bedrock channels.

There was considerable change from reference in Channel Form in the Slopes zone. The more serious impacts were changes in channel size and channel simplification. 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 40% of sites mostly as a result of bed aggradation. Channel simplification was indicated at 80% of sites mostly as a result of channel straightening. There was widespread evidence of channel straightening 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 30% 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 Upland, Slopes and Lowland zones.

There was minor change from Reference Condition in Bed Dynamics in the Upland, Slopes and Lowland zones mostly as a result of widespread elevated sediment load across all three zones (100% of the SedNet river segments) and widespread sedimentation in the Slopes and Lowland zones (40%-50% of the SedNet river segments). In the Slopes and 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 minor change from Reference Condition in Floodplain Sedimentation in the Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

# MACQUARIE VALLEY

**Table MCQ 10: Macquarie 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) | 79 (72–83) | 82 (71–88) | 64 (54–75) | 89 (74–96) |
| Indicator | Channel Form (volume and flow events) | 73 (68–79) | 77 (69–88) | 59 (45–74) | 82 (70–93) |
| Sub-ind. | Cross-section Form | 77 (71–83) | 92 (85–96) | 59 (48–73) | 78 (67–88) |
| Metric | Channel Depth (mean) | 0.99 (0.89–1.09) | 1.00 (0.90–1.07) | 0.98 (0.72–1.25) | 0.98 (0.82–1.19) |
| Metric | Channel Width (mean) | 1.21 (1.12–1.31) | 1.07 (1.01–1.14) | 1.48 (1.22–1.74) | 1.12 (1.01–1.28) |
| Sub-ind. | Cross-section Form (variability) | 96 (93–99) | 96 (92–100) | 93 (84–99) | 99 (98–100) |
| Metric | Channel Width (CV) | 0.98 (0.95–1.02) | 0.96 (0.93–0.99) | 0.95 (0.89–1.02) | 1.04 (1.00–1.12) |
| Sub-ind. | Channel Planform | 73 (66–81) | 67 (56–82) | 67 (52–82) | 86 (70–97) |
| Metric | Sinuosity | 0.98 (0.97–1.00) | 0.95 (0.93–0.98) | 0.99 (0.98–1.00) | 1.00 (0.97–1.04) |
| Metric | Meander Wavelength | 1.16 (1.10–1.21) | 1.20 (1.10–1.29) | 1.19 (1.10–1.29) | 1.07 (1.01–1.17) |

Continued/...

| Indexes<br>Indicators<br>Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Upland | Slopes | Lowland |
| Indicator | Bed Dynamics | 68 (65–70) | 67 (63–70) | 63 (59–67) | 73 (68–77) |
| Metric | Channel Sediment Ratio | 65 (65–72) | 69 (62–77) | 100 (83–118) | 29 (23–36) |
| Metric | Channel Sediment Depth | 0.002 (0.001–0.003) | 0.001 (0–0.003) | 0.003 (0.001–0.006) | 0.001 (0.001–0.002) |
| Indicator | Bank Dynamics | 97 (95–99) | 99 (99–100) | 94 (87–100) | 98 (94–100) |
| Metric | Bank Variability (longitudinal) | 1.03 (0.99–1.08) | 1.03 (0.99–1.06) | 1.04 (0.95–1.18) | 1.02 (0.97–1.09) |
| Indicator | Floodplain | 65 (61–70) | 53 (44–62) | 72 (65–79) | 73 (64–81) |
| Metric | Floodplain Sediment Deposition | 4 (3–5) | 4 (3–5) | 4 (2–7) | 4 (2–5) |

# MACQUARIE VALLEY

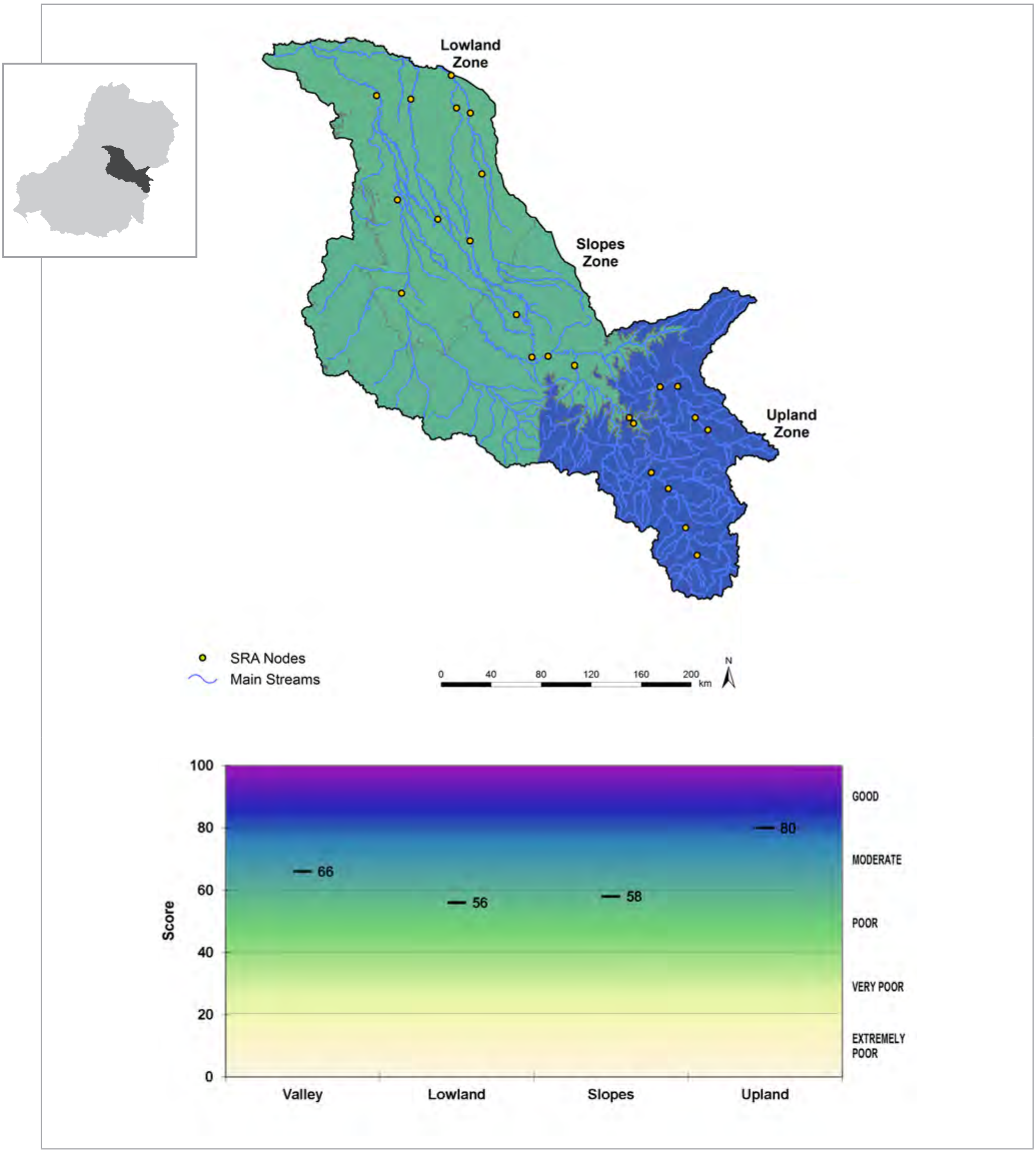



**Figure MCQ 6: Macquarie Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.**
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Macquarie Valley river system was in Moderate condition, with an aggregate Hydrology Index (SR–HI) score of 66. The Upland zone was in Good condition. The Lowland and Slopes zones were in Poor condition.*

*The mainstem river system of the Macquarie Valley was rated in Poor condition. Throughout much of the mainstem river system the duration and frequency of both flood and high flow spells were reduced relative to Reference Condition. This was accompanied by increased magnitude of low flows, reduced amplitude of seasonal flow variations and altered timing of seasonal flow variations throughout much of the mainstem river length.*

*The headwater streams of the Macquarie Valley were rated in Good condition. Throughout some of the headwater streams the magnitude of low flows was reduced relative to Reference Condition.*

The Macquarie River rises near Oberon, in the Central Highlands of New South Wales, and flows north-west through the Macquarie Marshes to join the Barwon River between Walgett and Brewarrina. The Macquarie system is a network of tributaries, anabranches and distributary streams. The hydrology of the lower reaches is complex, with water moving in either direction among the anabranches and the Castlereagh and Barwon, depending on relative flows. The Bogan River also flows through the valley, joining the Darling near Bourke. Instream storages include Burrendong Dam (1,189 GL), at the junction of the Macquarie and Cudgegong rivers, Windamere Dam (361 GL) on the Cudgegong and the Ben Chifley Dam (16 GL) on the upper Macquarie.

In the Macquarie Valley, hydrological condition is assessed using metrics of hydrological alteration available for 10,663 km of mainstem rivers and headwater streams. There is 1,619 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 Macquarie Valley there is 9,044 km of headwater stream (4,365 km in the Upland zone; 4,144 km in the Slopes zone; 534 km in the Lowland zone). 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 Macquarie Valley there is 6,383 km of these mid-size tributaries (1,139 km in the Upland zone; 2,099 km in the Slopes zone; 3,145 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 MCQ 6 and MCQ 7 show values of the Hydrology Condition Index (SR–HI) for the Macquarie Valley and its river network, and Table MCQ 11 and MCQ 12 show the index, sub-index, indicator and metric values. Analyses showed a moderate difference from Reference Condition for the

# MACQUARIE VALLEY

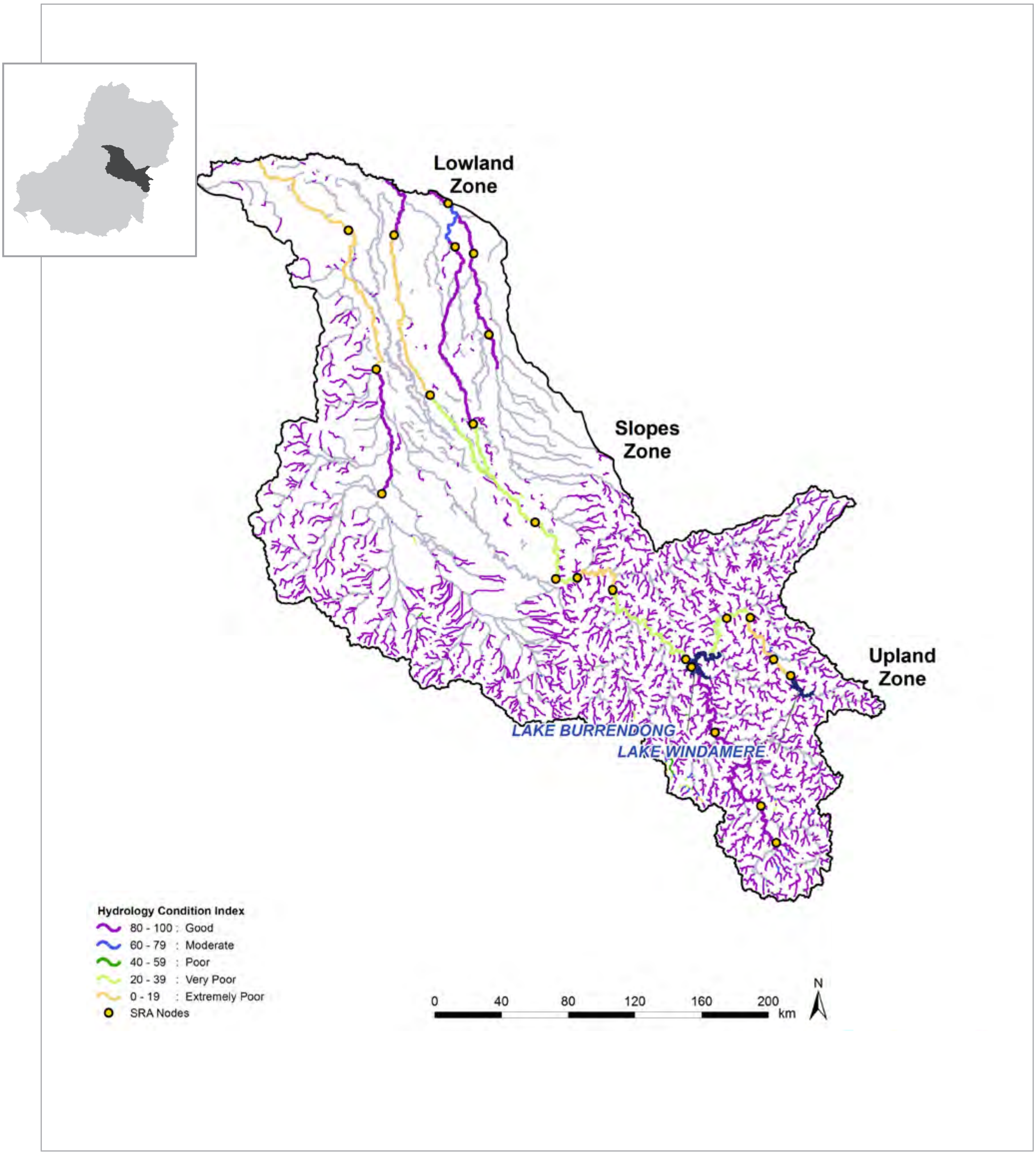



Figure MCQ 7: Macquarie Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Macquarie Valley, with:

- The Hydrology Condition Index for the whole valley = 66, indicating Moderate hydrological condition.
- The Hydrology Condition Index for the Upland, Slopes and Lowland zones = 80, 58 and 56 indicating Good, Poor and 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) = 53, indicating Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 51, 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 = 79, 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 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 proportion 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 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 most 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.

# MACQUARIE VALLEY

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High 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 are distributed across the valley, with most in the Lowland zone. Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 11% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 62% 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 2% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 15% 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 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 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 indicator showed a large difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 29% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 21% 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 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 22% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 6% 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. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 59% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference 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.

In the headwater streams, the Low and Zero Flow Events 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 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 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 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 3% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 63% 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 proportion in the Upland zone, 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 18% of the mainstem river length and a significant alteration from reference in 55% 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 2% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 16% 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 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 moderate difference from 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 reduced variability) and a significant alteration from reference in 48% of the mainstem 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.

# MACQUARIE VALLEY

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 most in the Upland zone, some in the Slopes zone and a small proportion in the Lowland 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 moderate difference from Reference Condition. Results for the Low Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 52% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 21% 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 19% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 47% 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.

***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 53% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 6% 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 30% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 30% 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 Macquarie Valley was generally characterised by considerable alteration in Low and Zero Flow Events relative to Reference Condition, moderate alteration in High Over Bank Floods, Low Over Bank Floods, Flow Variability and Flow Seasonality and little or no alteration in High Flow Events and Flow Gross Volume. Throughout much of the mainstem river system the duration and frequency of both flood and high flow spells were reduced relative to Reference Condition. This was accompanied by increased magnitude of low flows, reduced amplitude of seasonal flow variations and altered timing of seasonal flow variations throughout much of the mainstem river length.

***Summary: headwater streams***

The headwater streams of the Macquarie 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 MCQ 11: Macquarie 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 | 66 | | 80 | 58 | 56 |

# MACQUARIE VALLEY

**Table MCQ 12: Macquarie 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*)** | **53 (8–100)** | **99 (12–100)** |
| Sub-index | In-Channel Flow Regime | 51 (5–100) | 99 (12–100) |
| **Indicator** | **In-Channel Flow Regime A (volume and flow events)** | **64 (19–100)** | **100 (40–100)** |
| Sub-ind. | Flow Gross Volume | 95 (78–100) | 99 (86–100) |
| Metric | Mean Annual Flow | 0.89 (0.67–1.00) | 1.03 (0.77–1.24) |
| Metric | Flow Duration | 1.04 (0.93–1.11) | 0.99 (0.82–1.56) |
| Sub-ind. | High Flow Events | 88 (49–99) | 97 (32–100) |
| Metric | High Flow | 0.95 (0.57–1.47) | 1.00 (0.48–1.90) |
| Metric | High Flow Spells | 0.72 (0.16–1.00) | |
| Sub-ind. | Low and Zero Flow Events | 54 (8–98) | 96 (31–99) |
| Metric | Zero Flows Proportion | 1.20 (0.78–2.00) | 0.99 (0.96–1.00) |
| Metric | Low Flow | 1.28 (0.50–2.00) | 0.88 (0.07–1.50) |
| Metric | Low Flow Spells | 1.47 (0.62–2.00) | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 62 (3–100) | 98 (13–100) |
| Sub-ind. | Flow Seasonality | 65 (32–100) | 96 (56–100) |
| Metric | Flow Seasonal Amplitude | 0.72 (0.50–1.00) | 1.08 (0.89–1.68) |
| Metric | Flow Seasonal Period | 0.70 (0.40–1.00) | 0.96 (0.72–1.00) |
| Sub-ind. | Flow Variability | 67 (0–100) | 91 (0–100) |
| Metric | Flow Variation | 0.87 (0.44–1.40) | 0.92 (0.37–1.00) |
| Sub-index | Over Bank Flow Regime | 79 (28–100) | |
| Indicator | Over Bank Floods Low | 75 (54–99) | |
| Metric | OB Flow Duration (ARI 1) | 0.59 (0.17–1.00) | |
| Metric | OB Flow Spells (ARI 1) | 1.10 (0.44–1.62) | |
| Indicator | Over Bank Floods High | 67 (0–98) | |
| Metric | OB Flow Duration (ARI 8) | 0.59 (0.10–1.09) | |
| Metric | OB Flow Spells (ARI 8) | 0.81 (0.10–1.28) | |

| | Zone | | | | | |
|---|---|---|---|---|---|---|
| | Mainstem rivers | | | Headwater streams | | |
| | Upland | Slopes | Lowland | Montane | Upland | Slopes |
| | **73** | **40** | **56** | | **99** | **100** |
| | 65 | 40 | 53 | | 99 | 100 |
| | **65** | **66** | **63** | | **99** | **100** |
| | 98 | 98 | 93 | | 98 | 100 |
| | 0.94 | 0.93 | 0.86 | | 1.06 | 1.01 |
| | 1.02 | 1.06 | 1.03 | | 1.00 | 0.98 |
| | 97 | 94 | 83 | | 97 | 98 |
| | 1.03 | 1.06 | 0.88 | | 1.10 | 0.91 |
| | 0.87 | 0.74 | 0.69 | | | |
| | 54 | 52 | 56 | | 97 | 96 |
| | 1.00 | 0.95 | 1.36 | | 0.99 | 0.99 |
| | 1.48 | 1.57 | 1.09 | | 0.93 | 0.83 |
| | 1.65 | 1.61 | 1.36 | | | |
| | 71 | 51 | 66 | | 97 | 99 |
| | 84 | 60 | 63 | | 94 | 97 |
| | 0.84 | 0.69 | 0.71 | | 1.14 | 1.04 |
| | 0.87 | 0.65 | 0.69 | | 0.95 | 0.97 |
| | 67 | 53 | 74 | | 90 | 93 |
| | 0.83 | 0.77 | 0.92 | | 0.91 | 0.93 |
| | 89 | 81 | 75 | | | |
| | 85 | 72 | 75 | | | |
| | 0.73 | 0.54 | 0.58 | | | |
| | 1.10 | 1.19 | 1.05 | | | |
| | 96 | 48 | 73 | | | |
| | | | 0.59 | | | |
| | | | 0.81 | | | |

# MITTA MITTA VALLEY

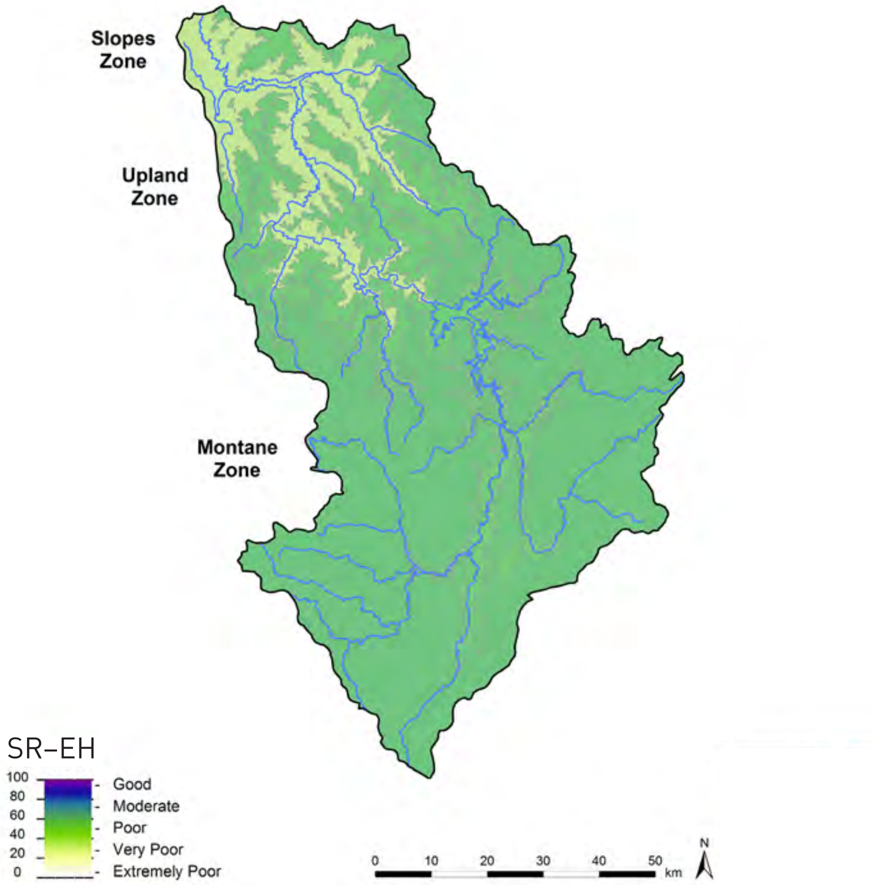



**Figure MIT 1: Mitta Mitta Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure MIT 1 shows the Ecosystem Health ratings for the Mitta Mitta Valley and Tables MIT 1 and MIT 2 also show the index values and ratings for each Theme. Ecosystem health shows a large difference from Reference Condition for the Mitta Mitta Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Good and Moderate 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 Mitta Mitta Valley river system. The River Ecosystem Health was rated as Poor (Slopes zone: Very Poor; Upland zone: Poor; Montane zone: Poor).

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

*The Mitta Mitta Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Montane and Upland Poor; Slopes Very Poor. The Fish community was in Extremely Poor condition. Most expected species were absent. Species count, abundance and biomass was dominated by aliens; and recruitment levels among the remaining native species were low. The Macroinvertebrate community was in Good condition, with minimal to no decline in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Moderate condition overall, with reduced abundance and nativeness in the Near Riparian domain. The Physical Form of the river system was in Good condition overall with channel form, bank and bed dynamics in Good condition. There were moderate levels of floodplain sedimentation. The river system's Hydrology was in Good condition, with mainstem river reaches experiencing considerable change from Reference Condition in flow seasonality, but few other significant changes.*

***Ecosystem health***

The Mitta Mitta River flows through a relatively steep and narrow valley discharging into the southern arm of Lake Hume. The Murray–Darling's largest in-stream storage, Lake Dartmouth (capacity 3900 GL), is situated on the river near the border between the Upland and Slopes zones. Like the Upper Murray, the other major input to Lake Hume, the Mitta Mitta has no Lowland zone (though a small stretch of floodplain exists immediately upstream of Lake Hume).

In terms of River Ecosystem Health the Mitta Mitta Valley ranked 15th amongst the 23 SRA valleys, among the lowest four valleys rated as being in Poor condition, similar to the Avoca, Kiewa and Murrumbidgee (see Table 5.2) It ranked in the upper 50% of valleys in terms of measures of physical condition; eighth in terms of Hydrological condition and equal first (with the Paroo) for Physical Form. The Mitta Mitta was the seventh highest valley in terms of Vegetation condition.

It is noteworthy that the Mitta Mitta was the highest ranking valley in terms of Macroinvertebrates and the lowest ranking in terms of the condition of the Fish community. The fact that this has occurred (and appears to reflect reality) is of interest, demonstrating the value of assessing river condition on a number of fronts.

The Mitta Mitta currently appears to present favourable conditions for sustaining its natural macroinvertebrate assemblage. Little or no alteration in Flow Variability, Low and Zero Flow Events, High Flow Events was reported throughout the valley and the only significant deviation from Reference Condition was in terms of Flow Seasonality in the Slopes zone—the result of irrigation releases from Dartmouth Dam—and the high score for Physical Form would indicate that the stream substrate was in Good condition[1]. Much of this might also describe an appropriate habitat for native fish (with the exception that the change of seasonality of flow through irrigation releases to the Slopes zone also indicates a risk of thermal pollution), but Fish condition was extremely depressed in all three zones (though not necessarily from the same factors throughout). The presence of high numbers of large-bodied alien predators, particularly during a period of extended drought conditions in the Upland and Montane zones may have contributed to the difference between Macroinvertebrate condition and Fish condition in the Mitta Mitta.

1 Personal observation of riffles and emergent vegetation in the Slopes zone supports this view.

# MITTA MITTA VALLEY

### Fish Theme

1. Personal observation of riffles and emergent vegetation in the Slopes zone supports this view.

The Fish Condition Index SR–FI = 5, indicating Extremely Poor condition (Lowland Slopes zone: Extremely Poor; Upland and Montane zones: Extremely Poor). The Expectedness indicator = 15, 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 = 20, 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 96% of the biomass in samples. Native fish recruitment was Very to Extremely Poor.

### Macroinvertebrate Theme

The Macroinvertebrate Condition Index SR–MI = 90, indicating Good condition (Slopes, Upland and Montane zones: Good). The simOE metric = 59, 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 site communities in Moderate or Good condition was high across both zones (97% overall), with 29 of the 34 rated sites in Good condition. Much of the catchment is public land i.e. forests and parks.

Family richness generally was high, and was comparable to Reference Condition.

### Riverine Vegetation Theme

The Riverine Vegetation Condition Index SR–VI = 73, indicating Moderate condition (Slopes zone: Extremely Poor; Upland zone: Good; Montane zone: Good).

The Vegetation Abundance and Diversity indicator = 74, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and richness of major vegetation groups in the Near Riparian domain. The Vegetation Quality and Integrity indicator = 72, indicating Moderate condition and a moderate difference from Reference Condition for the structure and nativeness and of communities and vegetation groups in the Near Riparian domain.

There was no Lowland Floodplain domain to assess in the Mitta Mitta Valley.

### Physical Form Theme

The Physical Form Condition Index SR–PI = 99, indicating Good condition (Slopes zone: Good; Upland zone: Good; Montane zone: Good). The Channel Form indicator = 89, the Bed Dynamics indicator = 85, the Bank Dynamics indicator = 97 and the Floodplain Form indicator = 91; all indicating Good condition and near Reference Condition.

Overall, river Channel Form was in close to Reference Condition, but there was indication of elevated sediment load delivery to the floodplain since European settlement.

### Hydrology Theme

The Hydrology Condition Index SR–HI = 99, indicating Good condition (Slopes, Upland and Montane zones: Good). The In-Channel Flow Regime sub-index = 98, indicating Good condition and near Reference Condition for the flow regime within the channels.

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

**Table MIT 1: Mitta Mitta 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 |
|---|---|---|---|---|---|
| | | Poor | Poor | Poor | Very Poor |

| THEME | | VALLEY | ZONE | | |
|---|---|---|---|---|---|
| | | | MONTANE | UPLAND | SLOPES |
| Fish | SCORE RATING | 5 (3–10) Ext' Poor | 4 (0–16) Ext' Poor | 7 (2–13) Ext' Poor | 5 (1–11) Ext' Poor |
| Macro-invertebrates | SCORE RATING | 90 (87–92) Good | 92 (89–95) Good | 93 (86–96) Good | 81 (75–89) Good |
| Vegetation | SCORE RATING | 73 Moderate | 100 Good | 87 Good | 14 Ext' Poor |

**Table MIT 2: Mitta Mitta 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 |
| Physical Form | SCORE RATING | 99 (96–100) Good | 99 (97–100) Good | 99 (97–100) Good | 98 (88–100) Good |
| Hydrology | SCORE RATING | 99 Good | 100 Good | 100 Good | 99 Good |

# MITTA MITTA VALLEY

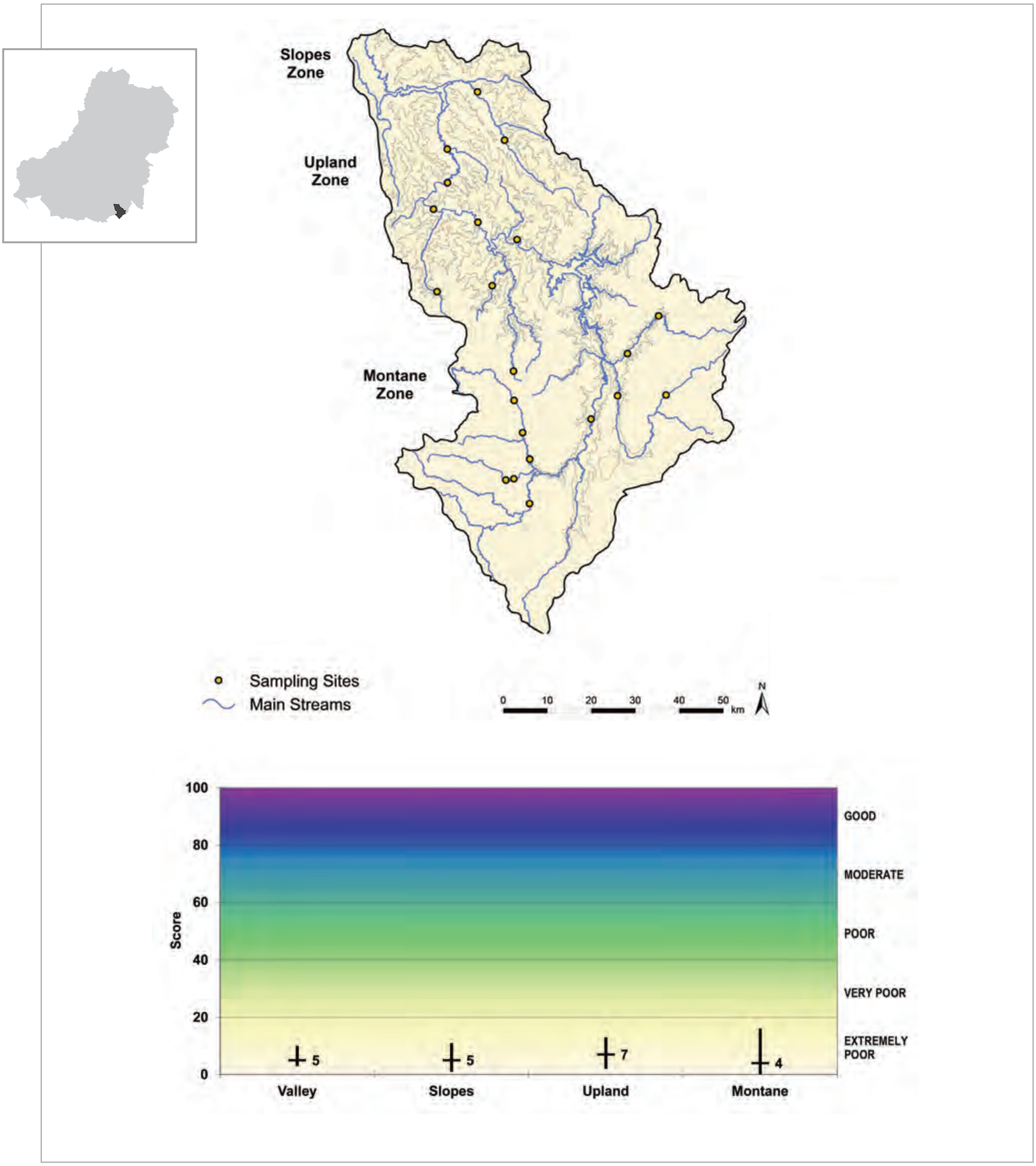



**Figure MIT 2: Mitta Mitta Valley map with sampling sites and zones coloured by SR Fish Index (SR–FI) scores.**

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

*The Fish community of the Mitta Mitta Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 5. The condition of the Fish community was Extremely Poor in all zones. The fish community was characterised by an Extremely Poor score for expected native fish species; and a Very Poor score for nativeness and native fish recruitment. Both the Montane and Upland zones had few fish and lacked almost 66% and 80% of the predicted native species respectively. 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 Extremely Poor, Very Poor, and Extremely Poor in the Montane, Upland, and Slopes zones respectively.*

Twenty-one sites were surveyed across the Mitta Mitta Valley in February–April 2008, yielding 980 fish. Analyses showed an extreme difference from Reference Condition for the Mitta Mitta Valley, with:

- SRA Fish Index (SR–FI) = 5 (CL 3–10), indicating Extremely Poor condition of the fish community.
- The Expectedness indicator = 15 (CL 9–21), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Only 50% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 29 (CL 19–39), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 20 (CL 11–29), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for three of the eight native species observed in the valley.

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

SR–FI for the Mitta Mitta Valley was the lowest for all valleys, and close to that for the Lachlan and Broken valleys. All three zones were in Extremely Poor condition (SR–FI = 4, 7, and 5 respectively for the Montane, Upland, and Slopes zones).

Expectedness was rated as Very Poor in the Montane zone and Extremely Poor in the other two zones, with two of six, two of ten and six of 16 expected native species caught in each zone respectively. The Mitta Mitta had the third lowest Expectedness score of the 23 SRA valleys, outscoring only the Campaspe and Lachlan valleys.

Nativeness varied amongst zones with the Montane zone rated as Extremely Poor, the Upland zone as Poor, and the Slopes zone as Very Poor. The relatively high Nativeness score for the Upland zone reflects both the low number and diversity of alien fish in the zone, and the capture of 114 two-spined blackfish in six of the seven sites sampled. Only one other native fish, a galaxias, was caught in that zone.

# MITTA MITTA VALLEY

Table MIT 4 shows native species abundances in the Mitta Mitta Valley compared with Reference Condition. Two-spined blackfish (mainly in the Upland zone) and Australian smelt (mainly in the Slopes zone) were the two most numerous native species. Macquarie perch and trout cod were not caught, though expected in all three zones. Freshwater catfish, golden perch, and silver perch were expected at lower altitudes but did not appear in any samples. Five alien species were recorded in the Mitta Mitta Valley with common carp, gambusia, and redfin perch restricted mainly to the Slopes zone.

The Mitta Mitta Valley had the fourth highest fish biomass per site (14.4 kg) of the 23 valleys, but only 3.5% of this was contributed by native species. Large-bodied native species were rare throughout the valley. The two Murray cod caught totalled 5.8 kg in weight with the remaining 363 native fish together weighing 4.8 kg. The common carp caught in the Slopes zone weighed a total of nearly 267 kg or 38 kg per site.

Recruitment was low amongst native species throughout the valley. It was rated as Extremely Poor in the Montane zone, Very Poor in the Upland zone and Extremely Poor in the Slopes zone. In both the Montane and Upland zones only one of two native species sighted was considered to show evidence of recruitment. The same statistic for the Slopes zone was two of six. All five alien species were considered to have recruited in at least some sites throughout the valley.

In general, the Fish community of the Mitta Mitta had considerably reduced numbers of expected native species. Native biomass, as a proportion of total fish biomass, was the lowest of all 23 Basin valleys, as was the Fish Index score (SR–FI of 5).

**Table MIT 3: Mitta Mitta 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 |
| Index | Fish Condition (SR–FI) | 5 (3–10) | 4 (0–16) | 7 (2–13) | 5 (1–11) |
| Indicator | Expectedness | 15 (9–21) | 24 (8–42) | 5 (2–9) | 18 (14–26) |
| Metric | O/E | 0.27 (0.17–0.36) | 0.36 (0.10–0.61) | 0.21 (0.12–0.30) | 0.23 (0.16–0.32) |
| Metric | O/P (Zone level) | 0.29 (0.29–0.29) | 0.33 (0.33–0.33) | 0.20 (0.20–0.20) | 0.38 (0.38–0.38) |

Continued/...

| Indexes<br>Indicators<br>Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes |
| Indicator | Nativeness | 29 (19–39) | 11 (1–33) | 40 (24–54) | 35 (10–54) |
| Metric | Proportion biomass native | 0.24 (0.13–0.37) | 0.15 (0–0.34) | 0.30 (0.13–0.46) | 0.29 (0.01–0.59) |
| Metric | Proportion abundance native | 0.36 (0.24–0.47) | 0.20 (0.04–0.370) | 0.52 (0.32–0.68) | 0.34 (0.11–0.61) |
| Metric | Proportion species native | 0.38 (0.27–0.49) | 0.33 (0.10–0.57) | 0.39 (0.23–0.52) | 0.42 (0.26–0.64) |
| Indicator | Recruitment | 20 (11–29) | 16 (5–30) | 28 (13–43) | 14 (1–23) |
| Metric | Proportion of sites with native recruits | 0.36 (0.21–0.43) | 0.31 (0.10–0.50) | 0.50 (0.20–0.50) | 0.24 (0.08–0.33) |
| Metric | Proportion of native taxa with recruits | 0.45 (0.36–0.69) | 0.50 (0.50–0.50) | 0.50 (0.50–1.00) | 0.33 (0.20–0.50) |
| Metric | Proportion of abundance as recruits | 0.19 (0.11–0.29) | 0.16 (0.03–0.36) | 0.12 (0.05–0.29) | 0.33 (0.20–0.50) |
| Variables | | | | | |
| | Number of sites sampled | 21 | 7 | 7 | 7 |
| | Total number of species | 13 | 4 | 5 | 11 |
| | Number of native species | 8 | 2 | 2 | 6 |
| | Number of predicted species | 16 | 6 | 10 | 16 |
| | Number of alien species | 5 | 2 | 3 | 5 |
| | Mean number of fish per site | 47 | 27 | 25 | 88 |
| | Biomass/site all species (g) | 14371 | 1007 | 1096 | 41010 |
| | Mean native biomass/fish (g) | 29 | 11 | 24 | 34 |
| | Mean alien biomass/fish (g) | 474 | 41 | 81 | 717 |

# MITTA MITTA VALLEY

**Table MIT 4: Mitta Mitta 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 |
| Sites sampled | 21 | 7 | 7 | 7 |
| Native species | | | | |
| Australian smelt | 150 | | 0 | 150 |
| Flathead gudgeon | 0 | | 0 | 0 |
| Freshwater catfish | 0 | | | 0 |
| Galaxias | 1 | 0 | 1 | 0 |
| Golden perch | 0 | | | 0 |
| Gudgeon | 0 | | | 0 |
| Macquarie perch | 0 | 0 | 0 | 0 |
| Mountain galaxias | 11 | 11 | 0 | 0 |
| Murray cod | 2 | 0 | 0 | 2 |
| Murray jollytail | 0 | | | 0 |
| Obscure galaxias complex | 5 | | | 5 |
| River blackfish | 35 | | 0 | 35 |
| Silver perch | 0 | | 0 | 0 |
| Southern pygmy perch | 18 | | | 18 |
| Trout cod | 0 | 0 | 0 | 0 |
| Two-spined blackfish | 143 | 16 | 114 | 13 |

Continued/...

| Fish species | Valley | Zone | | |
|---|---|---|---|---|
| | | Montane | Upland | Slopes |
| Alien species | | | | |
| Brown trout | 267 | 162 | 52 | 53 |
| Common carp | 165 | | 1 | 164 |
| Gambusia | 130 | | | 130 |
| Rainbow trout | 11 | 2 | 8 | 1 |
| Redfin perch | 42 | | | 42 |

# MITTA MITTA VALLEY

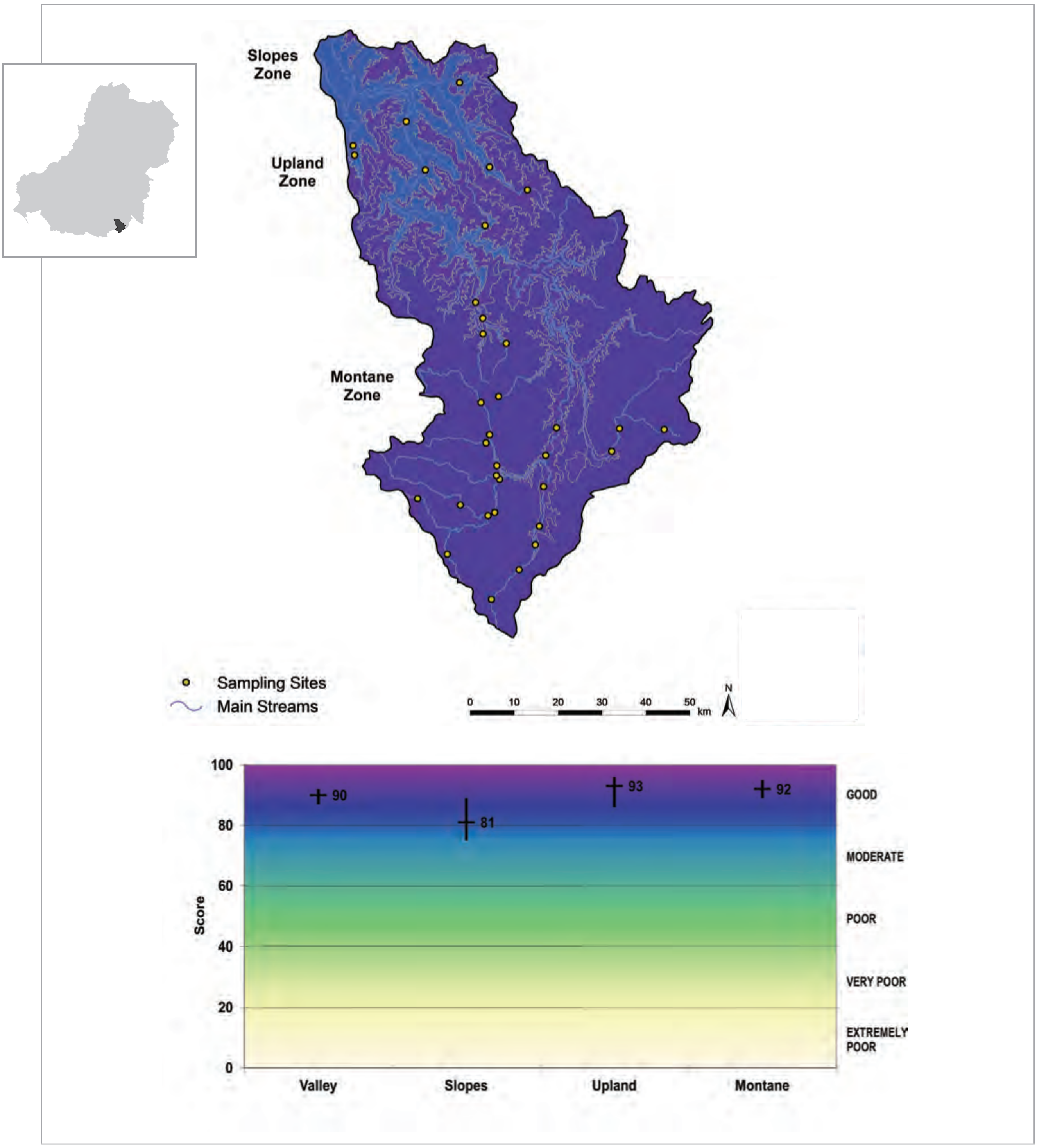



Figure MIT 3: Mitta Mitta Valley map with sampling sites and zones coloured by SR Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Mitta Mitta Valley river system was in Good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 90. The condition of the Macroinvertebrate community in the zones was as follows: Montane Good; Upland Good; Slopes Good. The proportion of sites in Good condition was high (85%). Family richness generally was high, and was comparable to Reference Condition.*

Thirty-four sites were surveyed across the Mitta Mitta Valley in November 2009 yielding 8,713 macroinvertebrates in 73 families (78% of Basin families). Analyses showed a minor difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 90 (CL 87–92), indicating Good condition of benthic macroinvertebrate communities.
- The simOE metric = 59 (CL 57–61) indicating a 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 site communities in Moderate or Good condition was high across both zones (97% overall), with 29 of the 34 rated sites (85%) in Good condition (spread across all zones).
- The number of families found was lowest in the Slopes zone (49 families) and highest in the Upland zone (59 families), with all zones having similar average numbers of families per site (27–31).

Figure MIT 3 shows sampling sites, zones and SR–MI values, and Table MIT 5 shows index and metric values. The SR–MI score for the Mitta Mitta Valley indicated Good condition of macroinvertebrate communities, rating 1st (in best condition) out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of all zones were rated in Good condition overall, with the Montane and Upland zones showing no or minor differences from Reference Condition (SR–MI = 92 and 93, respectively), while the Slopes zone rated slightly lower (SR–MI = 81). Small confidence interval (6–14 points) across all zone SR–MI values indicates little variability, with only one site (in the Upland zone) rating in Poor condition, falling just below moderate. Expectedness (simOE) was high to moderate across all sites and varied by up to 26 points among sites.

Table MIT 6 shows that most sites in all zones had high SR–MI values. No zone had sites with a low simOE score (<40 points). Most sites contained the expected diversities of macroinvertebrates, though coupled with some reductions in frequency of occurrence of several families present.

# MITTA MITTA VALLEY

Family richness generally was comparable to Reference Condition. Diversity was high (average 29 families per site), with the Upland zone being most diverse at site scale (average 31 families per site). The valley contained 78% of the families found across the Basin (Table MIT 6), with the Slopes zone having the lowest representation of Basin-wide fauna. Most (77 – 81%) of the fauna of the valley was found in each of the Montane and Upland zones.

**Table MIT 5: Mitta Mitta 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 |
| Index | Macroinvertebrate Condition (SR–MI) | 90 (87–92) | 92 (89–95) | 93 (86–96) | 81 (75–89) |
| Metric | SimOE | 59 (57–61) | 61 (58–63) | 61 (58–64) | 54 (50–59) |

Table MIT 6: Mitta Mitta Valley distribution of sample sites and values of derived variables.

| Number of sites and families sampled | Valley | Zone | | |
|---|---|---|---|---|
| | | Montane | Upland | Slopes |
| Sites | | | | |
| Number of sites sampled | 34 | 13 | 14 | 7 |
| Number of sites with index values* | 34 | 13 | 14 | 7 |
| N sites by SR–MI condition band | | | | |
| Good (80–100) | 29 | 12 | 13 | 4 |
| Moderate (60–80) | 4 | 1 | | 3 |
| Poor (40–60) | 1 | | 1 | |
| Very or Extremely Poor (0–40) | | | | |
| Families | | | | |
| Number of families sampled | 73 | 56 | 59 | 49 |
| No. families/site (min-max) | 29 (15–40) | 28 (22–38) | 31 (15–40) | 27 (18–37) |
| Percent of families in Basin | 78 | 60 | 63 | 52 |
| Percent of families in valley | 100 | 77 | 81 | 67 |

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

# MITTA MITTA VALLEY

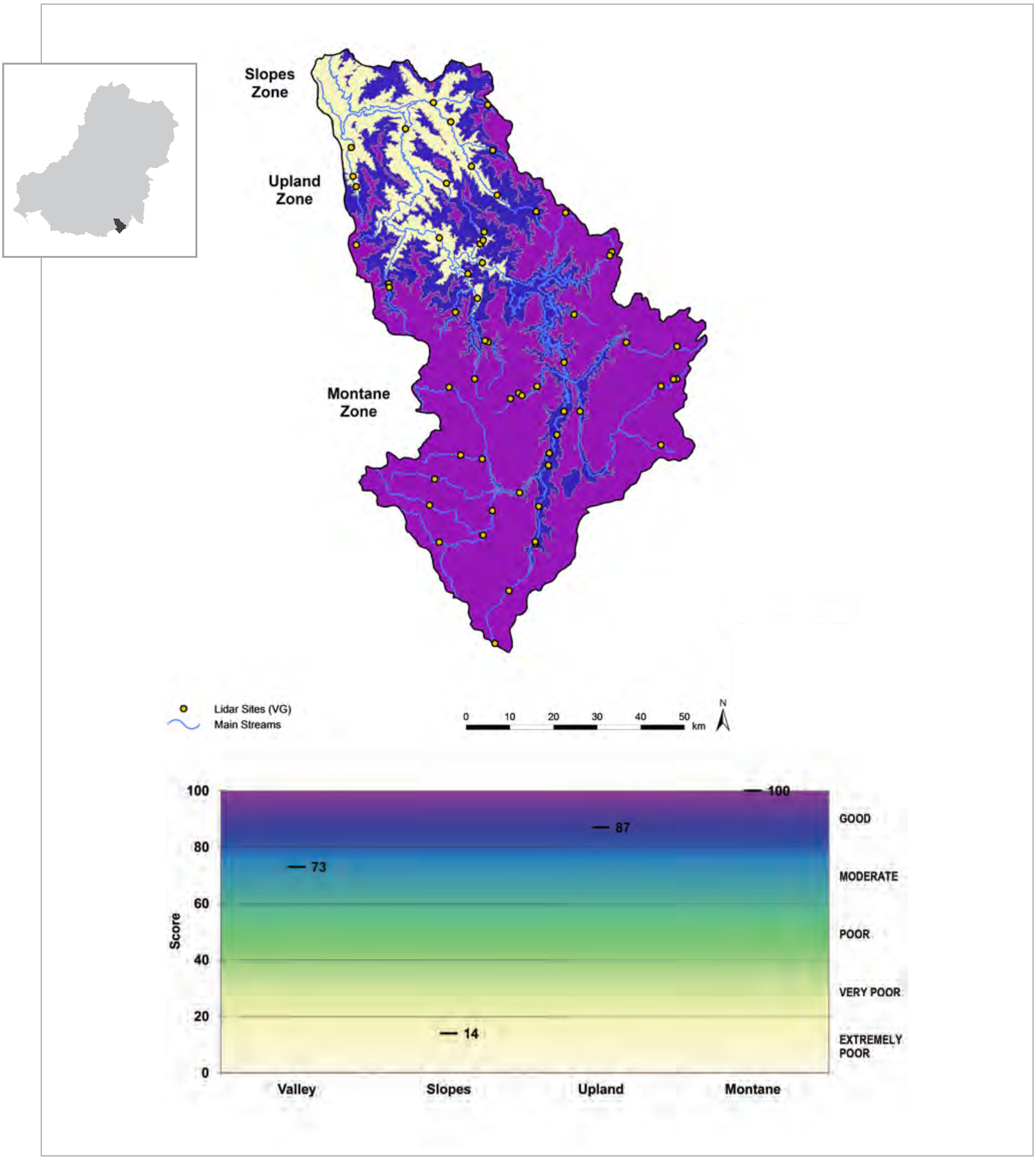



Figure MIT 4: Mitta Mitta Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR-VI) scores.

Graph shows mean SR-VI scores as horizontal bars.

*The Riverine Vegetation of the Mitta Mitta Valley river system was in Moderate condition, with an aggregate Vegetation Index score (SR–VI) of 73. Overall condition for the three zones in this valley was: Montane and Upland: Good; Slopes Extremely Poor.*

*The Abundance and Diversity indicator score was 74 for the valley, indicating a Moderate rating overall. In the three zones it was: Montane Good; Upland Moderate and Slopes Very Poor.*

*The Quality and Integrity indicator score was 72 for the valley, indicating a Moderate rating overall. In the three zones it was: Montane Good; Upland Moderate; Slopes Very Poor.*

The SRA Vegetation assessment for the Mitta Mitta Valley considers riverine vegetation in just one spatial domain, the Near Riparian, along 1,008 km of stream. Stream length per zone is as follows: Montane 386 km; Upland 367 km; and Slopes 255 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 61 sites set back 50 m from the top of the channel bank. LiDAR sites are distributed along the stream network, amongst the three zones as follows: Montane, 23 sites; Upland, 22 sites; and Slopes, 16 sites. There is no assessment of a Lowland Floodplain domain because the Mitta Mitta Valley does not have a Lowland zone.

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

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

- SRA Vegetation Index (SR–VI) = 73, indicating Moderate condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 74, indicating a moderate 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 = 72, indicating a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian domain.
- There is no Lowland zone so there is no Lowland Floodplain domain to assess in Mitta Mitta valley.

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with MVGs showing near Reference Condition in the Montane zone, a moderate difference from reference in the Upland zone, and a very large difference from reference in the Slopes 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 for the Near Riparian domain shows a large difference from reference. MVG richness is retained, as no vegetation group has been completely reduced.

# MITTA MITTA VALLEY

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, and highly variable between zones. It is near Reference Condition in the Montane zone, shows a moderate difference from Reference Condition in the Upland zone and a very large difference from reference in the Slopes 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 MIT 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.

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 domain, is in Good condition overall, with no loss of any MVG in any of the zones from the Near Riparian domain.

***Abundance***

- The Abundance of pre–1750 MVGs in the Near Riparian domain is in Poor condition overall, and highly variable between zones. Abundance is near Reference Condition in the Montane zone, shows a large difference from Reference Condition in the Upland zone, and a very large difference from Reference Condition in the Slopes zone.

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 Poor condition overall, and highly variable between zones. Nativeness is near Reference Condition in the Montane zone, shows a large difference from reference in the Upland zone, and a very large difference from reference in the Slopes zone.

***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, with little difference in scores between zones as shown by overlapping confidence limits. Structure is near Reference Condition in the Montane and Upland zones, and moderately different from reference in the Slopes 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.

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

- Montane zone: The Near Riparian domain is mostly (55% of domain area) Eucalypt Woodlands, with Eucalypt Open Forests (30%) and five other MVGs, of which only one was 5% of the domain.

- Upland zone: The Near Riparian domain is mostly (74%) Eucalypt Open Forests with five other MVGs of which two are at least 5% of the domain.
- Slopes zone: The Near Riparian domain is mostly (48%) Eucalypt Woodlands with Callitris Forests and Woodlands (22%) and Eucalypt Open Forests (20%).

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been considerably reduced in the Slopes zone but less elsewhere. The effect on individual MVGs varies between zones and is greatest in the Slopes zone:

- Montane zone: In the Near Riparian domain, Eucalypt Woodlands (41% of domain area) and Eucalypt Open Forests (28%) are still the most extensive MVGs. About 19% is either cleared or non-native vegetation. Five MVGs have areas close to their Reference Condition; the most severely proportionally reduced is Other Shrublands, though originally relatively small, it is now reduced to 14% of its reference area. The largest absolute area decline is in Eucalypt Woodland.
- Upland zone: In the Near Riparian domain, Eucalypt Open Forests are reduced but still the most extensive MVG (47% of the domain). About 25% of the domain is either cleared or non-native vegetation. All MVGs are affected. Two are reduced to 24% and 26% of their reference area, and the other four MVGs, including Eucalypt Open Forests, have areas that are 52% to 64% of their Reference Condition.
- Slopes zone: In the Near Riparian domain, the formerly extensive Eucalypt Woodlands, Callitris Forests and Woodlands, and Eucalypt Open Forests are reduced to 5%, 2% and 9% of total domain area, respectively. About 61% of the domain is either cleared or non-native vegetation. Most MVGs are reduced in area, except for the very smallest. Woodlands are more affected than forests: Eucalypt Woodlands is 10% of its reference area, and Eucalypt Open Forests is 46% of its reference area.

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–July 2010. This means that the Structure sub-indicator which is based on LiDAR data and mapping metrics such as 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, which is not current and can be variable in quality. About 45% of the Near Riparian domain in the Slopes zone is not assigned to an MVG. The condition of the Near Riparian domain, and hence of the three zones and of the valley itself, may have changed since the source mapping was compiled.

# MITTA MITTA VALLEY

The riverine vegetation of the Mitta Mitta Valley is notable for the marked contrast in condition between the top and bottom of the valley (the Montane and Slopes zones), and for the very low abundance of MVGs and low nativeness in the Near Riparian domain in the Slopes zone.

Condition of riverine vegetation is best in the Montane zone, where the metrics indicate that MVG abundance, nativeness, richness and structure are all in near Reference Condition. In contrast, the Slopes zone is in Extremely Poor condition, with very low scores for abundance and nativeness, although there is no loss of any MVG and structure is in Moderate condition. The Slopes zone has the least influence on the valley score.

**Table MIT 7: Mitta Mitta 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 |
| Index | Vegetation Condition (SR–VI) | 73 | 100 | 87 | 14 |
| Indicator | Abundance and diversity | 74 | 98 | 78 | 32 |
| Metric | LF stability | | | | |
| Sub-ind. | NRLF richness | | | | |
| Metric | NR richness | 1 | 1 | 1 | 1 |
| Metric | LF richness | | | | |
| Sub-ind. | NRLF abundance | | | | |
| Metric | NR abundance | 0.57 | 0.81 | 0.58 | 0.20 |
| Metric | LF abundance | | | | |

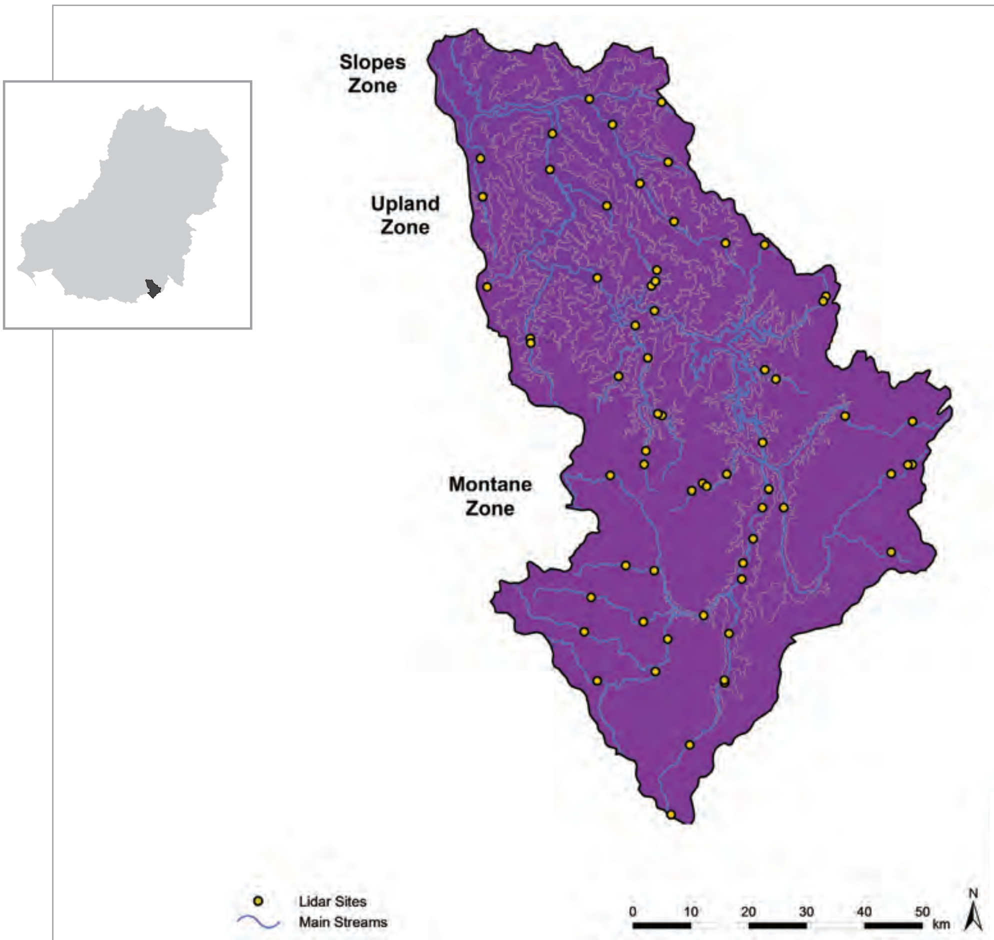
Continued/...

| Indexes Indicators Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes |
| Indicator | Quality and integrity | 72 | 96 | 74 | 31 |
| Sub-ind. | NRLF nativeness | | | | |
| Metric | NR nativeness | 0.57 | 0.81 | 0.58 | 0.20 |
| Metric | LF nativeness | | | | |
| Sub-ind. | NR structure | 81 (76–84) | 84 (79–88) | 80 (70–86) | 76 (68–84) |
| Sub-ind. | LF fragmentation | | | | |

**Table MIT 8: The most abundant MVGs in the Near Riparian domain in the Mitta Mitta 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 |
| MVG | | | |
| 2. Eucalypt Tall Open Forests | 9 | 10 | |
| 3. Eucalypt Open Forests | 30 | 74 | 20 |
| 5. Eucalypt Woodlands | 55 | 11 | 48 |
| 7. Callitris Forests and Woodlands | | | 22 |

# MITTA MITTA VALLEY



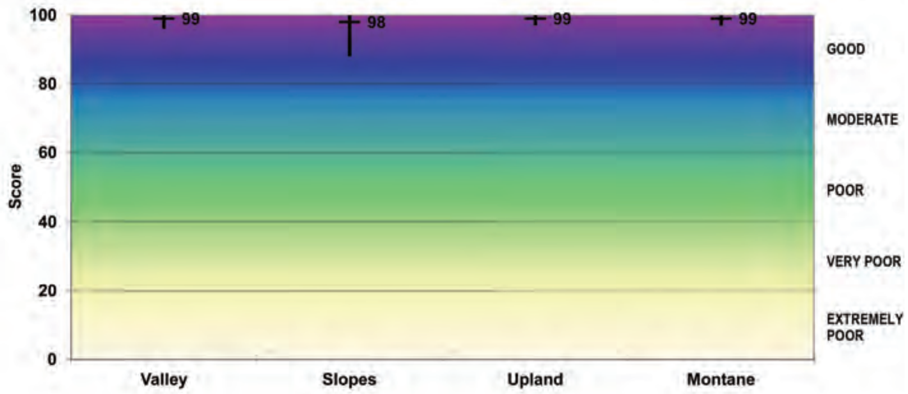




Figure MIT 5: Mitta Mitta Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

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

*The Physical Form of the Mitta Mitta Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 99. The condition of Physical Form in the zones was: Montane, Upland and Slopes Good. The valley's river Channel Form, Bank Dynamics, Bed Dynamics and Floodplain Dynamics were rated as Good. Overall, river Channel Form was in close to Reference Condition, but there was indication of elevated sediment load delivery to the floodplain since European settlement.*

The SRA Physical Form assessment considers physical form and processes along 1,008 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 71 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 MIT 5 shows values of the Physical Form Index (SR–PI) for the Mitta Mitta Valley and Table MIT 9 shows the index, indicator, sub-indicator and metric values.

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

- the SRA Physical Form condition Index (SR–PI) = 99 (CL 96–100), indicating Good Physical Form condition
- the Channel Form indicator = 89 (CL 84–93), showing near Reference Condition
- the Bed Dynamics indicator = 85 (CL 81–90), showing near Reference Condition
- the Bank Dynamics indicator = 97 (CL 95–99), showing near Reference Condition.
- the Floodplain indicator = 91 (CL 85–97), showing near Reference Condition.

This overall assessment of Good condition for this valley is consistent with previous field observations and geomorphology studies (M. Thoms pers. comm.).

***Montane zone***

There were 24 LiDAR survey sites and 16 SedNet river segments in the Montane zone of the Mitta Mitta 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 (a few sites having large increases). Meander Wavelength and Bank Variability were modified from reference for approximately half of the Montane zone. At these sites Meander Wavelength and Bank Variability were generally increased (many sites having large increases in Meander Wavelength). Channel Depth and

Sinuosity were modified from Reference Condition for less than half of the Montane zone. At these sites results show both increases and decreases in Channel Depth across the zone and Sinuosity was generally increased. Channel Width, Channel Width Variability and Channel Sediment Deposition were largely unmodified from Reference Condition in the Montane zone. These results are consistent with field observations (Rutherfurd pers. comm.).

***Upland zone***

There were 24 LiDAR survey sites and 32 SedNet river segments in the Upland zone of the Mitta Mitta Valley. Based on these samples, Channel Sediment Ratio was 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). Floodplain Sediment Deposition was modified from Reference Condition in more than half of the Upland zone. Channel Depth, Channel Width Variability and Bank Variability were modified from reference for approximately half of the Upland zone. At these sites results show both increases and decreases in Channel Depth across the zone, Channel Width Variability was generally reduced and Bank Variability was generally increased indicating enhanced Bank Dynamics. Sinuosity and Meander Wavelength were modified from reference for less than half of the Upland zone. At these sites Sinuosity and Meander Wavelength were generally increased (many sites having large increases in Sinuosity and a few sites having large increases in Meander Wavelength). Channel Width and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

***Slopes zone***

There were 16 LiDAR survey sites and 23 SedNet river segments in the Slopes zone of the Mitta Mitta 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 (a few sites having large increases). Floodplain Sediment Deposition was modified from Reference Condition in more than half of the Slopes zone. At these sites 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 for approximately half of the Slopes zone. At these sites Channel Width Variability was generally reduced and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Depth was modified from reference for less than half of the Slopes zone. At these sites results show both increases and decreases in Channel Depth across the zone. Channel Width, Sinuosity, Meander Wavelength and Channel Sediment Deposition were largely unmodified from Reference Condition in the Slopes zone. These changes are consistent with field observations, except that there is abundant evidence of major widening and instability in the main channel of the Mitta Mitta River due to effects of flow regulation (Watts 2005). Streams of the Slopes one have also been affected by sedimentation from historical gold mining.

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

There was little change from Reference Condition in Channel Form in the Upland and Slopes zones. There was widespread evidence of 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, Upland and Slopes zones. Bank variability exceeded Reference Conditions at 30–49% 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 zone.

There was little change from reference in Bed Dynamics in the Montane, Upland and Slopes zones despite widespread elevated sediment load (80%-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 little change from Reference Condition in Floodplain Sedimentation in the Slopes zone as a result of widespread sedimentation (70% of SedNet river segments).

# MITTA MITTA VALLEY

**Table MIT 9: Mitta Mitta 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 |
| Index | Physical Form Condition (SR–PI) | 99 (96–100) | 99 (97–100) | 99 (97–100) | 98 (88–100) |
| Indicator | Channel Form (volume and flow events) | 89 (84–93) | 85 (77–92) | 92 (85–98) | 89 (79–97) |
| Sub-ind. | Cross-section Form | 88 (83–93) | 87 (80–94) | 91 (81–97) | 87 (75–96) |
| Metric | Channel Depth (mean) | 1.03 (0.95–1.14) | 1.01 (0.92–1.10) | 1.02 (0.91–1.18) | 1.09 (0.90–1.37) |
| Metric | Channel Width (mean) | 1.06 (1.02–1.12) | 1.07 (0.99–1.18) | 1.04 (0.99–1.13) | 1.08 (1.02–1.17) |
| Sub-ind. | Cross-section Form (variability) | 95 (92–98) | 96 (92–99) | 95 (90–99) | 92 (84–99) |
| Metric | Channel Width (CV) | 0.96 (0.93–0.99) | 0.97 (0.93–0.99) | 0.97 (0.92–1.02) | 0.93 (0.87–0.98) |
| Sub-ind. | Channel Planform | 88 (83–92) | 84 (73–93) | 90 (82–96) | 91 (81–98) |
| Metric | Sinuosity | 1.06 (1.03–1.09) | 1.03 (1.01–1.07) | 1.09 (1.02–1.17) | 1.05 (1.00–1.13) |
| Metric | Meander Wavelength | 1.06 (1.02–1.12) | 1.12 (1.04–1.25) | 1.04 (1.00–1.10) | 1.00 (0.92–1.09) |

Continued/...

| Indexes Indicators Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes |
| Indicator | Bed Dynamics | 85 (81–90) | 87 (81–95) | 83 (78–91) | 84 (75–90) |
| Metric | Channel Sediment Ratio | 10 (7–13) | 10 (4–14) | 11 (5–15) | 10 (5–16) |
| Metric | Channel Sediment Depth | 0.004 (0–0.009) | 0 (0–0) | 0.002 (0–0.007) | 0.01 (0–0.03) |
| Indicator | Bank Dynamics | 97 (95–99) | 99 (97–100) | 99 (98–100) | 93 (82–100) |
| Metric | Bank Variability (longitudinal) | 1.07 (1.03–1.11) | 1.04 (1.00–1.08) | 1.08 (1.02–1.13) | 1.10 (1.00–1.24) |
| Indicator | Floodplain | 91 (85–97) | 93 (87–100) | 92 (87–99) | 84 (65–98) |
| Metric | Floodplain Sediment Deposition | 2.00 (0.55–4.00) | 0.60 (0.10–1.01) | 1.71 (0.25–4.00) | 5.00 (0.40–12.00) |

# MITTA MITTA VALLEY

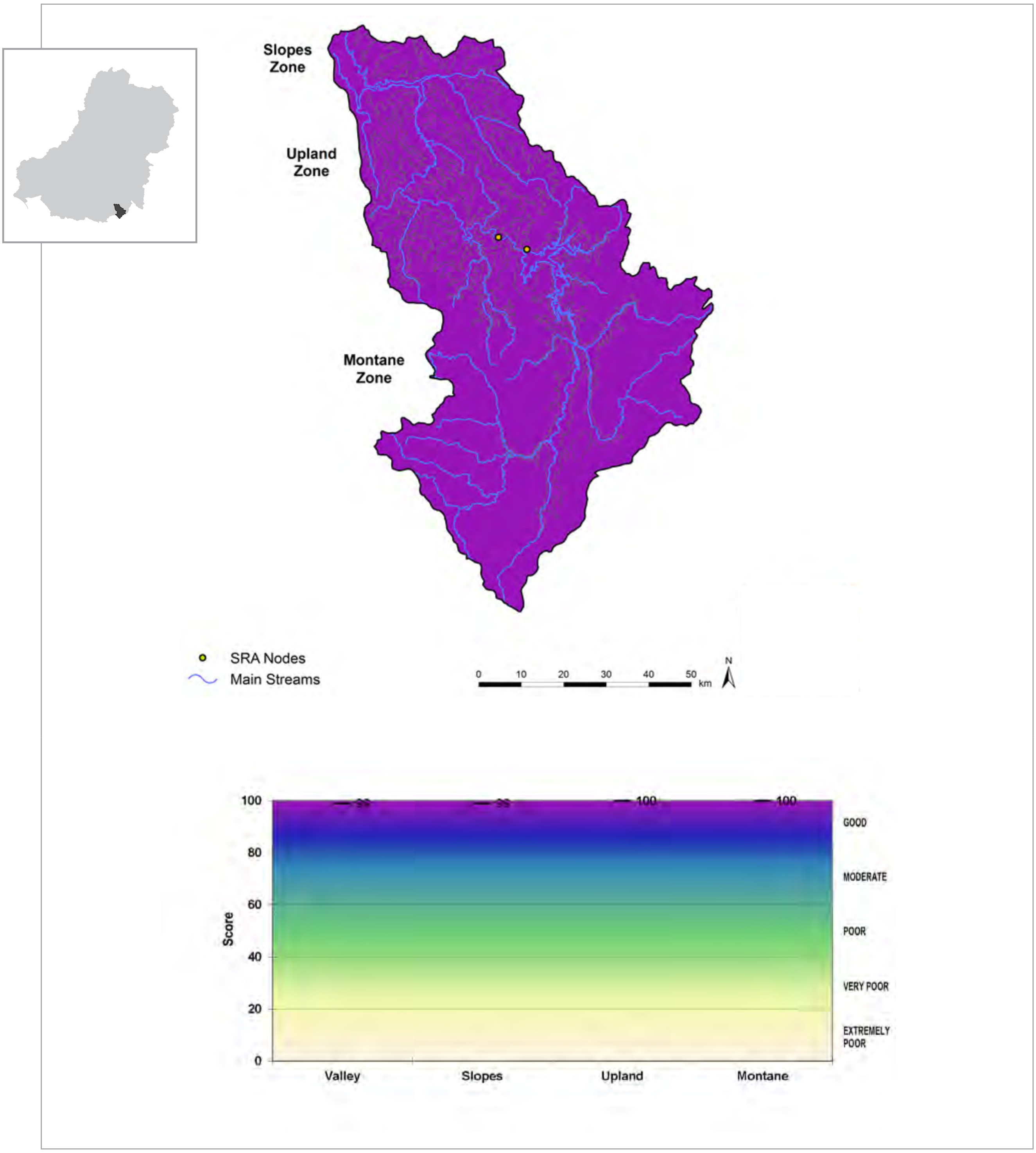



Figure MIT 6: Mitta Mitta Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

*The Hydrology of the Mitta Mitta Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 99. The Slopes, Upland and Montane zones were in Good condition. The mainstem river system of the Mitta Mitta Valley was rated in Good condition. However, throughout all of the mainstem river, high flows were increased and timing of seasonal flow variations was altered relative to Reference Condition. The headwater streams of the Mitta Mitta Valley were rated in Good condition.*

The Mitta Mitta River rises in the Great Dividing Range east of Falls Creek township, near the Kiewa headwaters, where four tributaries (Big, Bundara and Cobungra rivers, Livingstone Creek) join. The river flows north-west to meet the Murray via the south arm of Lake Hume. Tallangatta Creek, formerly a tributary to the Mitta Mitta, now enters Lake Hume nearby. Other tributaries to the Mitta Mitta Slopes zone are Snowy Creek and Little Snowy Creek, both rising at Mount Bogong. The Mitta Mitta Valley is narrow and steep for most of its length, forming a floodplain only as it approaches Lake Hume. The largest instream storage in the Basin, Lake Dartmouth (3,900 GL), is at the junction of the Mitta Mitta Slopes and Upland zones. Originally intended as a drought reserve, long periods of low rainfall and increased irrigation demand have resulted in substantial releases in most years since its construction in 1979.

In the Mitta Mitta Valley, hydrological condition is assessed using metrics of hydrological alteration available for 1,080 km of mainstem rivers and headwater streams. There are 111 km of mainstem river extending across the Slopes zone. 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 Mitta Mitta Valley there is 969 km of headwater stream (451 km in the Montane zone; 314 km in the Upland zone; 203 km in the Slopes zone). 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 Mitta Mitta Valley there is 403 km of these mid-size tributaries (105 km in the Montane zone; 198 km in the Upland zone; 100 km in the Slopes 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.

# MITTA MITTA VALLEY

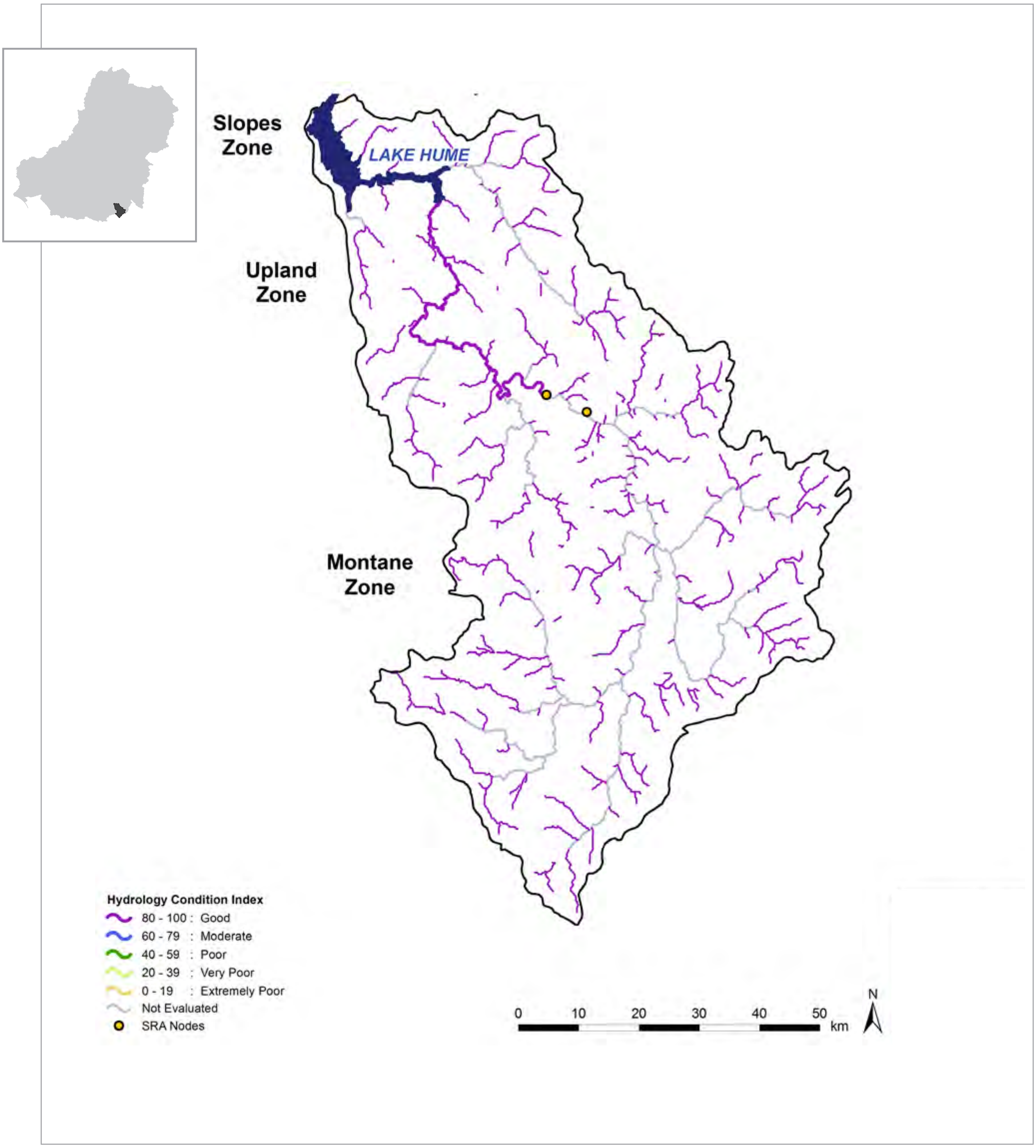



Figure MIT 7: Mitta Mitta Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures MIT 6 and MIT 7 show values of the Hydrology Condition Index (SR–HI) for the Mitta Mitta Valley and its river network, and Table MIT 10 and MIT 11 show the index, sub-index, indicator and metric values. Analyses showed near Reference Condition for the Mitta Mitta Valley, with:

- The Hydrology Condition Index for the whole valley = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for the Montane, Upland and Slopes zones = 100, 100 and 99 indicating Good, Good and Good 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) = 98, indicating Good hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 98, 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 only small variations from reference throughout the mainstem river length (mostly associated with increased flows). Results for the Flow Duration metric showed no significant variations from reference.

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 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 Slopes zone.

***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.

# MITTA MITTA VALLEY

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed a significant alteration from reference in 100% 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 Slopes 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 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 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. 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 only small variations from reference throughout the mainstem river length (mostly associated with reduced flows). 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 significant alteration from reference in 11% 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 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. The Seasonal Period metric quantifies change in the timing of the seasonal maximum and minimum monthly flows relative to Reference Condition.

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

Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 100% 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 19% of the headwater river length (mostly associated with 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 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 increased variability).

### *Summary: mainstem rivers*

The mainstem river system of the Mitta Mitta Valley was generally characterised by considerable alteration in Flow Seasonality, little or no alteration in Flow Variability, Low and Zero Flow Events, High Flow Events or Flow Gross Volume relative to Reference Condition. Throughout all of the mainstem river, high flows were increased and timing of seasonal flow variations was altered.

### *Summary: headwater streams*

The headwater streams of the Mitta Mitta 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.

**Table MIT 10: Mitta Mitta 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 |
| Hydrology Condition SR–HI | 99 | 100 | 100 | 99 |

# MITTA MITTA VALLEY

**Table MIT 11: Mitta Mitta 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*)** | **98 (98–98)** | **100 (80–100)** |
| Sub-index | In-Channel Flow Regime | 98 (98–98) | 100 (80–100) |
| **Indicator** | **In-Channel Flow Regime A (volume and flow events)** | **100 (100–100)** | **100 (93–100)** |
| Sub-ind. | Flow Gross Volume | 100 (100–100) | 99 (91–100) |
| Metric | Mean Annual Flow | 1.02 (1.02–1.02) | 1.04 (0.92–1.18) |
| Metric | Flow Duration | 0.99 (0.99–0.99) | 1.02 (0.94–1.31) |
| Sub-ind. | High Flow Events | 97 (97–97) | 99 (78–100) |
| Metric | High Flow | 1.20 (1.20–1.20) | 1.09 (0.93–1.57) |
| Metric | High Flow Spells | | |
| Sub-ind. | Low and Zero Flow Events | 98 (98–98) | 97 (77–99) |
| Metric | Zero Flows Proportion | 1.01 (1.01–1.01) | 1.00 (0.96–1.00) |
| Metric | Low Flow | 0.88 (0.88–0.88) | 1.07 (0.60–1.55) |
| Metric | Low Flow Spells | | |
| **Indicator** | **In-Channel Flow Regime B (seasonality & variability)** | **81 (81–81)** | **100 (60–100)** |
| Sub-ind. | Flow Seasonality | 56 (56–56) | 96 (70–100) |
| Metric | Flow Seasonal Amplitude | 1.11 (1.11–1.11) | 1.12 (0.95–1.57) |
| Metric | Flow Seasonal Period | 0.48 (0.48–0.48) | 0.99 (0.89–1.00) |
| Sub-ind. | Flow Variability | 89 (89–89) | 99 (50–100) |
| Metric | Flow Variation | 1.11 (1.11–1.11) | 0.98 (0.73–1.00) |
| 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 |
| | | **98** | | **100** | **100** | **100** |
| | | 98 | | 100 | 100 | 100 |
| | | **100** | | **100** | **100** | **100** |
| | | 100 | | 99 | 99 | 98 |
| | | 1.02 | | 1.04 | 1.03 | 1.07 |
| | | 0.99 | | 1.02 | 1.02 | 1.04 |
| | | 97 | | 99 | 99 | 97 |
| | | 1.20 | | 1.07 | 1.07 | 1.16 |
| | | 98 | | 98 | 98 | 96 |
| | | 1.01 | | 1.00 | 1.00 | 0.99 |
| | | 0.88 | | 1.04 | 1.06 | 1.16 |
| | | **81** | | **100** | **100** | **99** |
| | | 56 | | 97 | 97 | 92 |
| | | 1.11 | | 1.09 | 1.10 | 1.21 |
| | | 0.48 | | 0.99 | 0.99 | 0.98 |
| | | 89 | | 99 | 99 | 97 |
| | | 1.11 | | 0.99 | 0.99 | 0.96 |

# MURRAY VALLEY–UPPER

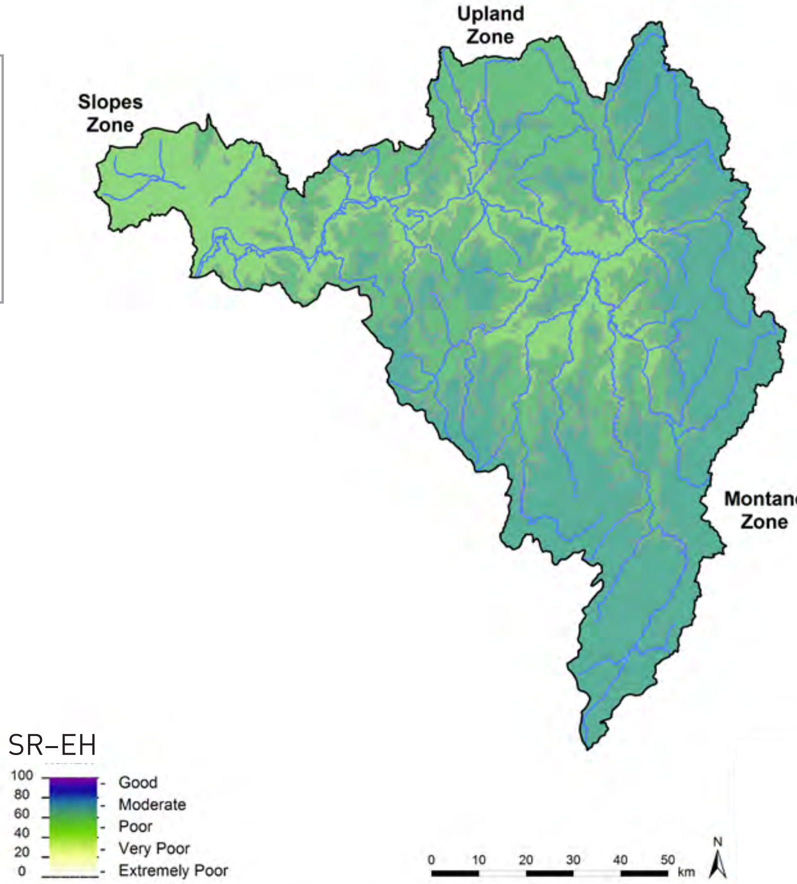



**Figure MUP 1: Upper Murray Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure MUP 1 shows values of the Ecosystem Health Rating for the Upper Murray Valley and Tables MUP 1 and MUP 2 shows the index values and ratings for each theme. Analyses showed a large difference from Reference Condition for the Upper Murray Valley as a whole. The river system's Fish, Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Good and Moderate 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 Upper Murray Valley river system. The River Ecosystem health was rated as Poor (Slopes zone: Poor; Upland zone: Poor; Montane zone: Moderate).

***Ecosystem health***

The Upper Murray Valley has no Lowland zone (like the Mitta Mitta Valley), though there are some areas of floodplain at its downstream end and along some tributaries. It has no large in-stream storages (other than Hume Dam in the Slopes zone which is shared with the Mitta Mitta Valley) and supports limited irrigation, mostly on tributary floodplains. It receives a large inter-valley transfer from the Snowy Mountains Hydroelectric Scheme, at Khancoban in the Slopes zone.

*The Upper Murray Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Montane Moderate, Upland Poor, Slopes 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. Recruitment levels among the remaining native species were Very to Extremely Poor across all zones. The Macroinvertebrate community was in Good condition, with substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Moderate condition overall, with 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 was low to moderate floodplain sedimentation. The river system's Hydrology was in Poor condition, with mainstem river reaches characterised by substantial changes from Reference Condition in flow variability and low and zero flow events; and minor changes in flow seasonality.*

The Upper Murray is ranked 11th amongst the 23 SRA valleys in terms of River Ecosystem Health, and is in mid-position among the 15 valleys rated as being in Poor Health (see Table 5.2). It is ranked second lowest (above the Lower Murray) in terms of Hydrological Condition as a result of the effect of the inter-valley transfer on the condition of the Slopes zone. It also ranks lowly (16th) for Fish condition, but is in the upper 50% of valleys for the other condition indices. It ranks second highest for Macroinvertebrate Condition.

Stream discharge from the Upper Murray catchment (and excluding inter-valley transfers) was very low in the period 2001–2009, although, as a large proportion of the catchment is above the snow-line, there would be annual Winter-Spring flows in Montane and Upland zones. Hydrological Condition was rated as Good in those zones. The difference in the state of fish and macroinvertebrates is similar to the situation in other upper catchment streams in the Murray–Darling Basin, implying that, under current conditions, Montane and Upland streams are capable of supporting macroinvertebrate communities in Good condition but that their native fish communities are in a depressed state. Several reasons are possible.

- Drought conditions may affect the two communities differently. Loss of habitat complexity and connectivity may have severe impacts on native fish whilst reduced areas of riffle and edge habitat might result in changes to macroinvertebrate densities on a zone scale but have limited influence on the diversity of organisms supported.
- There are few native fish species represented in low order streams making calculated metrics numerically sensitive to change.
- Native fish in these zones (usually small-bodied) are susceptible to relatively high densities of alien predators – particularly under drought (refugial) conditions.
- Some combination of these or other factors.

It is important that future studies are directed at understanding this situation to better guide river management in the future.

***Fish Theme***

The Fish Condition Index SR–FI = 19, indicating Extremely Poor condition (Slopes zone: Very Poor; Upland zone: Extremely Poor; Montane zone: Very Poor). The Expectedness indicator = 40, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 47, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 13, indicating Extremely Poor condition, and an extreme difference from Reference Condition.

# MURRAY VALLEY–UPPER

Native species richness and biomass was substantially reduced relative to Reference Condition and alien species contributed over 91% of fish biomass. Native fish recruitment was very to Extremely Poor across all zones, while the majority of alien species were actively recruiting.

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 89, indicating Good condition (Slopes zone: Good; Upland zone: Good; Montane zone: Good). The simOE metric = 59 (CL 56–61) 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 site communities in Good condition was high across all zones (72% overall), nine of the 32 rated sites (28%) were rated in Moderate condition, and none in Poor condition.

Family richness generally was high, and also high relative to Reference Condition.

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 63, indicating Moderate condition (Slopes zone: Extremely Poor; Upland zone: Good; Montane zone: Good). The Vegetation Abundance and Diversity indicator = 66, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and richness of major vegetation groups in the Near Riparian domain. The Vegetation Quality and Integrity indicator = 65, indicating Moderate condition and a moderate difference from Reference Condition for the structure and nativeness of communities and vegetation groups in the Near Riparian domain.

No Lowland Floodplain domain was present for assessment in the Upper Murray Valley.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 94, indicating Good condition (Slopes zone: Good; Upland zone: Good; Montane zone: Good). The Channel Form indicator = 87, the Bank Dynamics indicator = 96 and the Floodplain Form indicator = 81; all indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 75, 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.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 41, indicating Poor condition (Slopes zone: Poor; Upland zone: Good; Montane zone: Good). The In-Channel Flow Regime indicator = 16, indicating Extremely Poor condition and an extreme difference from Reference Condition for the flow regime within the channels.

The Over Bank Flow Regime sub-index in the mainstem river reaches = 77, indicating Moderate condition and a moderate difference from Reference Condition for the wetting regime in riparian and floodplain areas.

Mainstem river reaches were generally characterised by substantial alteration from Reference Condition values for Flow Variability and Low and Zero Flow Events and minor alteration in Flow Seasonality. The headwater streams were generally characterised by little or no alteration in these indicators.

**Table MUP 1: Upper Murray 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 |
|---|---|---|---|---|---|
| | | Poor | Moderate | Poor | Poor |

| THEME | | VALLEY | ZONE | | |
|---|---|---|---|---|---|
| | | | MONTANE | UPLAND | SLOPES |
| Fish | SCORE RATING | 19 (14–24) Ext' Poor | 22 (18–29) Very Poor | 12 (5–18) Ext' Poor | 24 (14–32) Very poor |
| Macro-invertebrates | SCORE RATING | 89 (86–92) Good | 95 (92–98) Good | 88 (81–94) Good | 86 (82–90) Good |
| Vegetation | SCORE RATING | 63 Moderate | 100 Good | 97 Good | 14 Ext' Poor |

**Table MUP 2: Upper Murray 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 |
| Physical Form | SCORE RATING | 94 (90–96) Good | 96 (87–100) Good | 95 (84–99) Good | 94 (88–96) Good |
| Hydrology | SCORE RATING | 41 Poor | 100 Good | 100 Good | 40 Poor |

# MURRAY VALLEY - UPPER

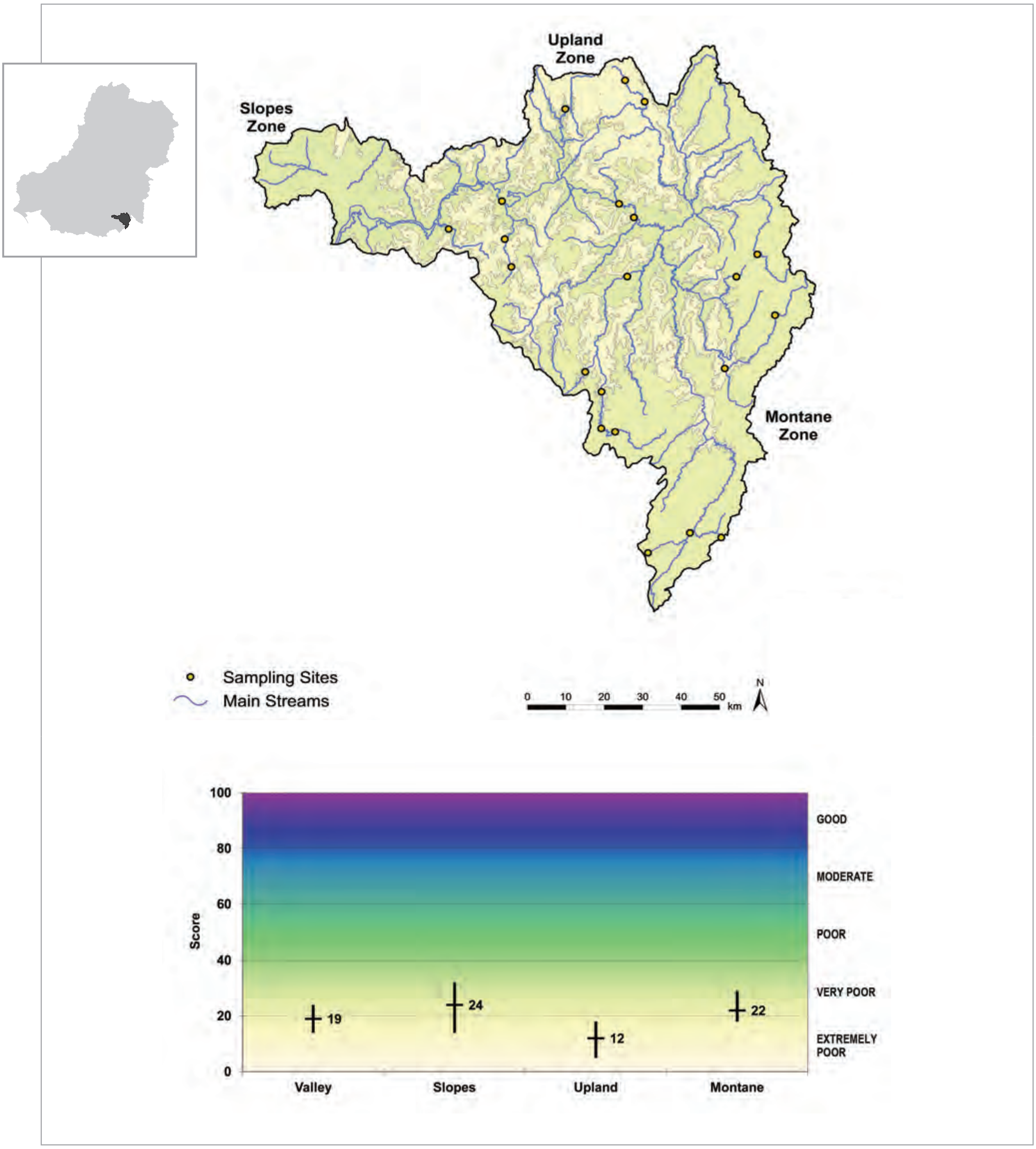



Figure MUP 2: Upper Murray Valley map with sampling sites and zones coloured by SR Fish Index scores.

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

*The Fish community of the Upper Murray Valley river system was in Extremely Poor condition, with an aggregate Fish Index score (SR–FI) of 19. The condition of the fish community in the zones was as follows: Montane zone Very Poor; Upland zone Extremely Poor; and Slopes zone Very Poor. The fish community was characterised by a Poor score for expected native fish species, a Poor score for nativeness and an Extremely Poor score for native fish recruitment. The valley had lost native species richness and alien species contributed over 91% of the biomass in samples. Native fish recruitment was Extremely Poor in the Montane and Upland zones and Very Poor in the Slopes zone.*

Twenty-one sites were surveyed across the Upper Murray Valley in March – April, 2008, yielding 1,321 fish. Analyses showed an extreme difference from Reference Condition for the Upper Murray Valley, with:

- SRA Fish Index (SR–FI) = 19 (CL 14–24), indicating Extremely Poor condition of the fish community.
- The Expectedness indicator = 40 (CL 35–48), indicating Poor condition, and a large difference from Reference Condition. 75 % of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 47 (CL 36–59), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 13 (CL 4–18), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Evidence of recruitment was observed for five of the 12 native species observed in the valley.

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

SR–FI for the Upper Murray Valley was the eighth lowest of all 23 Basin valleys, and close to that for the Campaspe and Kiewa Valleys. The Upland zone community was in worse condition (SR–FI = 12) than that in the Montane and Slopes zones (SR–FI = 22 and 24 respectively).

Expectedness varied amongst zones, ranging from Very Poor in the Upland and Slopes zones to Moderate in the Montane zone. The relatively high score for the Montane zone reflects that three of the (only) four expected species were caught. In the other two zones, only 50% of the species expected to occur under Reference Condition were captured.

Nativeness reflects the balance between native and alien fish in terms of numbers of individuals, numbers of species, and biomass. It varied amongst zones from Extremely Poor in the Montane zone to Moderate in the Slopes zone. In the Slopes zone native species outnumbered alien species two to one, and there were nearly twice as many native fish as aliens.

# MURRAY VALLEY - UPPER

The Upper Murray Valley had the fourth lowest total fish biomass per site of the 23 valleys: 3.9 kg/site. Of this, only 328 g/site (8.5%) came from native species.

Table MUP 4 shows native species abundances in the Upper Murray Valley compared with Reference Condition. Climbing galaxias, not expected to be present under Reference Condition, was found in all three zones—though it showed no evidence of recruitment. Three other galaxiid taxa were present in significant numbers; as were Australian smelt, two-spined blackfish, and southern pigmy perch. Nineteen Murray cod, one golden perch and one trout cod were caught in the Slopes zone. Freshwater catfish and silver perch were also expected but did not appear in samples. Macquarie perch were not caught, though predicted to be present in all three zones under Reference Condition. Of the six alien species caught in the Upper Murray Valley, the small-bodied species gambusia was the most numerous, followed by rainbow trout and brown trout. Common carp were caught only in the Slopes zone and in relatively modest numbers (5.6 fish/site) They were, however mostly large individuals, weighing nearly 1.6 kg each on average.

Recruitment was rated as Extremely Poor in the Montane and Upland zones and in the valley as a whole. The Slopes zone was scored as Very Poor for Recruitment. None of the four galaxias taxa showed evidence of recruitment in any sites and Murray cod was the only large-bodied native species to be recorded as recruiting. In both the Montane and Upland zones two-spined blackfish was the only native species to show evidence of recruitment. Of the six alien species, common carp was the only one not recruiting in any site in the valley.

In general, the fish community of the Upper Murray had reduced numbers of expected native species and a low biomass of native fish. Recruitment amongst native species was Extremely Poor, and the majority of alien species were actively recruiting.

**Table MUP 3: Upper Murray 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 |
| Index | Fish Condition (SR–FI) | 19 (14–24) | 22 (18–29) | 12 (5–18) | 24 (14–32) |
| Indicator | Expectedness | 40 (35–48) | 61 (54–80) | 35 (26–46) | 34 (28–42) |
| Metric | O/E | 0.29 (0.20–0.39) | 0.32 (0.13–0.57) | 0.29 (0.07–0.44) | 0.28 (0.17–0.39) |
| Metric | O/P (Zone level) | 0.56 (0.56–0.56) | 0.75 (0.75–0.75) | 0.50 (0.50–0.50) | 0.50 (0.50–0.50) |

Continued/....

| Indexes Indicators Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes |
| Indicator | Nativeness | 47 (36–59) | 17 (3–41) | 38 (14–55) | 68 (52–90) |
| Metric | Proportion biomass native | 0.36 (0.19–0.54) | 0.17 (0.02–0.45) | 0.35 (0.12–0.63) | 0.46 (0.16–0.85) |
| Metric | Proportion abundance native | 0.48 (0.33–0.64) | 0.26 (0.06–0.53) | 0.36 (0.14–0.63) | 0.68 (0.42–0.94) |
| Metric | Proportion species native | 0.54 (0.42–0.64) | 0.38 (0.17–0.62) | 0.38 (0.21–0.55) | 0.72 (0.57–0.88) |
| Indicator | Recruitment | 13 (4–18) | 2 (0–12) | 1 (0–6) | 26 (8–37) |
| Metric | Proportion of sites with native recruits | 0.22 (0.11–0.28) | 0.07 (0.00–0.20) | 0.12 (0.04–0.20) | 0.36 (0.18–0.49) |
| Metric | Proportion of native taxa with recruits | 0.37 (0.24–0.53) | 0.33 (0.00–0.50) | 0.20 (0.20–0.50) | 0.50 (0.33–0.67) |
| Metric | Proportion of abundance as recruits | 0.23 (0.13–0.32) | 0.18 (0.00–0.44) | 0.04 (0.01–0.12) | 0.39 (0.22–0.57) |
| Variables | | | | | |
| | Number of sites sampled | 21 | 7 | 7 | 7 |
| | Total number of species | 18 | 6 | 10 | 13 |
| | Number of native species | 12* | 4* | 6* | 9* |
| | Number of predicted species | 16 | 4 | 10 | 16 |
| | Number of alien species | 6 | 2 | 4 | 4 |
| | Mean number of fish per site | 63 | 50 | 95 | 44 |
| | Biomass/site all species (g) | 3882 | 1495 | 690 | 9460 |
| | Mean native biomass/ fish (g) | 14 | 3 | 12 | 25 |
| | Mean alien biomass/ fish (g) | 193 | 49 | 6 | 525 |

* Includes a native species (Climbing galaxias) not predicted to occur in this zone.

# MURRAY VALLEY - UPPER

**Table MUP 4: Upper Murray 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 |
| Sites sampled | 21 | 7 | 7 | 7 |
| Native species | | | | |
| Australian smelt | 83 | | 0 | 83 |
| Climbing galaxias | [5] | [2] | [2] | [1] |
| Flathead gudgeon | 7 | | 0 | 7 |
| Freshwater catfish | 0 | | | 0 |
| Galaxias | 26 | 7 | 19 | 0 |
| Golden perch | 1 | | | 1 |
| Gudgeon | 0 | | | 0 |
| Macquarie perch | 0 | 0 | 0 | 0 |
| Mountain galaxias | 137 | 127 | 10 | 0 |
| Murray cod | 19 | | 0 | 19 |
| Murray jollytail | 0 | | | 0 |
| Obscure galaxias complex | 53 | | 34 | 19 |
| River blackfish | 1 | | 1 | 0 |
| Silver perch | 0 | | | 0 |
| Southern pygmy perch | 55 | | | 55 |
| Trout cod | 1 | | 0 | 1 |
| Two-spined blackfish | 81 | 9 | 67 | 5 |

Continued/...

| Fish species | Valley | Zone | | |
|---|---|---|---|---|
| | | Montane | Upland | Slopes |
| Alien species | | | | |
| Brown trout | 86 | 52 | 34 | |
| Common carp | 39 | | | 39 |
| Gambusia | 531 | | 471 | 60 |
| Goldfish | 1 | | | 1 |
| Rainbow trout | 172 | 152 | 20 | |
| Redfin perch | 23 | | 6 | 17 |

# MURRAY VALLEY - UPPER

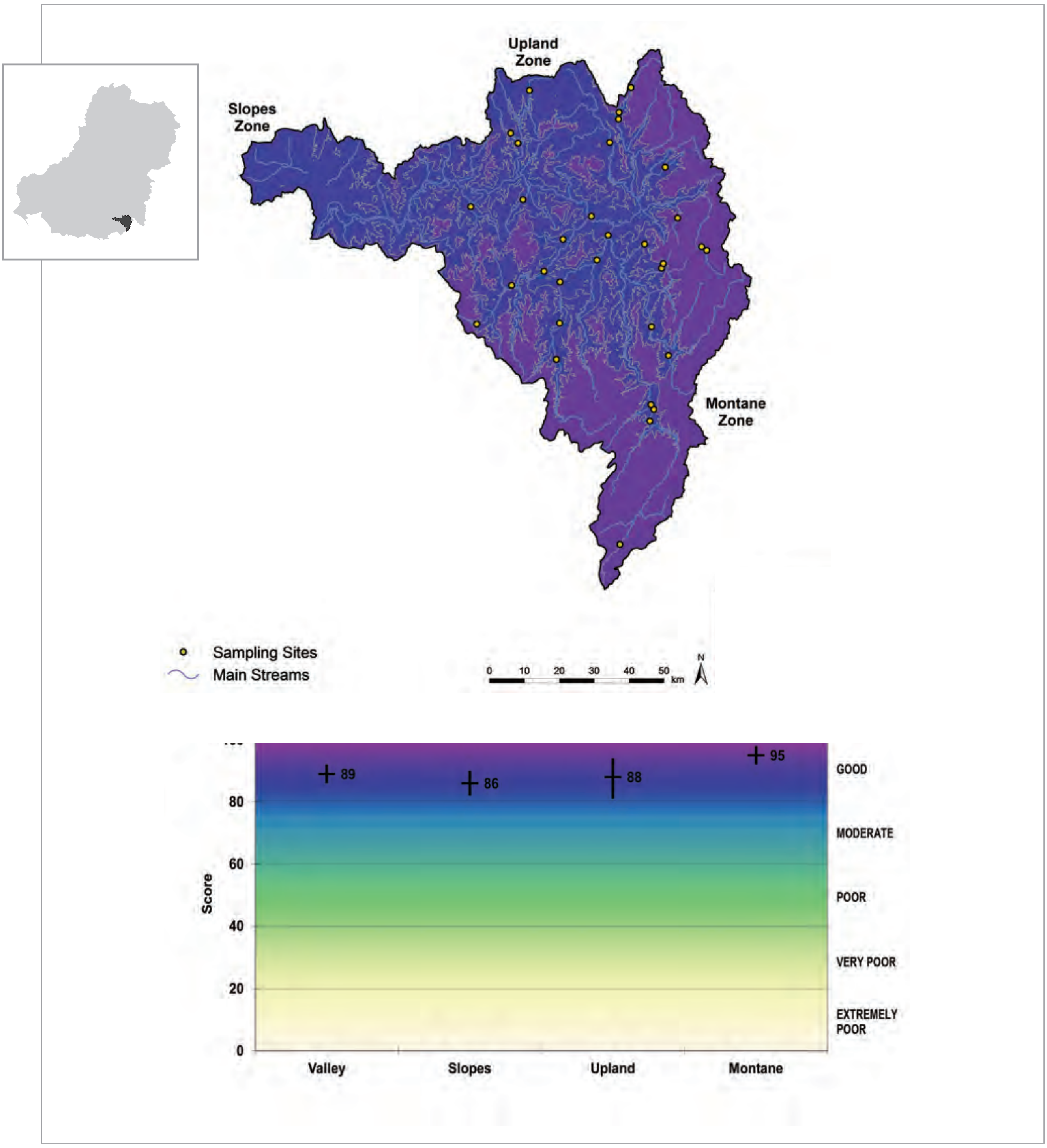



Figure MUP 3: Upper Murray Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Upper Murray Valley river system was in Good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 89. The condition of the macroinvertebrate community in the zones was as follows: Montane zone Good; Upland zone: Good; Slopes zone: Good. The proportion of sites in Good condition was high (72%); and the remaining nine of 32 rated sites (28%) were in Moderate condition. Family richness generally was high, and also high relative to Reference Condition.*

Thirty-two sites were surveyed across the Upper Murray Valley in October–November 2009 yielding 11,229 macroinvertebrates in 74 families (79% of Basin families). Analyses showed a minor difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 89 (CL 86–92), indicating Good condition of benthic macroinvertebrate communities.
- The simOE metric = 59 (CL 56–61) 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 site communities in Good condition was high across all zones (72% overall), nine of the 32 rated sites (28%) were rated in Moderate condition, and none in Poor condition.
- The number of families found was lowest in the Montane zone (49 families) and highest in the Slopes zone (57 families), though the Slopes zone had the lowest average number of families per site (29).

Figure MUP 3 shows sampling sites, zones and SR–MI values, and Table MUP 5 shows index and metric values. The SR–MI score for the Upper Murray Valley indicated Good condition of macroinvertebrate communities, rating 2nd highest out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of all zones showed no or minor differences from Reference Condition (SR–MI = 86–95). Narrow confidence intervals for the Montane and Slopes zone SR–MI values (six and seven points respectively) indicate a low level of spatial variability, with all Montane sites and all bar five Slope sites being equivalent to Reference Condition. Expectedness (simOE) was generally high and varied by up to 26 points among sites.

Table MUP 6 shows that most sites in both zones had moderate to high SR–MI values, with all sites rated either in Good condition (23 of 32 sites) or Moderate condition (nine sites). No site had a low simOE score (<40 points). Most sites had close to or slightly less than expected diversities of macroinvertebrates, coupled with little to moderate reduction in frequencies of occurrence of the families present.

# MURRAY VALLEY - UPPER

Family richness generally was high compared to Reference Condition. Diversity was high (average 34 families per site), with the Montane and Upland zones being most diverse at site scale (average 36 and 38 families per site, respectively). The valley contained 79% of the families found across the Basin (Table MUP 6), with the Montane zone having the lowest representation of Basin-wide fauna. Most (93%) of the fauna of the valley was found in the Upland zone.

**Table MUP 5: Upper Murray 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.

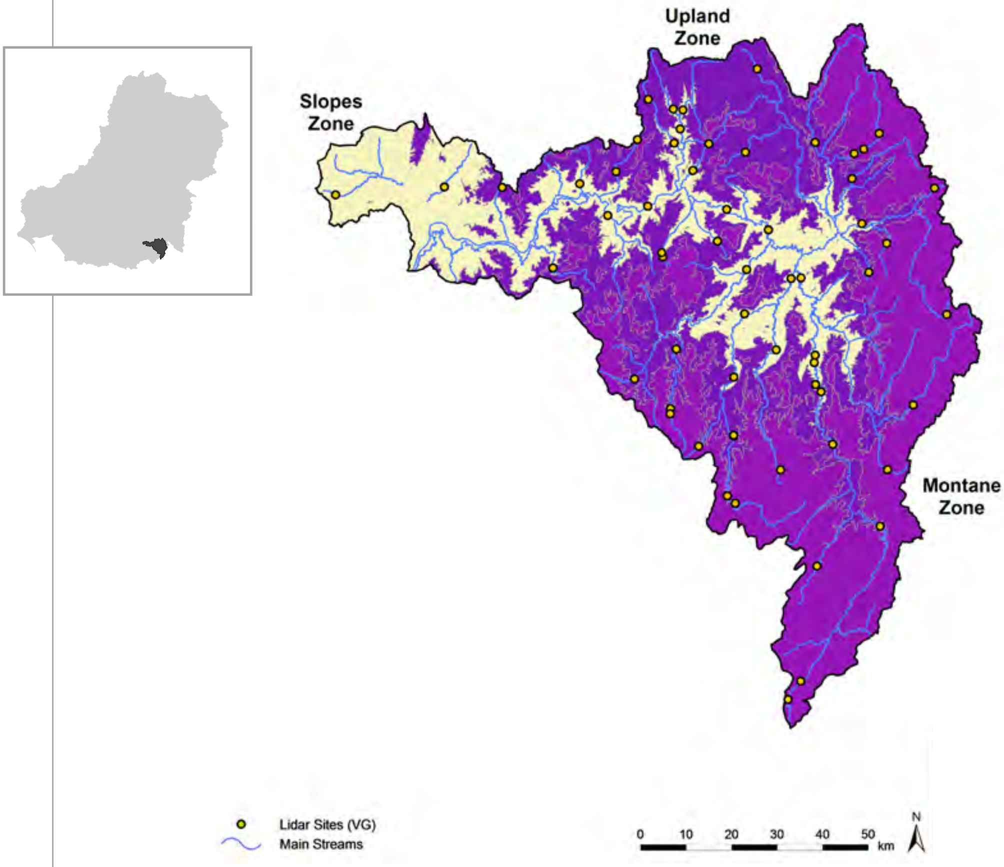
| Indexes metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes |
| Index | Macroinvertebrate Condition (SR–MI) | 89 (86–92) | 95 (92–98) | 88 (81–94) | 86 (82–90) |
| Metric | SimOE | 59 (56–61) | 63 (59–66) | 59 (54–63) | 56 (53–59) |

Table MUP 6: Upper Murray Valley: Distribution of sample sites and values of derived variables.

| Number of sites and families sampled | Valley | Zone | | |
|---|---|---|---|---|
| | | Montane | Upland | Slopes |
| Sites | | | | |
| Number of sites sampled | 32 | 5 | 13 | 14 |
| Number of sites with index values* | 32 | 5 | 13 | 14 |
| N sites by SR–MI condition band | | | | |
| Good (80–100) | 23 | 5 | 9 | 9 |
| Moderate (60–80) | 9 | | 4 | 5 |
| Poor (40–60) | | | | |
| Very or Extremely Poor (0–40) | | | | |
| Families | | | | |
| Number of families sampled | 74 | 49 | 69 | 57 |
| No. families/site (min–max) | 34 (13–50) | 36 (29–43) | 38 (17–50) | 29 (13–43) |
| Percent of families in Basin | 79 | 52 | 73 | 61 |
| Percent of families in valley | 100 | 66 | 93 | 77 |

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

# MURRAY VALLEY - UPPER



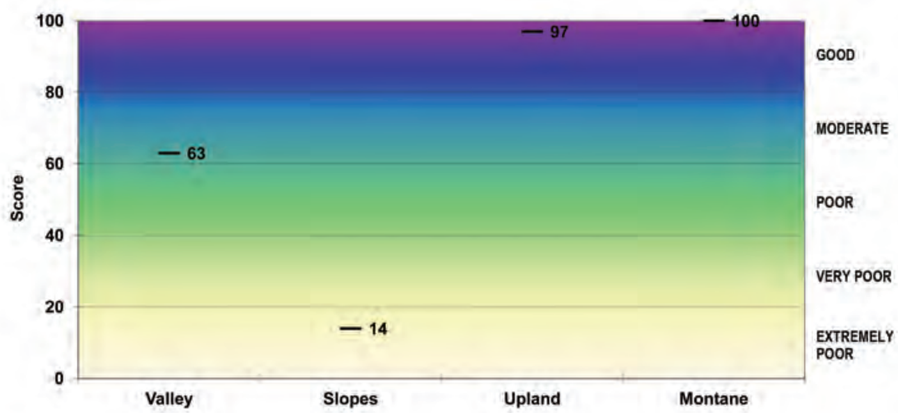




Figure MUP 4: Upper Murray Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Upper Murray Valley river system was in Moderate condition, with an aggregate Vegetation Index score (SR–VI) of 63.*

*Overall condition for the three zones in this valley was: Montane Good; Upland Good; Slopes Extremely Poor. The Abundance and Diversity indicator score was 66 for the valley, indicating a Moderate rating overall. In the three zones it was: Montane Good; Upland Good; Slopes Very Poor. The Quality and Integrity indicator score was 65 for the valley, indicating a Moderate rating overall. In the three zones it was: Montane Good; Upland Good; Slopes Very Poor.*

In this valley, the SRA Vegetation for the Upper Murray Valley assessment considers riverine vegetation in just one spatial domain: Near Riparian, along 1,753 km of stream. Most (42%) of the stream length is in the Slopes zone, and stream length per zone is as follows: Montane 425 km; Upland 589 km; and Slopes 739 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 59 sites set back 50 m from the top of the bank. These LiDAR sites are distributed along the stream network amongst the zones as follows: Montane 12 sites; Upland 22 sites; and Slopes 25 sites. There is no Lowland zone so there is no Lowland Floodplain domain to assess in the Upper Murray Valley.

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

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

- SRA Vegetation Index (SR–VI) = 63, indicating Moderate condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 66, indicating a moderate 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 = 65, indicating a moderate difference from Reference Condition for the structure, nativeness and fragmentation of communities and major vegetation groups in the Near Riparian domain.

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, and quite variable between zones. It is near Reference Condition in the Montane and Upland zones, and shows a very large difference from reference in the Slopes 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. MVG richness is near reference in the Montane, Upland and Slopes zones.

# MURRAY VALLEY - UPPER

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, and is near Reference Condition in the Montane and Upland zones, and shows a very large difference from reference in the Slopes 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 MUP 8 as well as other native but non-specific MVGs. Valley-wide Nativeness shows a 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 Good condition overall and the metrics for the Upland and Slopes zones show no loss of any MVG, when mapped at this scale.

***Abundance***

- The Abundance of pre–1750 MVGs in the Near Riparian spatial domain is in Poor condition overall, with large differences between zones. Abundance in the Near Riparian domain in the Montane zone is near reference, shows a moderate difference from reference in the Upland zone, and an extreme difference from reference in the Slopes zone.

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 Poor condition overall, with big differences between the zones. Nativeness in the Montane zone is near Reference Condition, shows a moderate difference from reference in the Upland zone and an extreme difference from reference in the Slopes zone.

***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. Differences between zones are not significant, as shown by the overlapping confidence limits. Structure refers only to height of the upper canopy of individual patches of woody vegetation types 50 metres or more away from the channel.

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

- Montane zone: The Near Riparian domain was mostly (66% of domain area) Eucalypt Open Forests, with seven other MVGs present of which three covered 5% of the domain.

- Upland zone: The Near Riparian domain was mostly (77% of domain area) Eucalypt Open Forests, with six other MVGs present, of which two covered more than 5% of the domain.

- Slopes zone: The Near Riparian domain was mostly (63% of domain area) Eucalypt Woodlands with Eucalypt Open Forests (23%), with five other MVGs present, none of which was extensive.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced in the lower zones. Eucalypt Woodlands and Eucalypt Open Forests, the two MVGs that formerly dominated the valley, have been particularly reduced.

- Montane zone: The Near Riparian domain shows little change with Eucalypt Open Forests reduced to 62% of domain area. About 4% of the domain is either cleared or non-native vegetation, and most of the MVGs are near reference in extent.

- Upland zone: In the Near Riparian domain, Eucalypt Open Forests are now reduced to 52% of the domain. About 35% is either cleared or non-native vegetation. The most affected MVG is Eucalypt Woodlands: three MVGs, all small in area, have the same extent as reference.

- Slopes zone: In the Near Riparian domain, Eucalypt Open Forests are now the most extensive MVG, although reduced to only 10% of the area of the domain. About 67% of the domain is either cleared or non-native vegetation. Two MVGs are severely reduced: Eucalypt Woodlands and Callitris Forests and Woodlands are now 8% and 13% of their reference area, and were formerly the most extensive MVGs.

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 depending on source, whereas the LiDAR was flown in May-June 2010. This means that the mapping metrics such as MVG abundance, nativeness and richness, are off-set slightly in time and space from the LiDAR-derived Structure sub-indicator. 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 used to assess the Upper Murray Valley are based on vegetation mapping which is not current and of variable quality. About 8% of the Near Riparian domain in the Slopes zone is not assigned to an MVG. The condition of the Near Riparian domain, and hence of the three zones, and of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Upper Murray Valley is notable for the marked contrast between the upper and lower zones, for the Extremely Poor condition of the Slopes zone, and for the way the condition of the Near Riparian domain decreases down the valley.

The condition of riverine vegetation is highly variable among the zones, and is near reference in the Montane and Upland zones and Extremely Poor in the Slopes zone. The Montane zone has the highest score, with MVG abundance, richness and nativeness being rated as near reference, and structure being rated moderate. Despite the loss of one MVG, Tussock Grasslands, the richness metric is near reference: under Reference Condition, there were nine MVGS present. In the Slopes zone, MVG abundance and nativeness have very low scores, implying severe loss of native vegetation, although without the loss of any MVGs and little to no effect on height of trees present. Although richness and structure are near reference, this has little influence on indicator scores because abundance and nativeness are weighted more strongly. The Slopes zone, with more stream length than other zones, has considerable influence on the condition index for the valley.

**Table MUP 7: Upper Murray 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 |
| Index | Vegetation Condition (SR–VI) | 63 | 100 | 97 | 14 |
| Indicator | Abundance and diversity | 66 | 100 | 86 | 31 |
| Metric | LF stability | | | | |
| Sub-ind. | NRLF richness | | | | |
| Metric | NR richness | 0.97 | 0.89 | 1 | 1 |
| Metric | LF richness | | | | |
| Sub-ind. | NRLF abundance | | | | |
| Metric | NR abundance | 0.53 | 0.96 | 0.65 | 0.19 |
| Metric | LF abundance | | | | |
| Indicator | Quality and integrity | 65 | 99 | 84 | 31 |
| Sub-ind. | NRLF nativeness | | | | |
| Metric | NR nativeness | 0.53 | 0.96 | 0.65 | 0.19 |
| Metric | LF nativeness | | | | |
| Sub-ind. | NR structure | 81 (77–85) | 79 (70–87) | 82 (76–87) | 82 (76–88) |
| Sub-ind. | LF fragmentation | | | | |

**Table MUP 8: The most abundant MVGs in the Near Riparian domain in the Upper Murray 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 |
| MVG | | | |
| 2. Eucalypt Tall Open Forests | 6 | 6 | |
| 3. Eucalypt Open Forests | 66 | 77 | 23 |
| 5. Eucalypt Woodlands | 17 | 15 | 63 |
| 21. Other Grasslands, Herblands, Sedgelands and Rushlands | 8 | | |

# MURRAY VALLEY - UPPER

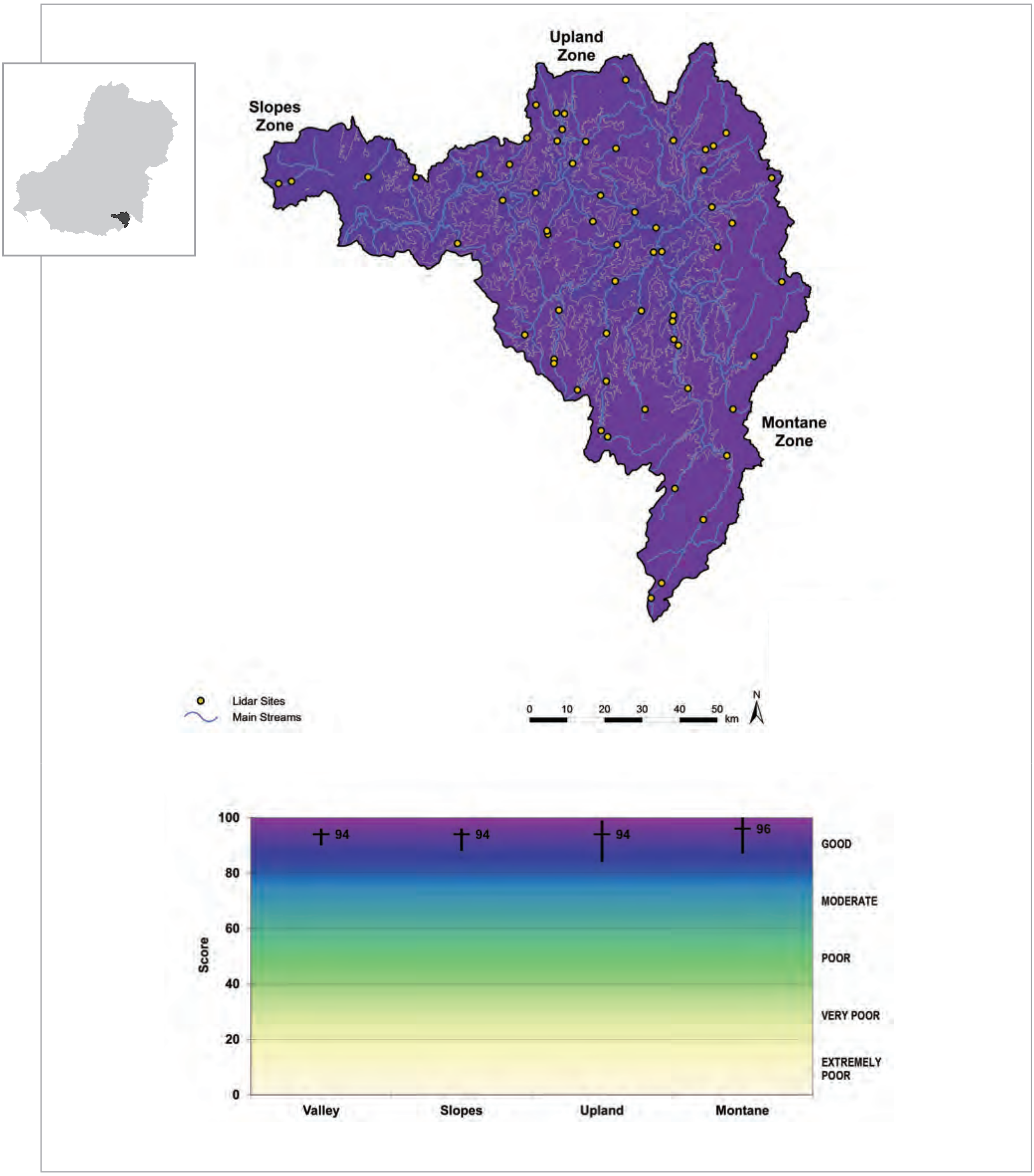



Figure MUP 5: Upper Murray Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR-PI) scores.

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

*The Physical Form of the Upper Murray 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: Montane, Upland and Slopes 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 riverine physical form was characterised by elevated sediment loads since European settlement.*

The SRA Physical Form assessment considers physical form and processes along 1,753 km of stream across the valley. It is based on LiDAR data collected at 62 sites along river channels, as well as modelling of all 116 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 MUP 5 shows values of the Physical Form Index (SR–PI) for the Upper Murray Valley and Table MUP 9 shows the index, indicator, sub-indicator and metric values.

Analyses showed near Reference Condition for the Upper Murray Valley with:

- SRA Physical Form Condition Index (SR–PI) = 94 (CL 90–96), indicating Good Physical Form condition.
- The Channel Form indicator = 87 (CL 80–92), showing near Reference Condition.
- The Bed Dynamics indicator = 75 (CL 73–79), showing a moderate difference from Reference Condition.
- The Bank Dynamics indicator = 96 (CL 93–99), showing near Reference Condition.
- The Floodplain indicator = 81 (CL 72–92), showing near Reference Condition.

***Montane zone***

There were 13 LiDAR survey sites and 18 SedNet river segments in the Montane zone of the Upper Murray 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 (a few 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 Meander Wavelength were modified from reference for approximately half of the Montane 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 Montane zone. At these sites Channel Depth was generally increased (a few sites having large increases), Channel Width Variability was generally reduced, Sinuosity was generally increased and Bank Variability was generally reduced indicating enhanced bank stability. Channel Sediment Deposition was largely unmodified from reference in the Montane zone. These results are generally consistent with previous field observations (Rutherfurd pers. comm.).

***Upland zone***

There were 22 LiDAR survey sites and 30 SedNet river segments in the Upland zone of the Upper Murray 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). 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 and Meander Wavelength were generally reduced (with a large reduction at over half of these sites) and results show both increases and decreases in Sinuosity across the zone. Channel Width and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

***Slopes zone***

There were 27 LiDAR survey sites and 68 SedNet river segments in the Slopes zone of the Upper Murray 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, Bank Variability and Floodplain Sediment Deposition were modified from reference in more than half of the Slopes zone. At these sites Channel Width and Bank Variability were generally increased 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 Slopes zone. At these sites 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 Slopes zone. At these sites Channel Width Variability was generally reduced, results show both increases and decreases in Sinuosity across the zone and Meander Wavelength was generally increased (many sites having large increases). Channel Sediment Deposition was largely unmodified from reference in the Slopes zone. In the cleared portion of the catchment, streams tend to have widened, with beds either deepening, or beds aggrading with coarse sediment (Rutherfurd pers. comm.). Tributaries have also been affected by accumulation of gold mining sediments. Field observations suggest that these effects are more substantial than the overall SRA assessment result of Good condition would indicate.

***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. Adjustments to Channel Planform in the Montane 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 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. 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. These results are generally not consistent with field observations (Rutherfurd pers. comm.). In the cleared portion of the catchment, streams tend to have widened and simplified, with beds either deepening, or beds aggrading with coarse sediment.

***Channel and Floodplain Dynamics***

There was little change from Reference Condition in Bank Dynamics in the Montane, Upland and Slopes zones. Bank variability exceeded Reference Conditions at 60% of sites in the Slopes 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 in Bed Dynamics in the Montane, 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.

# MURRAY VALLEY - UPPER

**Table MUP 9: Upper Murray 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 |
| Index | Physical Form Condition (SR–PI) | 94 (90–96) | 96 (87–100) | 95 (84–99) | 94 (88–96) |
| Indicator | Channel Form (volume and flow events) | 87 (80–92) | 84 (71–96) | 84 (72–94) | 91 (84–97) |
| Sub-ind. | Cross-section Form | 89 (81–94) | 89 (76–98) | 85 (71–97) | 91 (85–96) |
| Metric | Channel Depth (mean) | 1.14 (1.03–1.28) | 1.15 (0.97–1.42) | 1.34 (1.03–1.70) | 0.98 (0.94–1.02) |
| Metric | Channel Width (mean) | 1.16 (1.08–1.26) | 1.07 (0.98–1.20) | 1.22 (1.04–1.52) | 1.17 (1.09–1.25) |
| Sub-ind. | Cross-section Form (variability) | 94 (90–97) | 98 (96–100) | 87 (77–95) | 97 (94–99) |
| Metric | Channel Width (CV) | 0.95 (0.93–0.98) | 0.97 (0.94–1.00) | 0.92 (0.85–0.97) | 0.97 (0.94–1.01) |
| Sub-ind. | Channel Planform | 89 (83–93) | 81 (66–93) | 93 (86–98) | 89 (80–97) |
| Metric | Sinuosity | 1.01 (1.00–1.03) | 1.02 (1.00–1.04) | 1.00 (0.98–1.02) | 1.02 (1.00–1.05) |
| Metric | Meander Wavelength | 1.03 (0.99–1.08) | 1.10 (0.96–1.25) | 0.98 (0.92–1.03) | 1.04 (1.00–1.08) |
| Indicator | Bed Dynamics | 75 (73–79) | 82 (75–92) | 78 (73–85) | 70 (66–73) |
| Metric | Channel Sediment Ratio | 17 (15–20) | 12 (6–17) | 14 (10–180) | 22 (18–28) |
| Metric | Channel Sediment Depth | 0.001 (0–0.002) | 0.00009 (0–0.0003) | 0 (0–0) | 0.001 (0.0001–0.004) |
| Indicator | Bank Dynamics | 96 (93–99) | 96 (89–100) | 94 (86–99) | 98 (97–99) |
| Metric | Bank Variability (longitudinal) | 1.07 (1.03–1.10) | 1.00 (0.94–1.09) | 1.01 (0.93–1.09) | 1.15 (1.09–1.21) |
| Indicator | Floodplain | 81 (72–92) | 79 (51–100) | 84 (60–100) | 81 (67–94) |
| Metric | Floodplain Sediment Deposition | 1.15 (0.67–1.51) | 1.21 (0.30–2.00) | 1.06 (0.35–1.96) | 1.17 (0.64–1.68) |

# MURRAY VALLEY - UPPER

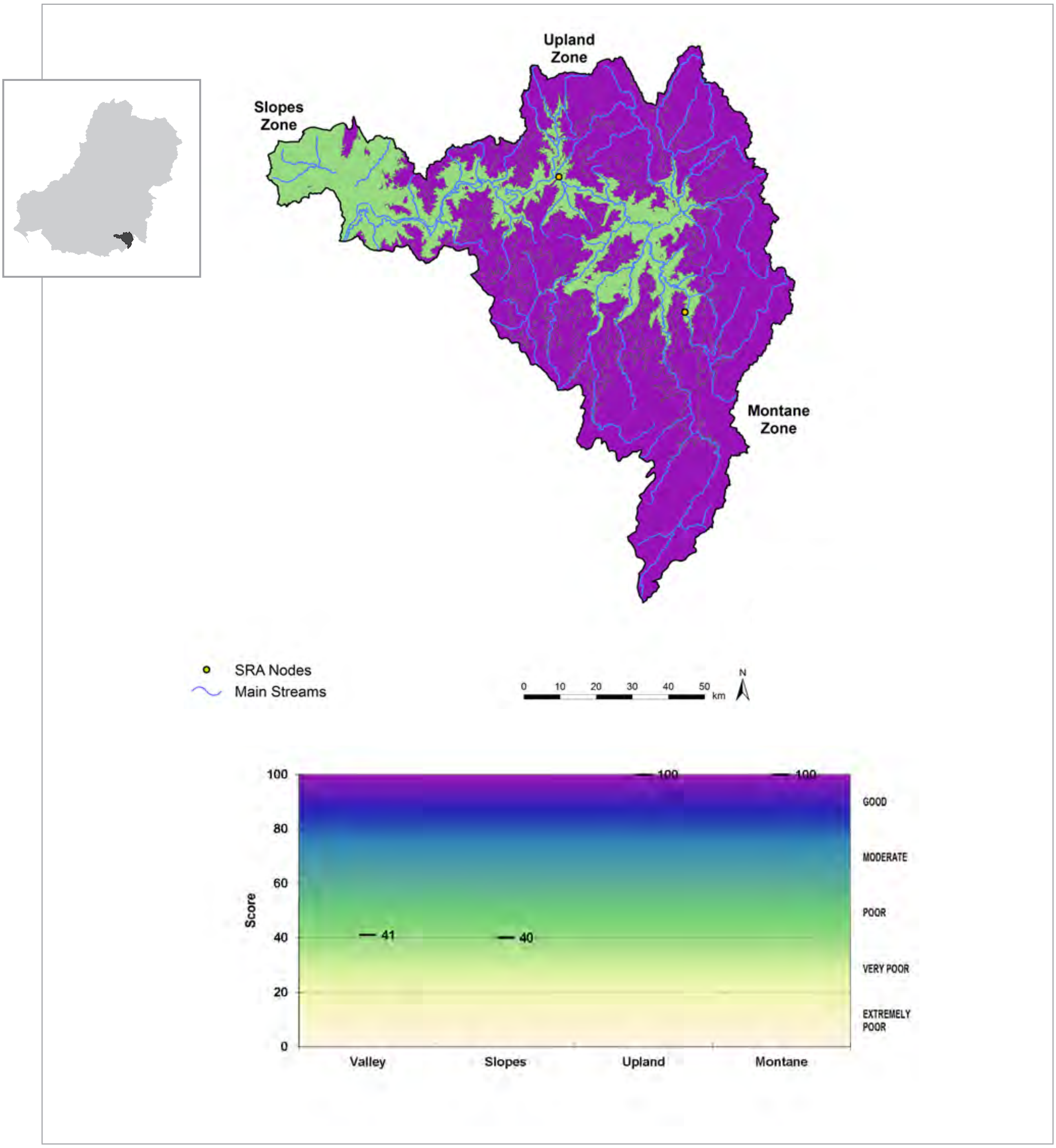



Figure MUP 6: Upper Murray Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Upper Murray Valley river system was in Poor condition, with an aggregate Hydrology Index (SR–HI) score of 41. The Upland and Montane zones were in Good condition. The Slopes zone was in Poor condition.*

*The mainstem river system of the Upper Murray Valley was rated in Extremely Poor condition. Throughout all of the mainstem river system the magnitude of low flows was increased and the amplitude of seasonal flow variations was reduced relative to Reference Condition. There was also a widespread increase in mean and high flows, altered flood durations and frequency along with altered timing of seasonal flow variations.*

*The headwater streams of the Upper Murray Valley were rated in Good condition.*

The Murray rises on the western slopes of the Great Dividing Range west of Albury–Wodonga. The headwater tributaries, in descending order of mean annual discharge, are the Swampy Plain River, Corryong, Cudgewa, Limestone, Burrowye, Koetong (which now discharges into Lake Hume), Walwa and Johnston creeks. From the junction of Cudgewa Creek, the Murray continues westward to enter the Murray Arm of Lake Hume. Much of the catchment is forested, but there is some irrigated agriculture, particularly near Corryong. The main hydrological change is the inter-valley transfer of water via the Snowy Mountains Scheme, which discharges into the Upper Murray near Khancoban, more than doubling the mean annual flow at that point. The lower reaches are impounded as part of Lake Hume.

In the Upper Murray Valley, hydrological condition is assessed using metrics of hydrological alteration available for 1,816 km of mainstem rivers and headwater streams. There are 189 km of mainstem river extending across the Slopes zone. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily 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 Upper Murray Valley there is 1,627 km of headwater stream (501 km in the Montane zone; 526 km in the Upland zone; 601 km in the Slopes zone). 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 Upper Murray Valley there is 588 km of these mid-size tributaries (71 km in the Montane zone; 202 km in the Upland zone; 316 km in the Slopes zone) which is 0.3 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.

# MURRAY VALLEY - UPPER

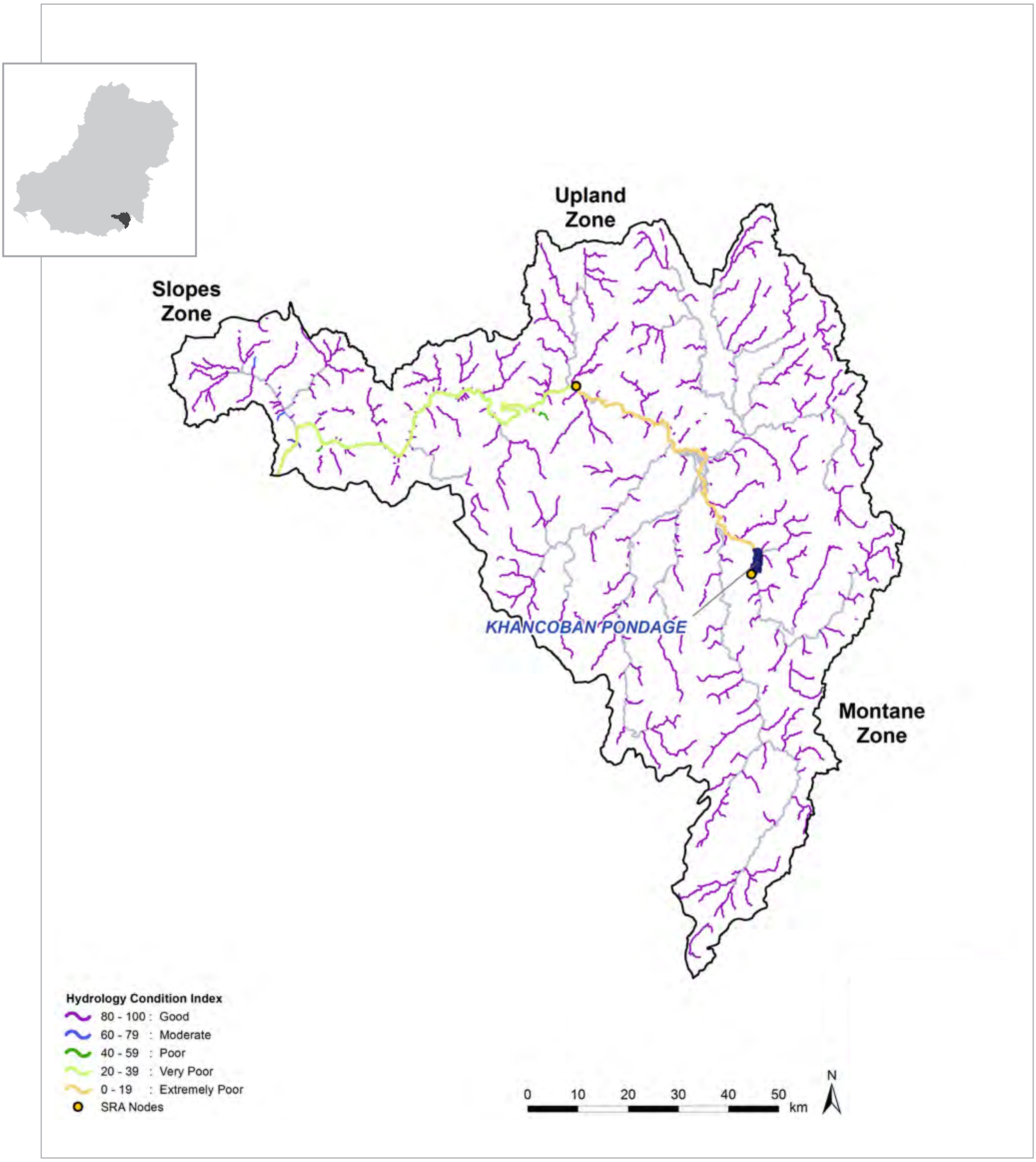



Figure MUP 7: Upper Murray Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures MUP 6 and MUP 7 show values of the Hydrology Condition Index (SR–HI) for the Upper Murray Valley and its river network, and Tables MUP 10 and MUP 11 show the index, sub-index, indicator and metric values. Analyses showed a large difference from Reference Condition for the Upper Murray Valley, with:

- The Hydrology Condition Index for the whole valley = 41, indicating Poor hydrological condition.
- The Hydrology Condition Index for the Montane, Upland and Slopes zones = 100, 100 and 40, indicating Good, Good 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) = 16, indicating Extremely Poor
hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 12, indicating Extremely Poor condition and an extreme difference from Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 77, 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 a large difference from Reference Condition. Results for the Flow Duration metric showed a significant alteration from reference in 43% 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 Slopes zone. Results for the Mean Annual Flow metric showed a very significant alteration from Reference Condition in 43% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 57% 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 Slopes 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).

# MURRAY VALLEY - UPPER

***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 43% 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 Slopes 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). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes 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 (mostly associated with increased flows) and a significant alteration from Reference Condition 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 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.

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 100% 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 Slopes zone. 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 a very significant alteration from Reference Condition in 57% 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 Slopes 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 2% of the headwater river length (associated with both increased and reduced flows) and a significant alteration from reference in 11% 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, a small proportion 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 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 100% of the mainstem river length (mostly associated with reduced 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 a significant alteration from reference in 43% 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 very significant alteration from Reference Condition in 2% of the headwater river length (mostly an increased amplitude) and a significant alteration from Reference Condition in 23% 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 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 very large difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 43% of the mainstem river length (mostly associated with reduced variability) and a significant alteration from reference in 57% of the mainstem river length (mostly associated with reduced variability). These river reaches with altered hydrology are distributed across the valley, with most in the Slopes 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 Upland zone and most in the Slopes zone.

# MURRAY VALLEY - UPPER

### *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 the reference flow regime. 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 significant alteration from reference in 43% 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 Slopes zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 43% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 57% 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.

### *Summary: mainstem rivers*

The mainstem river system of the Upper Murray Valley was generally characterised by substantial alteration in Flow Variability and Low and Zero Flow Events, considerable alteration in Flow Gross Volume, minor alteration in High Over Bank Floods, Low Over Bank Floods and Flow Seasonality and little or no alteration in High Flow Events. Throughout all of the mainstem river system mean flows were increased, the magnitude of low flows was increased, the amplitude of seasonal flow variations was reduced and monthly flow variation was reduced. Throughout most of the mainstem river system the duration of Low Over Bank flows was altered. Throughout much of the mainstem river system median flows were increased, high flows were increased, the duration and frequency of high flow spells were reduced, the frequency of low flow spells were reduced, timing of seasonal flow variations was altered and inter-flood durations for low over bank flows were reduced.

### *Summary: headwater streams*

The headwater streams of the Upper Murray 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.

**Table MUP 10: Upper Murray 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 |
| Hydrology Condition SR–HI | 41 | 100 | 100 | 40 |

# MURRAY VALLEY - UPPER

**Table MUP 11: Upper Murray 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*)** | **16 (9–21)** | **100 (32–100)** |
| Sub-index | In-Channel Flow Regime | 12 (4–18) | 100 (32–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 30 (27–32) | 100 (42–100) |
| Sub-ind. | Flow Gross Volume | 58 (27–82) | 99 (84–100) |
| Metric | Mean Annual Flow | 1.52 (1.27–1.83) | 1.04 (0.73–1.22) |
| Metric | Flow Duration | 1.21 (1.14–1.30) | 1.02 (0.84–1.44) |
| Sub-ind. | High Flow Events | 81 (58–98) | 98 (62–100) |
| Metric | High Flow | 1.30 (0.99–1.70) | 1.09 (0.72–1.71) |
| Metric | High Flow Spells | 0.66(0.39–0.86) | |
| Sub-ind. | Low and Zero Flow Events | 33 (20–50) | 97 (39–99) |
| Metric | Zero Flows Proportion | 1.01 (1.01–1.01) | 0.99 (0.96–1.00) |
| Metric | Low Flow | 2.00 (2.00–2.00) | 1.03 (0.28–1.87) |
| Metric | Low Flow Spells | 1.57 (1.00-2.00) | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 30 (14–43) | 99 (20–100) |
| Sub-ind. | Flow Seasonality | 71 (59–81) | 95 (65–100) |
| Metric | Flow Seasonal Amplitude | 0.64 (0.54–0.72) | 1.14 (0.89–1.67) |
| Metric | Flow Seasonal Period | 0.83 (0.78–0.88) | 0.98 (0.82–1.00) |
| Sub-ind. | Flow Variability | 23 (0–41) | 97 (1–100) |
| Metric | Flow Variation | 0.58 (0.42–0.70) | 0.97 (0.53–1.00) |
| Sub-index | Over Bank Flow Regime | 77 (48–100) | |
| Indicator | Over Bank Floods Low | 71 (49–88) | |
| Metric | OB Flow Duration (ARI 1) | 1.06 (0.86–1.31) | |
| Metric | OB Flow Spells (ARI 1) | 1.25 (0.71–1.95) | |
| Indicator | Over Bank Floods High | 73 (52–89) | |
| Metric | OB Flow Duration (ARI 8) | Not Reported | |
| Metric | OB Flow Spells (ARI 8) | | |

| | Zone | | | |
|---|---|---|---|---|
| | Mainstem rivers | Headwater streams | | |
| | Slopes | Montane | Upland | Slopes |
| | **16** | **100** | **100** | **99** |
| | 12 | 100 | 100 | 99 |
| | 30 | 100 | 100 | 100 |
| | 58 | 100 | 99 | 99 |
| | 1.52 | 1.02 | 1.04 | 1.05 |
| | 1.21 | 1.01 | 1.02 | 1.03 |
| | 81 | 100 | 98 | 97 |
| | 1.30 | 1.03 | 1.11 | 1.13 |
| | 0.66 | | | |
| | 33 | 97 | 98 | 96 |
| | 1.01 | 1.00 | 1.00 | 0.99 |
| | 2.00 | 1.00 | 1.02 | 1.06 |
| | 1.57 | | | |
| | 30 | 100 | 99 | 98 |
| | 71 | 98 | 94 | 92 |
| | 0.64 | 1.06 | 1.15 | 1.18 |
| | 0.83 | 1.00 | 0.97 | 0.99 |
| | 23 | 100 | 98 | 93 |
| | 0.58 | 1.00 | 0.98 | 0.94 |
| | 77 | | | |
| | 71 | | | |
| | 1.06 | | | |
| | 1.25 | | | |
| | 73 | | | |

# MURRAY VALLEY - CENTRAL

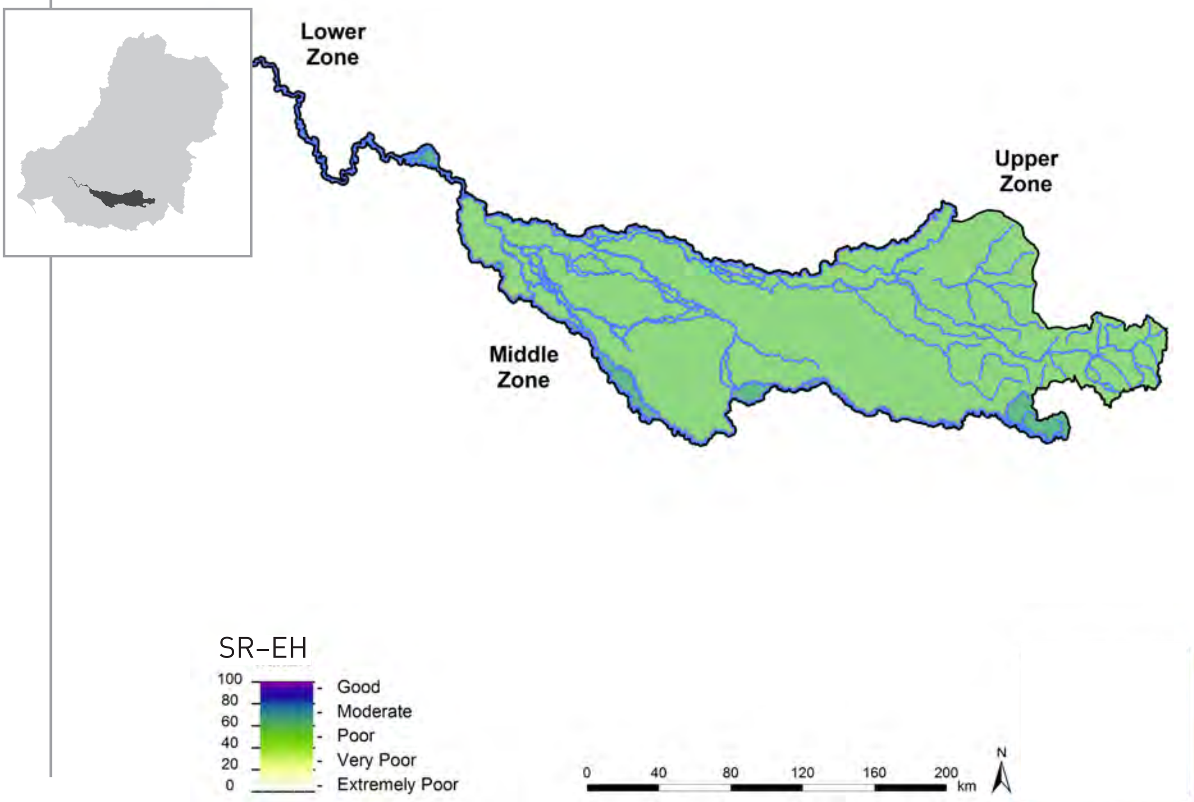



**Figure MCN 1: Central Murray Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure MCN 1 shows the Ecosystem Health ratings for the Central Murray Valley and Tables MCN 1 and MCN 2 show the index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Central Murray Valley as a whole. The river system's Riverine Vegetation, Fish and benthic Macroinvertebrate communities were in Very Poor, Poor and Good 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 Central Murray Valley river system. River Ecosystem Health was rated as Poor (Lower zone: Poor; Middle zone: Poor; Upper zone: Poor).

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

*The Central Murray Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Upper, Middle and Lower Poor. The Fish community was in Very Poor condition. Many expected species were absent; species count and abundance and biomass were dominated by alien species 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 high richness, abundance, stability and reduced nativeness in the Near Riparian and Lowland Floodplain domains, and little increase in 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 to high levels of floodplain sediment deposition. The river system's Hydrology was in Poor condition, with substantial changes in flow seasonality and high flow events; and minor changes in variability, low flows and gross volumes relative to Reference Condition.*

***Ecosystem Health***

The Central Murray Valley ranked equal first in terms of Vegetation Condition with three other valleys, all from the northern sub-basin. For the other four Themes it ranked in the lower 50% of all valleys—in the lowest quartile for Hydrology and Macroinvertebrates. It ranked in the middle of the 15 valleys rated in Poor River Ecosystem Health (see table 5.2).

This valley has floodplain wetlands of national and international (Ramsar) significance. The socio-economic values of floodplain forests, as a valued product in the 19th century and as an ecological resource in the 21st century, have afforded a degree of protection which is reflected in the high scores for abundance and fragmentation of the riverine vegetation in the Lowland Floodplain domain.

The Central Murray riverine ecosystem is strongly influenced by major tributaries. The channel also has a number of in-stream structures (weirs at Yarrawonga, Torrumbarry, Mildura and Wentworth) and its hydrology reflects significant regional irrigation diversions, the management of major storages upstream in the Murray and tributaries, and the delivery of water to supply substantial down-stream demands. Severe drought conditions over the whole SRA program monitoring period have exacerbated this situation, in particular in terms of those natural high flow events which support lateral connectivity.

All three indicators of the condition of the fish community, Expectedness, Nativeness, and Recruitment, showed a significant downward trend from SRA1 to SRA2. The Central Murray together with the Lower Murray showed the sharpest decline in recruitment at the valley scale.

During droughts the high degree of regulation and human demand may help support otherwise threatened refugial communities by avoiding low-flow extremes. However, it remains to be seen, following the cessation of drought conditions in 2010, to what extent these factors might restrict the capacity of the ecosystem to respond to more benign climatic conditions.

***Fish Theme***

The Fish Condition Index SR–FI = 20, indicating Very Poor condition (Lower zone: Poor; Middle zone: Very Poor; Upper zone: Extremely Poor). The Expectedness indicator = 27, indicating Very Poor condition, and a very large difference from Reference Condition. The Nativeness indicator = 49, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 33, indicating Very Poor condition, and a very large difference from Reference Condition.

# MURRAY VALLEY - CENTRAL

In general, the fish community of the Central Murray had substantially reduced numbers of expected native species, with low levels of recruitment. However, the ratio of native fish to alien fish was higher than in most valleys of the Murray–Darling Basin.

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 56, indicating Poor condition (Lower zone: Poor; Middle zone: Poor; Upper zone: Poor). The simOE metric = 42 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 condition was high, especially in the Upper zone. Only two of the 34 rated sites (6%) were in Good condition, and 11 sites (32%) were rated in Moderate condition.

Family richness generally was moderate and reduced 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 = 98, 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 = 89, indicating Good condition and a minor 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 shows little effect of clearing, with abundance and degree of fragmentation of major vegetation groups near Reference Condition.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 76, indicating Moderate condition (Lower zone: Poor; Middle zone: Poor; Upper zone: Good). The Channel Form indicator = 77, the Bed Dynamics indicator = 78 and the Floodplain Form indicator = 61; all indicating Moderate condition and a minor difference from Reference Condition. The Bank Dynamics indicator = 95, indicating Good condition and near Reference Condition.

The valley's riverine Physical Form was characterised by high rates of floodplain sediment deposition since European settlement and elevated sediment loads. There was also evidence of channel simplification, particularly in the Middle zone.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 56, indicating Poor condition (Lower zone: Very Poor; Middle zone: Very Poor; Upper zone: Poor). The In-Channel Flow Regime sub-index = 24, indicating Very Poor condition and a major difference from Reference Condition for the flow regime within the channels. The mainstem river reaches were generally characterised by substantial alteration in Flow Seasonality, considerable alteration in High Flow Events and Flow Gross Volume and minor alteration in High Over Bank Floods, Low Over Bank Floods, Flow Variability and Low and Zero Flow Events.

**Table MCN 1: Central Murray 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 | Poor | Poor |

| THEME | | VALLEY | ZONE | | |
|---|---|---|---|---|---|
| | | | UPPER | MIDDLE | LOWER |
| Fish | SCORE RATING | 20 (15–27) Very poor | 9 (2–19) Ext' Poor | 38 (28–44) Very poor | 49 (42–61) Poor |
| Macro-invertebrates | SCORE RATING | 56 (50–62) Poor | 56 (48–64) Poor | 57 (48–64) Poor | 55 (42–69) Poor |
| Vegetation | SCORE RATING | 100 Good | 100 Good | 100 Good | 100 Good |

**Table MCN 2: Central Murray 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 | 76 (69–82) Moderate | 89 (78–97) Good | 44 (36–61) Poor | 48 (37–59) Poor |
| Hydrology | SCORE RATING | 56 Poor | 46 Poor | 36 Very Poor | 33 Very Poor |

# MURRAY VALLEY - CENTRAL

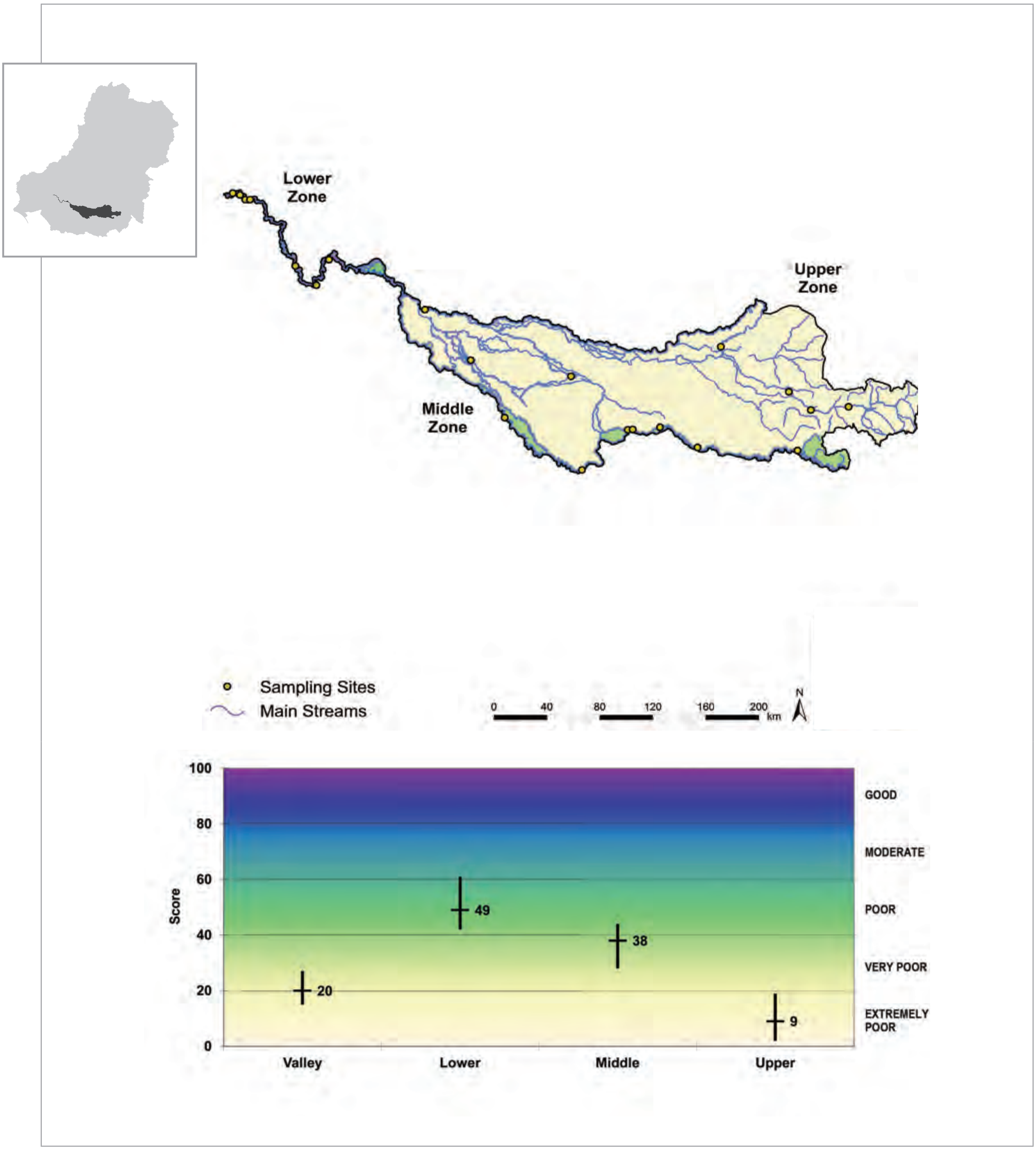



**Figure MCN 2: Central Murray Valley map with sampling sites and zones coloured by SR Fish Index (SR-FI) scores.**

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

*The Fish community of the Central Murray 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: Upper zone Extremely Poor; Middle zone Very Poor; and Lower zone Poor. The fish community was characterised by a Very Poor score for expected native fish species, a Poor score for nativeness and a Very Poor score for native fish recruitment. The Upper zone in particular lacked 62% of the predicted native species. The valley had lost much of its native species richness, and alien species contributed over 56% of the biomass in samples. Native fish recruitment was Very Poor, Poor and Poor in the Upper, Middle and Lower zones respectively.*

Twenty-one sites were surveyed across the Central Murray Valley in January–April 2008, yielding 2,672 fish. Analyses showed a very large difference from Reference Condition for the Central Murray Valley, with:

- SRA Fish Index (SR–FI) = 20 (CL 15–27), indicating Very Poor condition of the fish community.
- The Expectedness indicator = 27 (CL 22–35), indicating Very Poor condition, and a very large difference from Reference Condition. Only 55% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 49 (CL 32–62), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 33 (CL 22–45), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for eight of the 12 native species observed in the valley.

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

SR–FI for the Central Murray Valley was fourteenth highest for all valleys, and close to that for the Avoca and Campaspe valleys – both tributaries of the Central Murray Valley. The Upper zone community was in much worse condition (SR–FI = 9) than that in either the Middle zone (SR–FI = 38) or the Upper zone (SR–FI = 49).

Nativeness and expectedness varied in all zones with the Upper zone scoring significantly less than the other two zones for both indicators.

Table MCN 4 shows native species abundances in the Central Murray Valley compared with Reference Condition. A number of small-bodied native species, predicted to be present in two or all three zones under Reference Condition, were not caught at any of the 21 sampling sites. These included the endangered southern purple-spotted gudgeon, olive perchlet, Murray hardyhead and mountain galaxias.

# MURRAY VALLEY - CENTRAL

The Central Murray Valley had the seventh largest number of fish caught per site (127.2), amongst all 23 valleys. Of the 2672 fish caught, 2257 (84%) belonged to native species. Total fish biomass (16.6 kg/site) in the Central Murray Valley was the second largest amongst the 23 valleys. 44% of this biomass (7.3 kg/site) was contributed by native species. This reflects the numerical dominance of small-bodied native species such as gudgeon, Australian smelt and unspecked hardyhead. Despite this, several large-bodied native species were represented in the catch in small to moderate numbers. These included Murray cod, golden perch, silver perch, and trout cod. River blackfish and freshwater catfish were rare and sighted in only one of the three zones in which they were expected. Macquarie perch was expected in all three zones but not sighted.

Recruitment varied in all zones. All four alien species were recorded as recruiting in at least some sites in the Central Murray Valley. Recruits were also recorded in the Murray cod and trout cod populations but not for golden perch or silver perch. This latter may reflect the extended drought conditions.

In general, the fish community of the Central Murray Valley had substantially reduced numbers of expected native species. However, the ratio of native fish to alien fish was higher than in most valleys of the Murray–Darling Basin.

**Table MCN 3: Central Murray 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) | 20 (15–27) | 9 (2–19) | 38 (28–44) | 49 (42–61) |
| Indicator | Expectedness | 27 (22–35) | 16 (12–28) | 41 (30–50) | 56 (52–62) |
| Metric | O/E | 0.32 (0.22–0.42) | 0.21 (0.06–0.35) | 0.49 (0.34–0.62) | 0.62 (0.56–0.70) |
| Metric | O/P (Zone level) | 0.40 (0.40–0.40) | 0.38 (0.38–0.38) | 0.41 (0.41–0.41) | 0.48 (0.48–0.48) |
| Indicator | Nativeness | 49 (32–62) | 38 (11–59) | 64 (57–70) | 79 (73–86) |
| Metric | Proportion biomass native | 0.30 (0.14–0.46) | 0.32 (0.10–0.57) | 0.20 (0.07–0.33) | 0.46 (0.33–0.58) |
| Metric | Proportion abundance native | 0.60 (0.41–0.8) | 0.49 (0.20–0.78) | 0.78 (0.68–0.86) | 0.90 (0.86–0.93) |
| Metric | Proportion species native | 0.47 (0.33–0.61) | 0.33 (0.10–0.54) | 0.72 (0.63–0.81) | 0.74 (0.71–0.77) |
| Indicator | Recruitment | 33 (22–45) | 26 (10–43) | 47 (34–59) | 44 (34–62) |
| Metric | Proportion of sites with native recruits | 0.41 (0.29–0.50) | 0.32 (0.15–0.47) | 0.54 (0.41–0.64) | 0.59 (0.50–0.60) |
| Metric | Proportion of native taxa with recruits | 0.63 (0.50–0.86) | 0.62 (0.40–1.00) | 0.67 (0.62–0.75) | 0.60 (0.50–0.86) |
| Metric | Proportion of abundance as recruits | 0.50 (0.41–0.65) | 0.48 (0.34–0.75) | 0.55 (0.43–0.62) | 0.47 (0.43–0.63) |

Continued/...

# MURRAY VALLEY - CENTRAL

| Indexes Indicators Metrics | Description | Valley | Zone | | |
|---|---|---|---|---|---|
| | | | Upper | Middle | Lower |
| **Variables** | | | | | |
| | Number of sites sampled | 21 | 7 | 7 | 7 |
| | Total number of species | 16 | 12 | 12 | 13 |
| | Number of native species | 12 | 8 | 9 | 10 |
| | Number of predicted species | 22 | 21 | 22 | 21 |
| | Number of alien species | 4 | 4 | 3 | 3 |
| | Mean number of fish per site | 127 | 130 | 93 | 159 |
| | Biomass/site all species (g) | 16646 | 5844 | 16272 | 27822 |
| | Mean native biomass/fish (g) | 68 | 32 | 62 | 97 |
| | Mean alien biomass/fish (g) | 473 | 101 | 581 | 913 |

**Table MCN 4: Central Murray 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 | 368 | 22 | 259 | 87 |
| Bony herring | 442 | 21 | 0 | 421 |
| Flathead gudgeon | 38 | 12 | 0 | 26 |
| Freshwater catfish | 1 | 0 | 0 | 1 |
| Golden perch | 50 | 1 | 6 | 43 |
| Gudgeon | 877 | 641 | 50 | 186 |
| Macquarie perch | 0 | 0 | 0 | 0 |
| Murray cod | 68 | 28 | 39 | 1 |
| Murray hardyhead | 0 | 0 | 0 | 0 |
| Murray–Darling rainbowfish | 26 | 0 | 2 | 24 |
| Olive perchlet | 0 | 0 | 0 | 0 |
| Obscure galaxias complex | 0 | | 0 | 0 |
| River blackfish | 3 | 0 | 3 | 0 |
| Silver perch | 21 | 2 | 11 | 8 |
| Spangled perch | 66 | 0 | 15 | 51 |
| Trout cod | 17 | 0 | 17 | 0 |
| Unspecked hardyhead | 346 | 13 | 121 | 212 |
| Alien species | | | | |
| Common carp | 243 | 23 | 135 | 85 |
| Gambusia | 84 | 77 | | 7 |
| Goldfish | 65 | 64 | 1 | |
| Redfin perch | 53 | | | |

# MURRAY VALLEY - CENTRAL

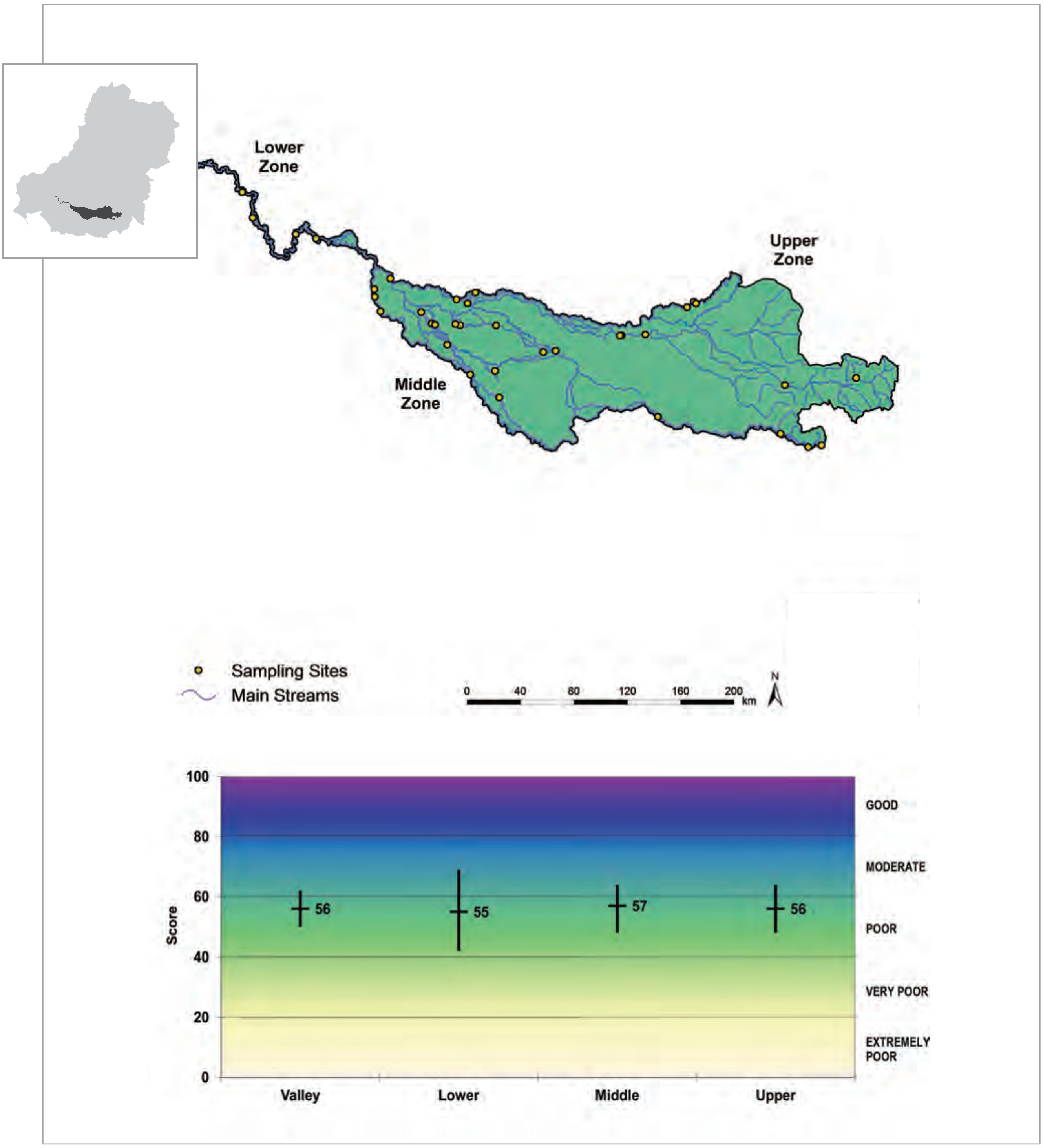



**Figure MCN 3: Central Murray Valley map with sampling sites and zones coloured by SR Macroinvertebrate Index (SR–MI) scores.**

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

*The Macroinvertebrate community of the Central Murray Valley river system was in Poor condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 56.*

*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 condition was high (47%), especially in the Upper zone. Only two of the 34 rated sites (6%) were in Good condition. Family richness generally was Moderate, and was reduced compared to Reference Condition.*

Thirty-five sites were surveyed across the Central Murray Valley in September–November 2009 yielding 5,127 macroinvertebrates in 52 families (55% of Basin families). Analyses showed a large difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 56 (CL 50–62), indicating Poor condition of benthic macroinvertebrate communities.
- The simOE metric = 42 (CL 40–45) 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 condition was high (47%), especially in the Upper zone. Two of the 34 rated sites (6%) were in Good condition (both in the Upper zone), and 11 sites (32%) were rated in Moderate condition.
- The number of families found was lowest in the Lower zone (29 families) and highest in the Upper zone (47 families), and the Upper zone had the highest average number of families per site (23).

Figure MCN 3 shows sampling sites, zones and SR–MI values, and Table MCN 5 shows index and metric values. The SR–MI score for the Central Murray Valley indicated Poor condition of macroinvertebrate communities, rating 21st out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of all three zones showed large differences from Reference Condition (SR–MI = 55–57 at zone level). A wide confidence interval (27 points) for the Lower zone SR–MI value indicates more variability there, but most sites showed a moderate to large difference from Reference Condition. Expectedness (simOE) was low to moderate overall.

Table MCN 6 shows that most sites in all zones had Poor to Moderate SR–MI values, and only two sites were rated in Good condition. Thirteen sites had a low simOE score (<40 points), eight of which were in the Upper zone. Most sites had lower than expected diversities of macroinvertebrates, coupled with reductions in frequency of occurrence of the families present.

# MURRAY VALLEY - CENTRAL

Family richness generally was reduced compared to Reference Condition. Diversity was moderate (average 22 families per site), with the Upper zone being most diverse (average 23 families per site). The valley contained 55% of the families found across the Basin (Table MCN 6), with the Slopes zone having the lowest representation of Basin-wide fauna. Most (56–100%) of the fauna of the valley was found in each of the zones.

**Table MCN 5: Central Murray 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) | 56 (50–62) | 56 (48–64) | 57 (48–64) | 55 (42–69) |
| Metric | SimOE | 42 (40–45) | 42 (39–45) | 42 (39–45) | 42 (37–47) |

Table MCN 6: Central Murray 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 | 22 | 9 | 4 |
| Number of sites with index values* | 34 | 21 | 9 | 4 |
| N sites by SR–MI condition band | | | | |
| Good (80–100) | 2 | 2 | | |
| Moderate (60–80) | 11 | 5 | 4 | 2 |
| Poor (40–60) | 16 | 10 | 4 | 2 |
| Very or Extremely Poor (0–40) | 5 | 4 | 1 | |
| Families | | | | |
| Number of families sampled | 52 | 47 | 37 | 29 |
| No. families/site (min–max) | 22 (7–33) | 23 (7–33) | 20 (13–28) | 20 (15–27) |
| Percent of families in Basin | 55 | 50 | 39 | 31 |
| Percent of families in valley | 100 | 90 | 71 | 56 |

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

# MURRAY VALLEY - CENTRAL

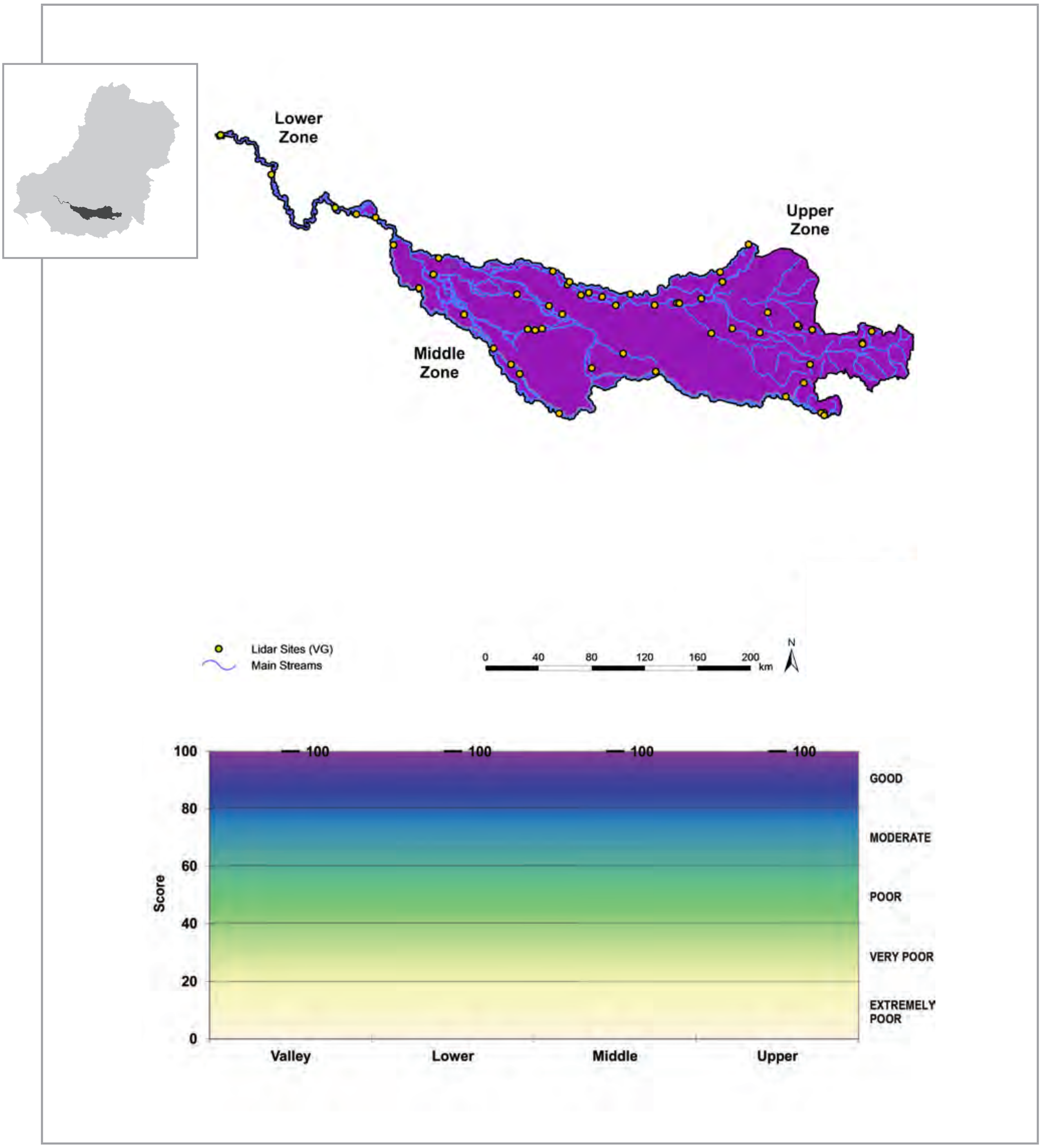



Figure MCN 4: Central Murray Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Central Murray Valley river system was in Good condition, with an aggregate Vegetation Index score (SR–VI) of 100. Overall condition was Good for all three zones in this valley (Upper, Middle, Lower).*

*The Abundance and Diversity indicator score was 98 for the valley, indicating a high rating overall. In all three zones it was rated Good.*

*The Quality and Integrity score was 89 for the valley, indicating a Good rating overall. In all three zones it was rated Good.*

The SRA Vegetation assessment for the Central Murray Valley considers riverine vegetation in two spatial domains: Near Riparian, along 6,014 km of stream, and Lowland Floodplain, for a total of 3,808 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 (71%) of the stream length is in the Upper zone, and the length of stream assessed per zone is as follows: Upper 4,250 km; Middle 1,289 km; and Lower 475 km. Similarly, most of the Lowland Floodplain (60%) being assessed is in the Upper zone. 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 55 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream network in each zone as follows: Upper 38 sites; Middle 12 sites; and Lower 5 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups (MVGs).

Figure MCN 4 shows values of the Vegetation Index (SR–VI) for the Central Murray Valley, and Table MCN 7 shows the index, indicator and sub-indicator values. Tables MCN 8 and MCN 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 Central Murray Valley, with:

- SRA Vegetation Index (SR–VI) = 100, indicating Good condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 98, 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 = 89, indicating near 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 shows little effect of clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

# MURRAY VALLEY - CENTRAL

The Abundance and Diversity of valley riverine vegetation is in Good condition overall, with MVGs in near Reference Condition in the Middle and Lower zones and moderate difference from reference in the Upper zone. 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 shows a moderate difference from reference in the Near Riparian domain, and the Lowland Floodplain domain is in near Reference Condition. MVG richness is maintained near reference in the Near Riparian domain as no MVG has been completely reduced there; MVG richness is close to reference in the Lowland Floodplain domain where one MVG has been completely reduced. Vegetation stability in the Lowland Floodplain domains in the Upper, Middle and Lower zones was 89%, 100% and 100% respectively.

In addition, the Quality and Integrity of valley riverine vegetation is in Good condition overall, and in near Reference Condition for 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 MCN  8 as well as other native but non-specific MVGs. Valley-wide nativeness in the Near Riparian domain shows a moderate difference from reference and is near reference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain domain is near Reference Condition overall.

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, with the metrics showing some difference between the domains. Richness for the Near Riparian domain is near Reference Condition with no loss of any MVG in any zone, and near Reference Condition for the Lowland Floodplain domain in the Upper, Middle and Lower zones, although one MVG out of nine was completely reduced in the Upper zone, when mapped at this scale.

***Abundance***

- The Abundance of pre–1750s 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 is moderately different from Reference Condition in the Upper and Middle zones, and near reference in the Lower zone. Abundance in the Lowland Floodplain domain is near reference in all three zones.

***Stability***

- Floodplain areas within the Lowland Floodplain domain are in Good condition, with little evidence of turnover or change when 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 Good condition overall, with the metrics showing differences between zones and domains. Nativeness in the Near Riparian domain shows a moderate difference from Reference Condition in the Upper and Middle zones and near reference in the Lower zone. Nativeness in the Lowland Floodplain domain is in near Reference Condition in all three 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 differences between zones. Structure shows a moderate difference from Reference Condition in the Upper zone, is near reference in the Middle zone, and shows a moderate difference from reference in the Lower 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 the integrity of MVGs is near Reference Condition in the Upper zone, moderately different from Reference Condition in the Middle zone and near reference in the Lower zone. Eucalypt Woodlands, one of the most extensive MVG in the three zones of the Central Murray Valley, is close to reference in the Upper and Lower zones but in the Middle zone, the increase in patch number and decrease in mean patch size indicate dissection and clearing.

Under Reference Conditions, the riverine vegetation in the three Lowland zones of the Central Murray Valley was as follows:

- Upper Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (64%) and Eucalypt Open Forests (12%), with seven other MVGs of which three were at least 5% of the domain area.
- Middle Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (67%) and Eucalypt Open Forest (27%), with five other MVGs, none of which covered more than 5% of the domain.
- Lower Lowland zone: The Near Riparian was mostly Eucalypt Open Forests (51%) and Eucalypt Woodlands (26%) with five other MVGs, none of which covered more than 5% of the domain.
- Upper Lowland zone: The Lowland Floodplain domain was mostly covered by Eucalypt Woodlands (77%) with seven other MVGs, of which two were at least 5% of the domain.
- Middle Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (67%) and Eucalypt Open Forests (27%), with four other MVGs, none of which was more than 5% of the domain.

- Lower Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Open Forests (46%) and Eucalypt Woodlands (38%), with five other MVGs, none of which was more than 5% of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the dominant vegetation types Eucalypt Woodlands and Eucalypt Open Forests were reduced in all domains, but the level of clearing was generally higher for Eucalypt Woodlands:

- Upper Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG although reduced (now 32% of the domain area). About 39% is cleared or non-native vegetation. Proportionally, Acacia Forests and Woodlands is the most reduced of all MVGs in this domain relative to their area under Reference Condition.

- Middle Lowland zone: In the Near Riparian domain, although reduced, Eucalypt Woodlands are still the most extensive MVG in the domain (31% of the domain area): the extent of Eucalypt Open Forest is almost unchanged. About 29% of the domain is cleared or non-native vegetation. Proportionately, the most reduced MVGs are Casuarina Forests and Woodlands, and Mallee Woodlands and Shrublands, though these were both very small in original area.

- Lower Lowland zone: In the Near Riparian domain, Eucalypt Open Forests is unchanged (51%) and Eucalypt Woodlands reduced (20% of the domain area). About 6% of the domain is cleared or non-native vegetation. Proportionately the most reduced MVGs are Other Forested and Woodlands, and Mallee Woodlands and Shrublands.

- Upper Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands is reduced to 65% of the domain area, and is still the most extensive MVG. About 13% is now cleared or non-native vegetation. Proportionately, the most reduced MVGs are Acacia Forests and Woodlands, and Mallee Woodlands and Shrublands.

- Middle Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands is slightly reduced but still the most extensive MVG (54% of the domain area) and Eucalypt Open Forests (29%). About 8% of the domain is cleared or non-native vegetation. Proportionately, the most reduced MVG is Chenopod Shrublands, Samphire Shrublands and Forblands.

- Lower Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands is slightly reduced (now 32% of the domain area) and Eucalypt Open Forests are unchanged (46%). About 6% of the domain is cleared or non-native vegetation. Proportionately, the most reduced MVGs are Mallee Woodlands and Shrublands, and Other Forests and Woodlands, though these were both very small in original area.

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: for example, in this valley, the on-ground date for the current NVIS 3.0 mapping is 1997–2004, whereas LiDAR was flown in February–March 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 Central Murray Valley is notable for being in near Reference Condition in all three zones and in both domains. Most of the metrics are based on vegetation mapping, which is not current and can be of variable quality. In the Lower zone, 6% of the Lowland Floodplain domain and 15% of the Near Riparian domain was not assigned to an MVG, so current total MVG area is less than domain area. The condition of either or both of the Near Riparian and Lowland Floodplain domains in this valley, and hence of the valley itself, may have changed since the source mapping was compiled.

All three zones are rated as near Reference Condition for overall condition, and for the two indicators, Abundance and Diversity, and Quality and Integrity. However, the condition of riverine vegetation in the Upper zone is not quite as high as in the other two zones. All metrics except fragmentation score slightly less, notably Structure, in both the Near Riparian and Lowland Floodplain domains; notable differences are lower score for Structure, and loss of one MVG: Mallee Woodlands and Shrublands.

There are indications throughout the valley that the Near Riparian domain is not in as good condition as the Lowland Floodplain domain, as its abundance and nativeness are consistently lower. Metrics for the Lowland Floodplain rate consistently in Moderate to Good condition. The two domains cover differing although slightly overlapping parts of the landscape: the Lowland Floodplain is land that floods near the main river channels and covers more area than the Near Riparian domain, which is centred on all stream channels across the valley.

# MURRAY VALLEY - CENTRAL

**Table MCN 7: Central Murray 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 | 98 | 97 | 99 | 100 |
| Metric | LF stability | 0.88 | 0.87 | 0.89 | 0.94 |
| Sub-ind. | NRLF richness | 100 | 100 | 100 | 100 |
| Metric | NR richness | 1 | 1 | 1 | 1 |
| Metric | LF richness | 0.92 | 0.89 | 1 | 1 |
| Sub-ind. | NRLF abundance | 82 | 79 | 84 | 100 |
| Metric | NR abundance | 0.63 | 0.60 | 0.64 | 0.90 |
| Metric | LF abundance | 0.87 | 0.86 | 0.88 | 0.93 |
| Indicator | Quality and integrity | 89 | 87 | 94 | 99 |
| Sub-ind. | NRLF nativeness | 82 | 79 | 84 | 100 |
| Metric | NR nativeness | 0.63 | 0.60 | 0.64 | 0.90 |
| Metric | LF nativeness | 0.87 | 0.86 | 0.88 | 0.93 |
| Sub-ind. | NR structure | 68 (62–75) | 60 (51–69) | 91 (86–95) | 79 (69–89) |
| Sub-ind. | LF fragmentation | 89 | 93 | 74 | 97 |

**Table MCN 8: The most abundant MVGs in the Near Riparian domain in the Central Murray 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 | | | |
| 3. Eucalypt Open Forests | 12 | 27 | 51 |
| 5. Eucalypt Woodlands | 64 | 67 | 26 |
| 6. Acacia Forests and Woodlands | 6 | | |
| 19. Tussock Grasslands | 11 | | |
| 22. Chenopod Shrublands, Samphire Shrublands and Forblands | 5 | | |

# MURRAY VALLEY - CENTRAL

**Table MCN 9: Most abundant MVGs in the Lowland Floodplain domain in the Murray Valley (Central).**
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 | | | |
| Central Murray (Upper) | | | |
| 3. Eucalypt Open Forests | 10 | 0.45 | 1.89 |
| 5. Eucalypt Woodlands | 77 | 0.94 | 0.90 |
| Central Murray (Middle) | | | |
| 3. Eucalypt Open Forests | 27 | 1.22 | 0.87 |
| 5. Eucalypt Woodlands | 67 | 1.44 | 0.56 |
| Central Murray (Lower) | | | |
| 3. Eucalypt Open Forests | 46 | 1.04 | 0.97 |
| 5. Eucalypt Woodlands | 38 | 0.85 | 1.00 |

# MURRAY VALLEY - CENTRAL

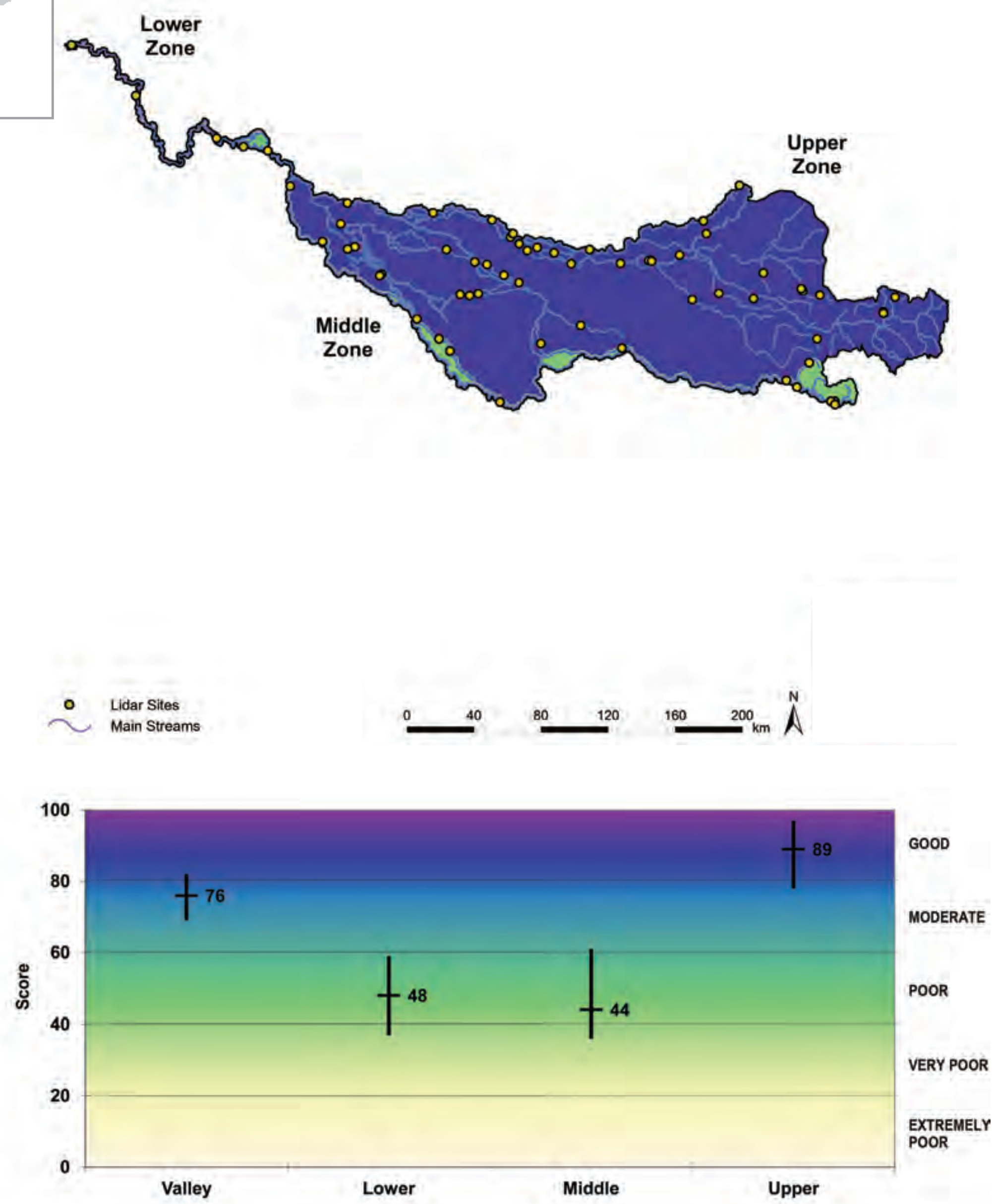



**Figure MCN 5: Central Murray Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.**

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

*The Physical Form of the Central Murray Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 76. The condition of Physical Form in the zones was: Upper Good; Middle and Lower Poor. 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 riverine physical form was characterised by high rates of floodplain sediment deposition since European settlement and elevated sediment loads. There was also evidence of channel simplification, particularly in the Middle zone.*

The SRA Physical Form assessment considers physical form and processes along 6,014 km of stream across the valley. It is based on LiDAR data collected at 63 sites along river channels (including along the main Murray channel), as well as modelling of all 350 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 MCN 5 shows values of the Physical Form Index (SR–PI) for the Central Murray Valley and Table MCN 10 shows the index, sub-index, indicator and metric values.

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

- the SRA Physical Form Condition Index (SR–PI) = 76 (CL 69–82), indicating Moderate Physical Form condition.
- the Channel Form indicator = 77 (CL 70–83), showing a moderate difference from Reference Condition.
- the Bed Dynamics indicator = 78 (CL 75–81), showing a moderate difference from Reference Condition.
- the Bank Dynamics indicator = 95 (CL 91–99), showing a near Reference Condition.
- the Floodplain indicator = 61 (CL 56–68), showing a moderate difference from Reference Condition.

These SRA assessment results are generally inconsistent with assessment results from the River Styles Geomorphic Condition Sub-index of the NSW River Condition Index (GHD 2012a). River Styles results show areas within the Upper zone that are in Moderate and Poor condition (with very little in Good condition), while the SRA results indicate Good condition throughout. River Styles assessment rated the Middle zone (the River Murray) in Moderate condition, while the SRA assessment has rated it in Poor condition. These differences can be explained by fundamental differences in methodology. For example, River Styles assessments take riparian vegetation condition and bed particle size into account, while the SRA assessment does not. In addition, River Styles assessments are based on 'worst case' indicator results, while the SRA assessment is based on integration of all indicator results.

# MURRAY VALLEY - CENTRAL

***Upper zone***

There were 45 LiDAR survey sites and 198 SedNet river segments in the Upper zone of the Central Murray Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upper 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 Width, Meander Wavelength and Bank Variability were modified from reference for approximately half of the Upper zone. At these sites results show both increases and decreases in Channel Width across the zone, Meander Wavelength was generally increased (many sites having large increases) and Bank Variability was generally increased, indicating enhanced Bank Dynamics. Channel Depth, Channel Width Variability, Sinuosity and Channel Sediment Deposition were modified from reference for less than half of the Upper zone. At these sites Channel Depth was generally reduced (with a large reduction at over half of these sites), Channel Width Variability was generally reduced, Sinuosity was generally increased (a few sites having large increases) and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period.

***Middle zone***

There were 13 LiDAR survey sites and 90 SedNet river segments in the Middle zone of the Central Murray Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Middle 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. These results are generally consistent with field observations (Rutherfurd, pers. comm.). Channel Width and Channel Width Variability were modified from reference in more than half of the Middle zone. At these sites Channel Width was generally increased and Channel Width Variability was generally reduced (with a large reduction at over half of these sites). Channel Depth, Meander Wavelength and Bank Variability were modified from reference for approximately half of the Middle zone. At these sites Channel Depth was generally increased (a few sites having large increases), Meander Wavelength was generally increased (many sites having large increases) and results show both increases and decreases in Bank Variability across the zone. Sinuosity and Channel Sediment Deposition were modified from reference for less than half of the Middle zone. At these sites Sinuosity was generally reduced 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 previous field observations in the Murray River and its anabranches (Rutherfurd, pers. comm.).

***Lower zone***

There were five LiDAR survey sites and 62 SedNet river segments in the Lower zone of the Central Murray Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lower zone. At these sites Channel Sediment Ratio was generally increased and there was a large increase in Floodplain Sediment Deposition across 30% of the zone for the post-European period. Channel Width and Channel Width Variability were modified from reference in more than half of the Lower zone. At these sites Channel Width was generally increased and Channel Width Variability was generally reduced (with a large reduction at over half of these sites). Channel Depth and Meander Wavelength were modified from reference for approximately half of the Lower zone. At these sites Channel Depth was generally increased (a few sites having large increases) and Meander Wavelength was generally increased (a few sites having large increases). Bank Variability and Channel Sediment Deposition were modified from reference for less than half of the Lower zone. At these sites 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. Sinuosity was largely unmodified from reference in the Lower zone. These results are generally consistent with previous field observations (Rutherfurd, pers. comm.). Comparisons of historical surveys show that the Murray through this reach has widened and slightly deepened (Rutherfurd 1993).

***Channel Form***

There was little change from Reference Condition in Channel Form in the Upper zone. The most 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 contraction and channel straightening 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 Middle zone. The more serious impacts were channel straightening and channel simplification. Channel straightening was indicated at 70% 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 had little influence on scores when aggregated at the zone scale. These results are generally consistent with previous field observations, although field observations have also indicated that many stream reaches have widened and increased their meander migration rates (Rutherfurd, pers. comm.).

There was minor change from Reference Condition in Channel Form in the Lower zone. The more serious impact was channel straightening. Channel straightening was indicated at 60% of sites mostly as a result of increased meander wavelength. 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.

***Channel and Floodplain Dynamics***

There was little change from Reference Condition in Bank Dynamics in the Upper, Middle and Lower zones. Bank variability exceeded Reference Conditions at 30%, 20% and 40% of sites in these zones respectively. 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.

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There was minor change from Reference Condition in Bed Dynamics in the Upper zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was little change from reference in Bed Dynamics in the Middle zone mostly as a result of widespread elevated sediment load (100% of the SedNet river segments). There was little change from Reference Condition for Bed Dynamics in the Lower zone as a result of widespread sedimentation in 40% of the SedNet river segments and increased sediment load in 100% of the SedNet river segments. In the Lower 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 is also uncertainty around measured deposition rates on floodplains of the middle Murray, with some studies showing high rates (Thoms 1993) and others showing low rates (Kenyon and Rutherfurd 1999).

There was minor change from Reference Condition in Floodplain Sedimentation in the Upper zone as a result of widespread sedimentation (100% of SedNet river segments). There was substantial change from reference in Floodplain Sedimentation in the Middle zone as a result of widespread sedimentation (90% of SedNet river segments). There was severe change from reference in Floodplain Sedimentation in the Lower zone as a result of widespread sedimentation (90% of SedNet river segments).

**Table MCN 10: Central Murray 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) | 76 (69–82) | 89 (78–97) | 44 (36–61) | 48 (37–59) |
| Indicator | Channel Form (volume and flow events) | 77 (70–83) | 81 (74–88) | 61 (48–75) | 78 (58–95) |
| Sub-ind. | Cross-section Form | 84 (80–90) | 84 (78–91) | 83 (74–92) | 88 (83–95) |
| Metric | Channel Depth (mean) | 1.11 (1.00–1.23) | 1.03 (0.92–1.19) | 1.33 (1.07–1.66) | 1.23 (1.03–1.43) |
| Metric | Channel Width (mean) | 1.11 (1.04–1.21) | 1.09 (1.01–1.23) | 1.15 (1.06–1.27) | 1.19 (1.07–1.31) |
| Sub-ind. | Cross-section Form (variability) | 87 (81–93) | 94 (86–99) | 70 (54–90) | 69 (52–88) |
| Metric | Channel Width (CV) | 0.91 (0.88–0.94) | 0.95 (0.92–0.98) | 0.82 (0.73–0.92) | 0.77 (0.67–0.90) |
| Sub-ind. | Channel Planform | 78 (71–85) | 80 (73–87) | 69 (51–87) | 85 (60–99) |
| Metric | Sinuosity | 1.02 (1.00–1.06) | 1.03 (1.00–1.07) | 0.99 (0.97–1.02) | 1.00 (1.00–1.00) |
| Metric | Meander Wavelength | 1.13 (1.08–1.18) | 1.11 (1.04–1.17) | 1.19 (1.08–1.33) | 1.09 (1.01–1.20) |
| Indicator | Bed Dynamics | 78 (75–81) | 75 (71–79) | 84 (80–89) | 89 (80–95) |
| Metric | Channel Sediment Ratio | 27 (22–32) | 31 (25–38) | 20 (9–35) | 5 (4–7) |
| Metric | Channel Sediment Depth | 0.002 (0.001–0.003) | 0.001 (0.001–0.002) | 0.005 (0.001–0.01) | 0.001 (0–0.003) |
| Indicator | Bank Dynamics | 95 (91–99) | 95 (88–99) | 95 (88–100) | 99 (97–100) |
| Metric | Bank Variability (longitudinal) | 1.03 (0.99–1.09) | 1.03 (0.99–1.10) | 1.00 (0.93–1.08) | 1.10 (1.00–1.26) |
| Indicator | Floodplain | 61 (56–68) | 74 (67–83) | 36 (21–53) | 19 (11–32) |
| Metric | Floodplain Sediment Deposition | 4.00 (3.00–5.00) | 1.82 (1.07–3.00) | 10.00 (6.00–14.00) | 9.00 (5.00–12.00) |

# MURRAY VALLEY - CENTRAL

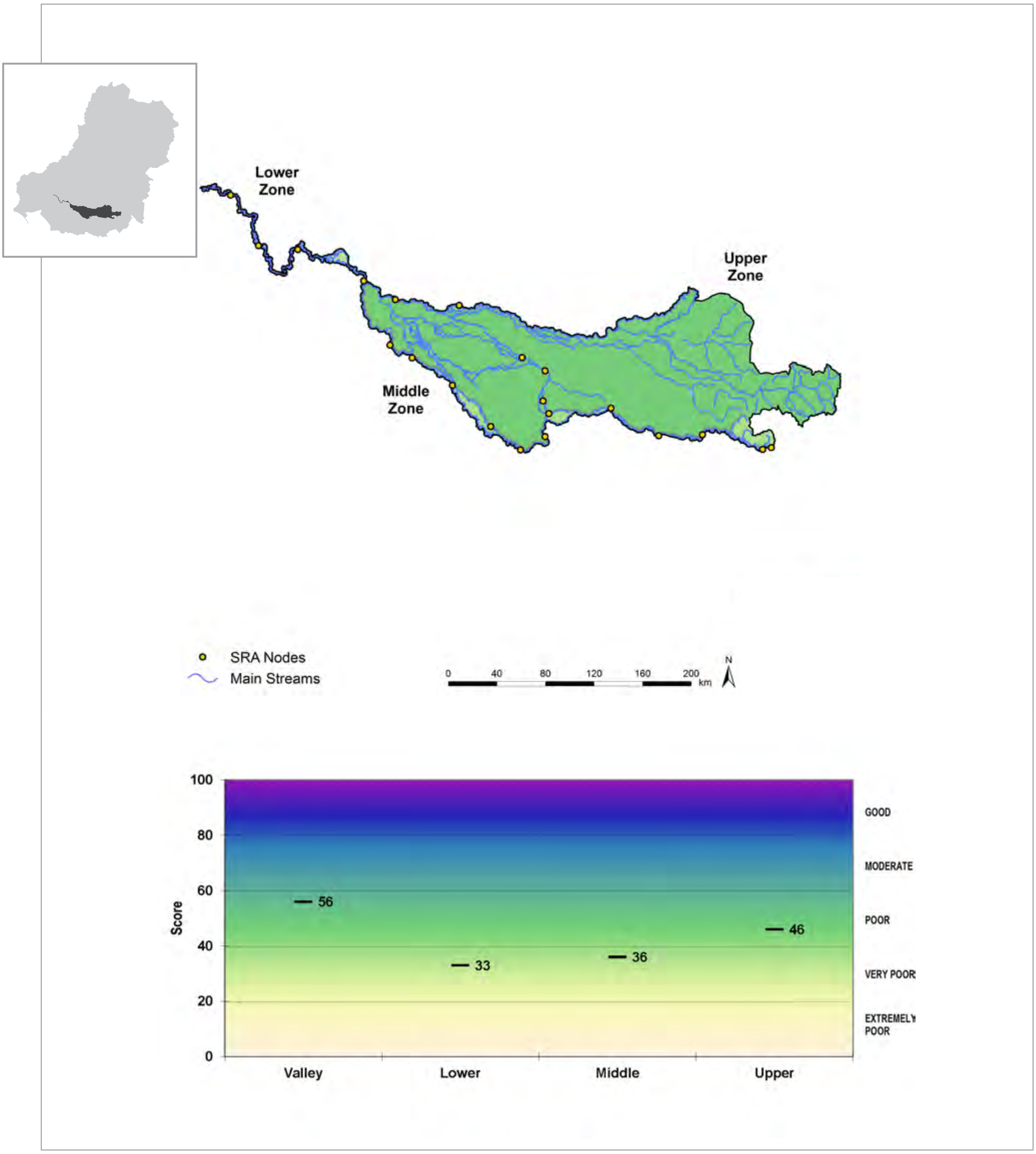



Figure MCN 6: Central Murray Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

*The Hydrology of the Central Murray Valley river system was in Poor condition, with an aggregate Hydrology Index (SR–HI) score of 56. The Upper zone was in Poor condition. The Middle and Lower zones were in Very Poor condition.*

*The mainstem river system of the Central Murray Valley was rated in Very Poor condition. The timing of seasonal flow variations was altered, duration and frequency of High Flow Spells were reduced, 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 relative to Reference Condition. These changes were associated with widespread reduced mean and high flows and increased low flows and reduced duration of high and low flow spells in most reaches, relative to reference.*

*Headwater stream scores did not receive any weight in the valley assessment because all zones in the Central Murray Valley are classed as Lowland and flow alterations in mainstem rivers are hydrologically dominant in the Lowland zones.*



The Central Murray Valley extends from below Lake Hume to Lock 10, below the Murray–Darling junction at Wentworth. Major tributaries include the Murrumbidgee, Darling, Kiewa, Ovens, Goulburn, Campaspe and Loddon rivers. In addition to Lake Hume, there are lesser instream storages at Yarrawonga, Torrumbarry, Mildura and Wentworth weirs, used to provide hydraulic heads for diversions and to regulate flows to meet downstream demand. Tributary flows are highly modified before they reach the Murray. Limited channel capacity near Barmah (Barmah Choke: <9 GL/day) means that some irrigation releases are diverted via the Edward River.

In the Central Murray Valley, hydrological condition is assessed using metrics of hydrological alteration available for 2,754 km of mainstem rivers and headwater streams. There are 1,507 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 modelling in 2% of river reaches and daily modelling in the remainder. 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 Central Murray Valley there is 1,247 km of headwater stream (Lower zone: 14 km; Middle zone: 152 km; Upper zone: 1,081 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 Central Murray Valley there is 3,747 km of these mid-size tributaries (75 km in the Lower zone; 323 km in the Middle zone; 3,349 km in the Upper zone) which is 1.4 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 a 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.

# MURRAY VALLEY - CENTRAL

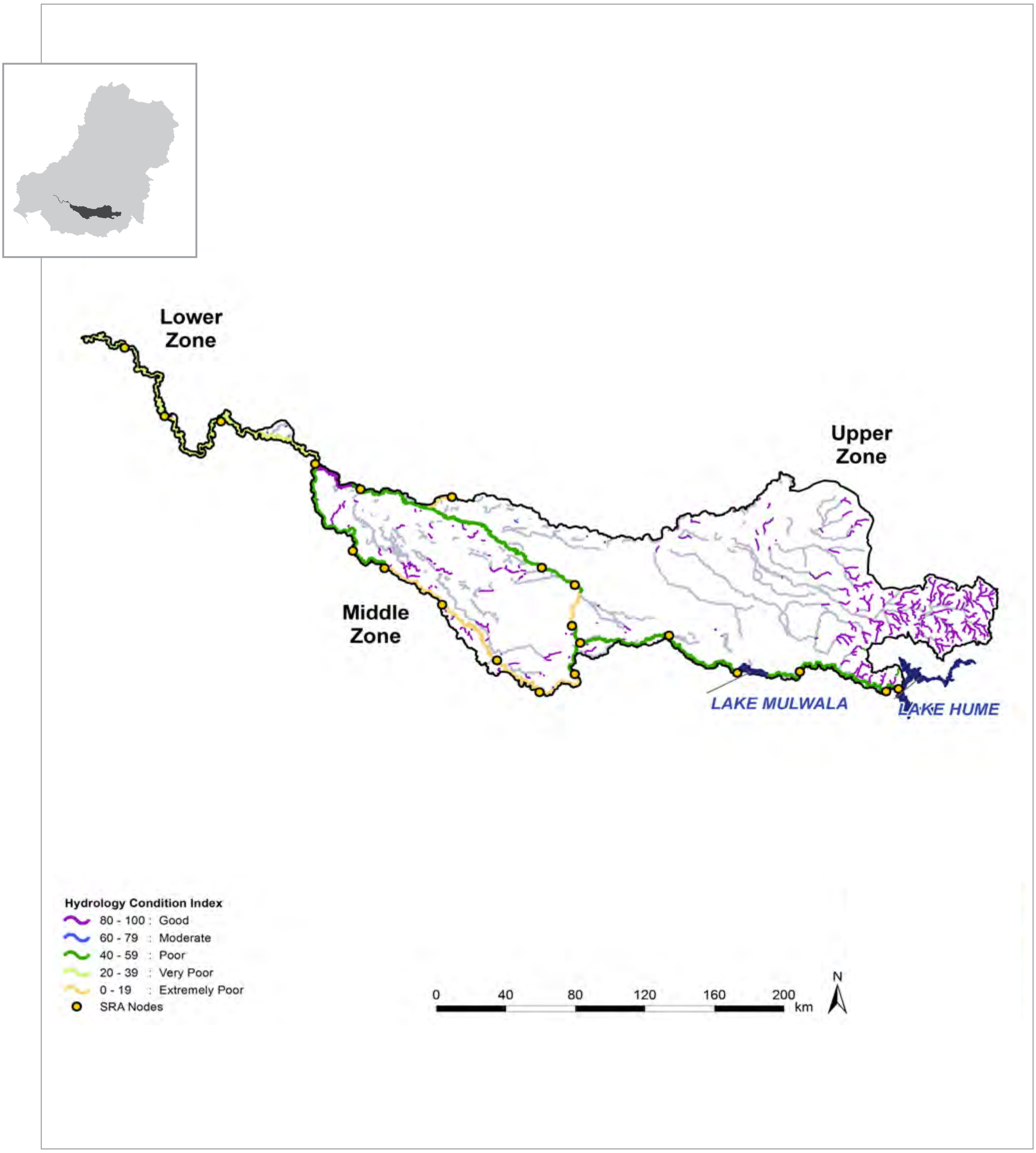



Figure MCN 7: Central Murray Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures MCN 6 and MCN 7 show values of the Hydrology Condition Index (SR–HI) for the Central Murray Valley and its river network, and Table MCN 11 and MCN 12 show the index, sub-index, indicator and metric values. Analyses showed a large difference from Reference Condition for the Central Murray Valley, with:

- The Hydrology Condition Index for the whole valley = 56, indicating Poor hydrological condition.
- The Hydrology Condition Index for the Lower, Middle and Upper zones = 33, 36 and 46 indicating Very Poor, Very Poor 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) = 38, 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 = 78, 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 a large difference from Reference Condition. Results for the Flow Duration metric showed only small variations from reference throughout the mainstem river length (associated with both increased and reduced flows). Results for the Mean Annual Flow metric showed a very significant alteration from Reference Condition in 63% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 24% 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).

***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.

# MURRAY VALLEY - CENTRAL

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 7% 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. Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 81% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference 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 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 very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 17% 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 Lower zone, some in the Middle zone and most in the Upper 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 31% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 24% 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 Lower zone, some in the Middle zone and some in the Upper zone. Results for the Zero Flows Proportion metric showed a significant alteration from reference in 2% 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 Upper zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 48% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference 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 Lower zone, some in the Middle zone and a small portion 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 a significant alteration from reference in 28% 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 Middle zone and most in the Upper 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 Condition.

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 48% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 45% 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 zone, some in the Middle zone and some in the Upper zone. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 29% of the mainstem river length and a significant alteration from reference in 71% of the mainstem river length. 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 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 26% 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 Lower zone, a small proportion in the Middle zone and most in the Upper 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 2% of the mainstem river length (mostly associated with reduced variability) and a significant alteration from reference in 59% 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 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 some in the Middle zone and some in the Upper 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 the reference flow regime. 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 60% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 40% 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 25% 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 Lower zone, some in the Middle zone and some 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 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 the reference flow regime. 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 42% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 58% 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 22% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 20% 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.

***Summary: mainstem rivers***

The mainstem river system of the Central Murray Valley was generally characterised by substantial alteration in Flow Seasonality, considerable alteration in High Flow Events, minor alteration in Flow Variability and little or no alteration in Low and Zero Flow Events and Flow Gross Volume relative to Reference Condition. Flow seasonality was substantially altered with reduced amplitude and altered timing of seasonal flow variations throughout all of the mainstem river system. These changes were associated with widespread reduced high flows and increased low flows in some reaches. The mainstem river system of the Central Murray Valley was generally characterised by substantial alteration in Flow Seasonality, considerable alteration in High Flow Events and Flow Gross Volume and moderate alteration in High Over Bank Floods, Low Over Bank Floods, Flow Variability and Low and Zero Flow Events. The duration and frequency of high flow spells were reduced, timing of seasonal flow variations was altered, 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. These changes were associated with widespread reduced mean and high flows and increased low flows and reduced duration of high and low flow spells in most reaches, relative to reference.

***Summary: headwater streams***

The headwater streams of the Central Murray 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 and the amplitude of seasonal flow variations was increased. headwater stream scores did not receive any weight in the valley assessment because all zones in the Central Murray Valley are classed as Lowland and flow alterations in mainstem rivers are hydrologically dominant in the Lowland zones.

**Table MCN 11: Central Murray Valley: SRA Hydrology Condition Index at valley and zone scales.**

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

| Index | Valley | Upper | Middle | Lower |
|---|---|---|---|---|
| Hydrology Condition SR–HI | 56 | 46 | 36 | 33 |

# MURRAY VALLEY - CENTRAL

**Table MCN 12: Central Murray 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 | Valley: Headwater streams |
|---|---|---|---|
| **Index** | **Hydrological Condition (Mainstem: SR-HIm, Headwater: SR-HIh)** | **38 (2–100)** | **100 (11–100)** |
| Sub-index | In-Channel Flow Regime | 24 (3–100) | 100 (11–100) |
| **Indicator** | **In-Channel Flow Regime A (volume and flow events)** | **44 (27–100)** | **100 (37–100)** |
| Sub-ind. | Flow Gross Volume | 47 (9–96) | 99 (92–100) |
| Metric | Mean Annual Flow | 0.51 (0.17–1.5) | 1.03 (0.81–1.17) |
| Metric | Flow Duration | 0.97 (0.92–1.10) | 0.98 (0.86–1.14) |
| Sub-ind. | High Flow Events | 56 (20–92) | 97 (62–100) |
| Metric | High Flow | 0.41 (0.15–1.44) | 1.02 (0.53–1.72) |
| Metric | High Flow Spells | 0.44 (0.2–0.71) | |
| Sub-ind. | Low and Zero Flow Events | 72 (19–97) | 96 (28–99) |
| Metric | Zero Flows Proportion | 1.02 (1.01–1.36) | 0.99 (0.96–1.00) |
| Metric | Low Flow | 1.20 (0.30–1.94) | 0.92 (0.05–1.34) |
| Metric | Low Flow Spells | 1.46 (0.46-2.00) | |
| **Indicator** | **In-Channel Flow Regime B (seasonality & variability)** | **46 (11–89)** | **98 (21–100)** |
| Sub-ind. | Flow Seasonality | 39 (26–64) | 94 (62–100) |
| Metric | Flow Seasonal Amplitude | 0.52 (0.32–1.25) | 1.12 (0.89–1.71) |
| Metric | Flow Seasonal Period | 0.56 (0.22–0.71) | 0.96 (0.85–1.00) |
| Sub-ind. | Flow Variability | 69 (0–100) | 88 (17–100) |
| Metric | Flow Variation | 1.09 (0.44–1.32) | 0.90 (0.61–1.00) |
| Sub-index | Over Bank Flow Regime | 78 (25–99) | |
| **Indicator** | **Over Bank Floods Low** | **69 (33–94)** | |
| Metric | OB Flow Duration (ARI 1) | 0.50 (0.27–2.00) | |
| Metric | OB Flow Spells (ARI 1) | 0.78 (0.32–1.56) | |
| **Indicator** | **Over Bank Floods High** | **70 (0–94)** | |
| Metric | OB Flow Duration (ARI 8) | 0.59 (0.12–2.00) | |
| Metric | OB Flow Spells (ARI 8) | 0.85 (0–1.65) | |

| | Zone | | | | | |
|---|---|---|---|---|---|---|
| | Mainstem rivers | | | Headwater streams | | |
| | Upper | Middle | Lower | Upper | Middle | Lower |
| | **46** | **36** | **33** | **100** | **97** | **100** |
| | 31 | 24 | 18 | 100 | 97 | 100 |
| | **45** | **48** | **33** | **100** | **100** | **100** |
| | 51 | 60 | 17 | 99 | 99 | 99 |
| | 0.59 | 0.62 | 0.23 | 1.03 | 1.04 | 1.04 |
| | 0.99 | 0.99 | 0.93 | 0.98 | 0.99 | 1.00 |
| | 59 | 60 | 46 | 98 | 96 | 96 |
| | 0.51 | 0.44 | 0.28 | 1.01 | 1.07 | 1.09 |
| | 0.47 | 0.46 | 0.36 | | | |
| | 70 | 67 | 84 | 96 | 97 | 98 |
| | 1.04 | 1.01 | 1.01 | 0.99 | 0.98 | 1.00 |
| | 1.12 | 1.30 | 1.07 | 0.91 | 0.97 | 1.05 |
| | 1.28 | 1.54 | 1.45 | | | |
| | **45** | **47** | **43** | **99** | **94** | **98** |
| | 47 | 36 | 37 | 95 | 91 | 88 |
| | 0.64 | 0.54 | 0.36 | 1.11 | 1.19 | 1.24 |
| | 0.57 | 0.50 | 0.68 | 0.96 | 0.96 | 0.99 |
| | 59 | 76 | 65 | 89 | 85 | 97 |
| | 1.12 | 1.00 | 1.25 | 0.90 | 0.89 | 0.96 |
| | 83 | 80 | 68 | | | |
| | **65** | **80** | 54 | | | |
| | 0.63 | 0.49 | 0.41 | | | |
| | 0.72 | 0.99 | 0.44 | | | |
| | **79** | **64** | 71 | | | |
| | 0.69 | 0.60 | 0.49 | | | |
| | 0.86 | 0.74 | 1.02 | | | |

# MURRAY VALLEY - LOWER

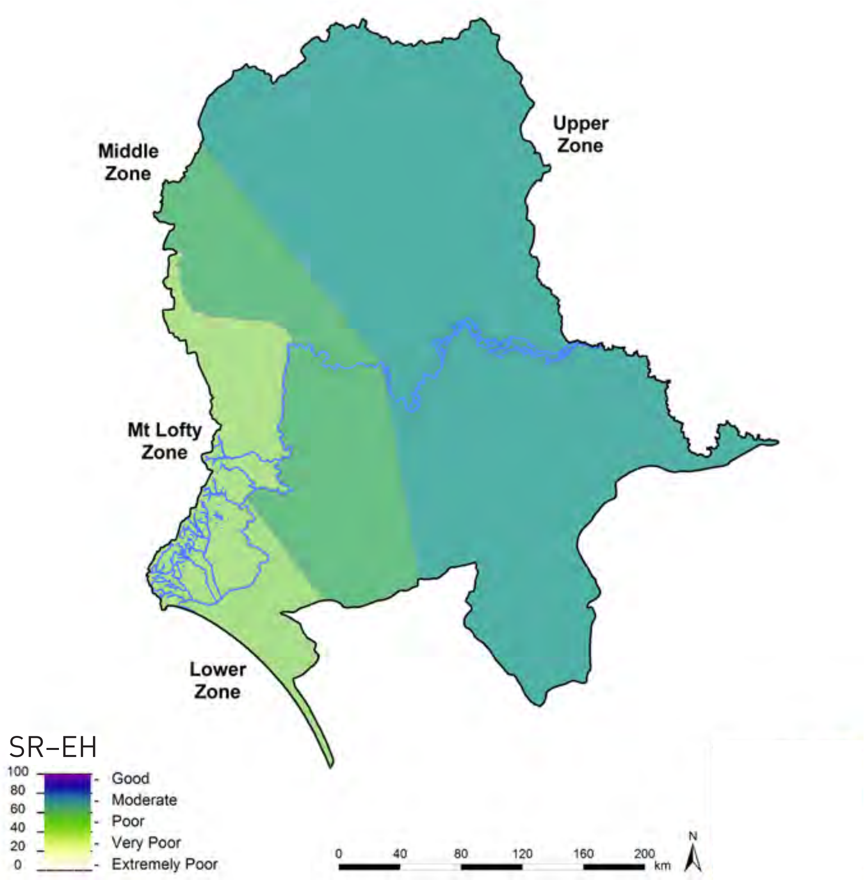



**Figure MLW 1: Lower Murray Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure MLW 1 shows the Ecosystem Health ratings for the Lower Murray Valley and Tables MLW 1 and MLW 2 also show the index values and ratings for each Theme. Ecosystem Health shows a large difference from Reference Condition for the Lower Murray Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Poor, Moderate and Poor condition respectively, while Physical Form and Hydrology were in Moderate and Very 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 Lower Murray Valley river system. The River Ecosystem health was rated as Poor (Lower zone: Very Poor; Middle zone: Poor; Upper zone: Moderate; Mt Lofty zone: Very Poor).

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

***Ecosystem health***

Themes rating the condition of physical characteristics of the Lower Murray river system (Hydrology and Physical Form) ranked it very lowly—23rd (worst) and 22nd respectively out of the 23 SRA valleys. By contrast, it ranked seventh, in terms of River Ecosystem Health, in the middle of those valleys rated as being in Poor condition (see Table 5.2).

*The Lower Murray Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Upper Moderate, Middle Poor, Lower and Mt Lofty Very 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. 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 to high levels of sediment delivery to the Floodplain. Riverine Vegetation was in Poor condition overall, with reduced abundance, stability, nativeness and structural integrity in the Near Riparian and Lowland Floodplain domains, and minor to no increase in fragmentation in the Lowland Floodplain. The river system's Hydrology was in Very Poor condition, with the mainstem Murray River reaches in Extremely Poor condition and characterised by substantial alteration in flow variability, flow seasonality and high flow events relative to Reference Condition; and considerable alteration in flow gross volume and low flow events in the main channel.*

The physical characteristics of the valley are dominated by the fact that it is at the end of a highly regulated system with substantial upstream diversions, contains a series of locks and associated weir pools (extensive because of the low channel grade) with levees and some channel modification in the lower reaches.

Overall vegetation condition was rated as Poor. However the high ratings for the Upper and Middle zones reflect the poor quality of the available vegetation mapping data rather than reality.

The combination of flow management and drought conditions most likely results in changes to lateral connectivity and interactions between floodplain and main channel systems. Fish and macroinvertebrate samples were, however, restricted to main channel sites and indicate that these communities are in relatively sound condition. The relativity of these rankings should be stressed, however, as other streams may be exposed to greater impact from current climatic patterns than the relatively large and managed Lower Murray.

***Fish Theme***

The Fish Condition Index SR–FI = 43, indicating Poor condition (Lower zone: Poor; Middle zone: Poor; Upper zone: Poor; Mt Lofty zone: Extremely Poor). The Expectedness indicator = 45, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 74, indicating Moderate condition, and a moderate difference from Reference Condition. The Recruitment indicator = 48, indicating Poor condition, and a large difference from Reference Condition.

The valley had lost much of its native species richness and alien species contributed over 69% of fish biomass. Native fish recruitment was Very Poor in the Mt. Lofty zone and Poor to Moderate in the Upper, Middle and Lower zones of the River Murray, respectively.

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 76, indicating Moderate condition (Mt Lofty zone: Good; Lower zone: Poor; Middle zone: Moderate; Upper zone: Moderate). The simOE metric = 51, 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 or Good condition was high (81% overall), with ten of the 32 rated sites being in Good condition.

Family richness generally was low, and was also low compared to Reference Condition.

# MURRAY VALLEY - LOWER

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 56, indicating Poor condition (Lower zone: Extremely Poor; Middle zone: Good; Upper zone: Good; Mt Lofty zone: Extremely Poor). The Vegetation Abundance and Diversity indicator = 65, indicating Moderate condition and a moderate difference from Reference Condition for the abundance and stability of major vegetation groups within 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 within the Near Riparian and Lowland Floodplain domains.

The Lowland Floodplain domain, as best can be determined from the available mapping, is relatively little affected by clearing. High vegetation condition and abundance ratings for the Upper and Middle zones are suspect due to gaps and quality in the low reliability source mapping. The abundance and degree of fragmentation of major vegetation groups is near Reference Condition in the sampled floodplain area.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 68, indicating Moderate condition (Lower zone: Very Poor; Middle zone: Poor; Upper zone: Moderate; Mt Lofty zone: Moderate). The Channel Form indicator = 69, the Bed Dynamics indicator = 60, and the Floodplain Form indicator = 74; all indicating Moderate condition and showing a minor difference from Reference Condition. The Bank Dynamics indicator = 96, indicating Good condition and showing near Reference Condition.

Overall, the valley's riverine physical form was characterised by channel enlargement and straightening. There was also indication of elevated sediment loads since European settlement, particularly in the Mt Lofty zone, and associated sedimentation.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 31, indicating Very Poor condition for the valley overall – which includes the mainstream Murray along with the Mt Lofty zone. The mainstem Murray River intself was in Extremely Poor condition in all three zones, while the Mt Lofty zone was in Good hydrological condition. The In-Channel Flow Regime and Over Bank Flow Regime sub-indexs = 4 and 9 respectively, indicating Extremely Poor condition and an extreme difference from Reference Condition for the flow regime within and outside the channels.

The mainstem river reaches (all in the Murray River) were generally characterised by reduced magnitude of High and Mean Flows, frequency of High Flow Spells, duration of High and Low Over Bank Flows and amplitude of Seasonal Flow Variation. In addition, monthly Flow Variation and the frequency of Low Flow Spells were increased, inter-flood durations for Low and High Over Bank Flows were increased and the timing of seasonal flow variations was altered. The headwater streams were generally characterised by little or no alteration in any hydrology indicator relative to Reference Condition.

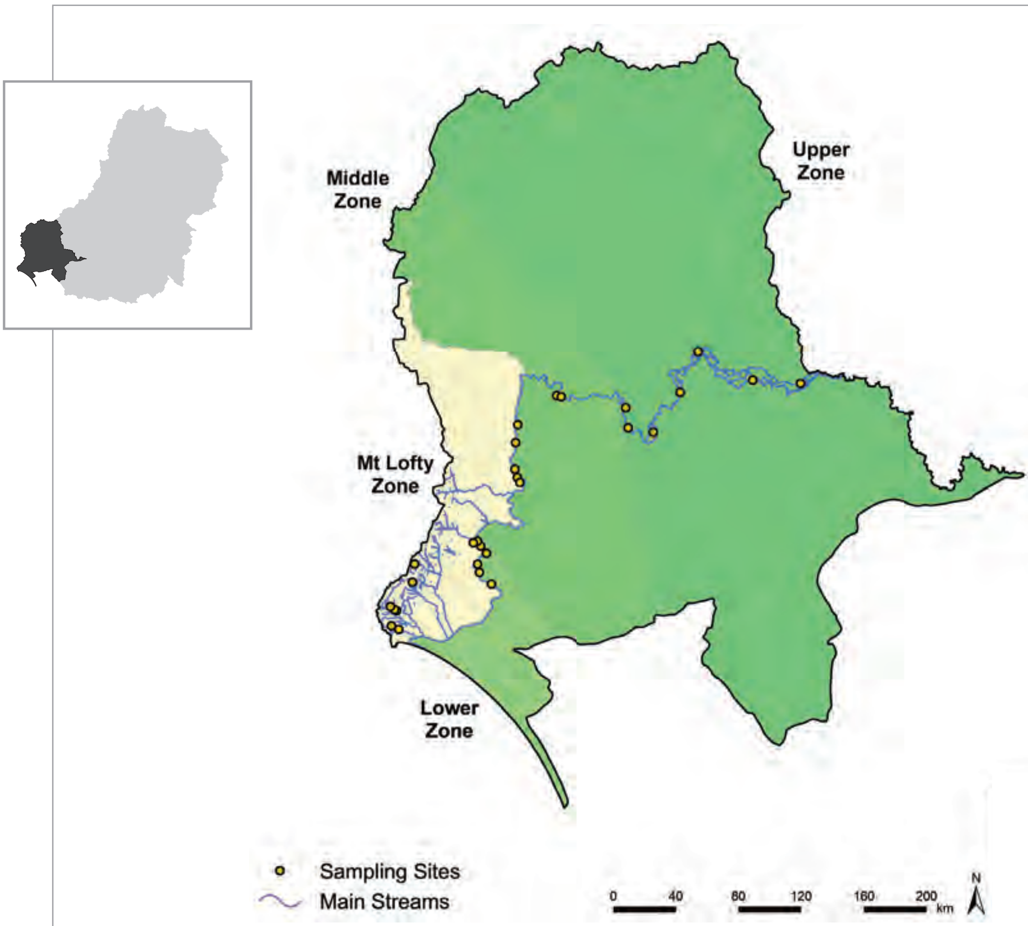
**Table MLW 1: Lower Murray Valley Ecosystem Health and condition assessments.**
Index values are means (lower–upper 95% confidence limits shown for themes where calculated).

| Ecosystem Health | HEALTH RATING | VALLEY | UPPER | MIDDLE | LOWER | MT LOFTY |
|---|---|---|---|---|---|---|
| | | Poor | Moderate | Poor | Very Poor | Very Poor |

| THEME | | VALLEY | ZONE | | | |
|---|---|---|---|---|---|---|
| | | | UPPER | MIDDLE | LOWER | MT LOFTY |
| Fish | SCORE RATING | 43 (39–49) Poor | 48 Poor (42–57) | 45 Poor (43–53) | 42 Poor (36–48) | 11 Ext' Poor (4–17) |
| Macro-invertebrates | SCORE RATING | 76 (72–80) Moderate | 78 (75–82) Moderate | 61 (55–67) Moderate | 59 (59–59) Poor | 83 (76–91) Good |
| Vegetation | SCORE RATING | 56 Poor | 100 Good | 87 Good | 6 Ext' Poor | 12 Ext' Poor |

**Table MLW 2: Lower Murray 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 | MT LOFTY |
| Physical Form | SCORE RATING | 68 (60–75) Moderate | 72 Moderate (60–86) | 51 Poor (41–66) | 29 Very Poor (20–38) | 72 Moderate (62–83) |
| Hydrology | SCORE RATING | 31 Very Poor | 3 Ext' Poor | 3 Ext' Poor | 2 Ext' Poor | 96 Good |



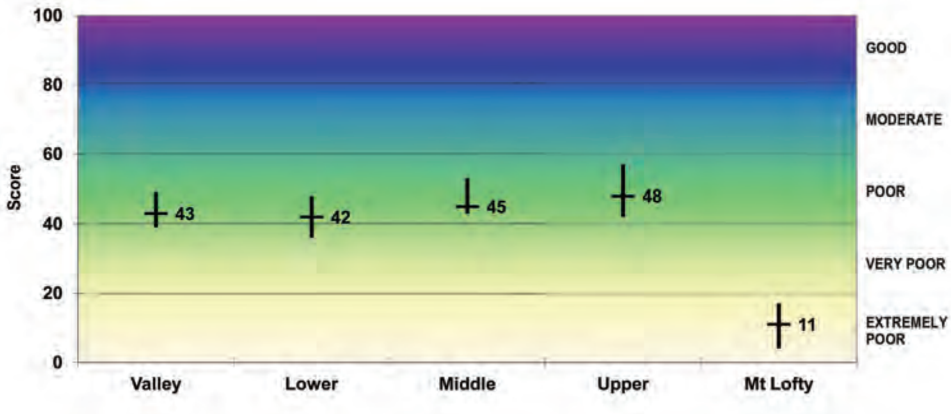




**Figure MLW 2: Lower Murray Valley map with sampling sites and zones coloured by SR Fish Index scores.**

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

*The Fish community of the Lower Murray Valley river system was in Poor condition, with an aggregate Fish Index score (SR–FI) of 43. The condition of the fish community in the zones was as follows: Mt. Lofty Extremely Poor; and Poor in the Upper, Middle and Lower zones. The fish community was characterised by a Poor score for expected native fish species, a Moderate score for nativeness and a Poor score for native fish recruitment. The Mt. Lofty zone lacked 75% of the predicted native species. The valley had lost much of its native species richness and alien species contributed over 69% of the biomass in samples. Native fish recruitment was Very Poor, Poor, Poor and Moderate in the Mt. Lofty, Upper, Middle, and Lower zones respectively.*

Twenty-eight sites were surveyed across the Lower Murray Valley in February–April 2008, yielding 8,407 fish. Analyses showed a large difference from Reference Condition for the Lower Murray Valley, with:

- SRA Fish Index (SR–FI) = 43 (CL 39–49), indicating Poor condition of the fish community.
- The Expectedness indicator = 45 (CL 42–49), indicating Poor condition, and a large difference from Reference Condition. Only 43% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 74 (CL 67–79), indicating Moderate condition, and a moderate difference from Reference Condition.
- The Recruitment indicator = 48 (CL 42–56), indicating Poor condition, and a large difference from Reference Condition. Evidence of recruitment was observed for nine of the 15 native species observed in the valley.

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

SR–FI for the Lower Murray Valley was seventh highest for all valleys, and close to that for the Wimmera and Ovens valleys. The Mt. Lofty zone community was in much worse condition (SR–FI = 11) than that in the three zones on the main channel of the Murray (SR–FI = 48, 45, and 42 for Upper, Middle, and Lower zones respectively).

Expectedness varied between zones and was lowest in the Mt. Lofty zone (rated as Extremely Poor) and the Lowland zone (Very Poor). Eleven of the native species expected to occur in the Lower Murray Valley (and in the Lower zone) are either estuarine species or spend some part of their life in the sea. None of these species were observed at any sample site, perhaps reflecting in part the extended drought conditions and extremely low river flows prior to sampling.

Nativeness was rated as Moderate throughout the valley reflecting the fact that there were only three or four alien species present in any zone and the fact that individuals of some native species (all small-bodied fish) were very numerous.

# MURRAY VALLEY - LOWER

Native fish were more numerous than alien fish in the Lower Murray Valley as a whole; constituting 66% of the total fish caught. This pattern was repeated in the three main-channel zones – the Upper, Middle, and Lower zones – where the proportion of the total catch belonging to native species was 88%, 90%, and 88% respectively. In the Mt. Lofty zone, native species contributed only 18% of the catch.

The Lower Murray Valley produced the largest biomass of fish of all the valleys (26.9 kg of fish per site). Alien species contributed the major part of this, though native fish outnumbered aliens by nearly 2:1. In the valley as a whole, 31% of the fish biomass came from native species. This statistic for each of the zones was 25%, 43%, 31%, and 19% in the Mt Lofty, Upper, Middle, and Lower zones respectively.

Table MLW 4 shows native species abundances in the Lower Murray Valley compared with Reference Condition. Bony herring and the alien gambusia, were the most numerous fish, followed by gudgeons and unspecked hardyheads. Four hundred and forty-nine common carp were caught throughout the valley. However, as they weighed an average of 1.1 kg, this constituted a biomass of common carp of 18.1 kg/site or 67% of total fish biomass. Trout cod, river blackfish, and Macquarie perch were expected, but not caught at any site.

Recruitment was rated as Poor in the Lower Murray Valley. In the Mt Lofty zone it was Very Poor, Poor in both the Upper and Middle zones and Moderate in the Lower zone. Nine of the 15 native species sighted were observed to be recruiting at least in some parts of the valley. Silver perch and Murray cod (both caught in low numbers) and golden perch were not recorded as recruiting at any site. All five alien species were noted as recruiting at least some sites.

In general, the fish community of the Lower Murray had reduced numbers of expected native species. The valley had the largest biomass of fish per site (of any Basin valley) dominated by alien species; and the second largest number of fish caught per site (dominated by small native species).

**Table MLW 3: Lower Murray 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 | Mt Lofty |
| Index | Fish Condition (SR–FI) | 43 (39–49) | 48 (42–57) | 45 (43–53) | 42 (36–48) | 11 (4–17) |
| Indicator | Expectedness | 45 (42–49) | 53 (47–58) | 44 (41–46) | 32 (27–35) | 14 (7–24) |
| Metric | O/E | 0.55 (0.49–0.60) | 0.57 (0.48–0.65) | 0.61 (0.56–0.64) | 0.50 (0.44–0.55) | 0.32 (0.19–0.48) |
| Metric | O/P (Zone level) | 0.42 (0.42–0.42) | 0.48 (0.48–0.48) | 0.36 (0.36–0.36) | 0.31 (0.31–0.31) | 0.25 (0.25–0.25) |
| Indicator | Nativeness | 74 (67–79) | 76 (66–84) | 75 (71–81) | 70 (68–72) | 61 (38–81) |

Continued/...

| Indexes Indicators metrics | Description | Valley | Zone | | | |
|---|---|---|---|---|---|---|
| | | | Upper | Middle | Lower | Mt Lofty |
| Metric | Proportion biomass native | 0.42 (0.33–0.50) | 0.46 (0.33–0.57) | 0.36 (0.24–0.47) | 0.20 (0.14–0.25) | 0.46 (0.18–0.76) |
| Metric | Proportion abundance native | 0.82 (0.71–0.90) | 0.82 (0.65–0.92) | 0.89 (0.86–0.93) | 0.86 (0.80–0.91) | 0.67 (0.40–0.89) |
| Metric | Proportion species native | 0.73 (0.69–0.76) | 0.73 (0.69–0.77) | 0.79 (0.74–0.84) | 0.84 (0.80–0.87) | 0.51 (0.31–0.72) |
| Indicator | Recruitment | 48 (42–56) | 48 (40–61) | 54 (52–72) | 73 (58–82) | 24 (0–30) |
| Metric | Proportion of sites with native recruits | 0.59 (0.53–0.62) | 0.59 (0.51–0.64) | 0.67 (0.65–0.67) | 0.71 (0.60–0.78) | 0.36 (0–0.49) |
| Metric | Proportion of native taxa with recruits | 0.64 (0.60–0.72) | 0.64 (0.60–0.78) | 0.67 (0.67–0.86) | 0.80 (0.78–0.88) | 0.50 (0–0.50) |
| Metric | Proportion of abundance as recruits | 0.51 (0.45–0.57) | 0.54 (0.48–0.66) | 0.49 (0.47–0.62) | 0.63 (0.54–0.67) | 0.29 (0–0.33) |
| Variables | | | | | | |
| | Number of sites sampled | 28 | 7 | 7 | 7 | 7 |
| | Total number of species | 20 | 15 | 13 | 13 | 7 |
| | Number of native species | 15 | 11 | 9 | 10 | 4 |
| | Number of predicted species | 35 | 23 | 25 | 32 | 16 |
| | Number of alien species | 5 | 4 | 4 | 3 | 3 |
| | Mean number of fish per site | 300 | 329 | 331 | 148 | 392 |
| | Biomass/site all species (g) | 26,871 | 23,135 | 57,595 | 25,784 | 973 |
| | Mean native biomass/fish (g) | 42 | 34 | 60 | 38 | 3 |
| | Mean alien biomass/fish (g) | 181 | 330 | 1227 | 1131 | 2 |

**Table MLW 4: Lower Murray 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 | Mt Lofty |
| Sites sampled | 28 | 7 | 7 | 7 | 7 |
| Native species | | | | | |
| Australian smelt | 244 | 84 | 104 | 56 | 0 |
| Black bream | 0 | | | 0 | |
| Blue spot goby | 0 | | | 0 | |
| Bony herring | 2127 | 696 | 939 | 492 | |
| Climbing galaxias | 0 | | | | 0 |
| Common jollytail | 6 | | 0 | 6 | 0 |
| Congolli | 0 | 0 | 0 | 0 | 0 |
| Dwarf flathead gudgeon | 2 | 1 | 0 | 1 | 0 |
| Estuary perch | 0 | | 0 | 0 | |
| Flathead gudgeon | 443 | 32 | 56 | 56 | 299 |
| Freshwater catfish | 5 | 2 | 0 | 3 | |
| Golden perch | 117 | 37 | 71 | 9 | 0 |
| Gudgeon | 987 | 452 | 439 | 96 | 0 |
| Lagoon goby | 0 | | | 0 | |
| Macquarie perch | 0 | 0 | 0 | | |
| Mountain galaxias | 132 | | | | 132 |
| Murray cod | 2 | 1 | 1 | 0 | 0 |
| Murray hardyhead | 0 | 0 | 0 | 0 | |
| Murray jollytail | 0 | 0 | 0 | 0 | |
| Murray–Darling rainbowfish | 427 | 221 | 98 | 108 | |

Continued/...

| Fish species | Valley | Zone | | | |
|---|---|---|---|---|---|
| | | Upper | Middle | Lower | Mt Lofty |
| Obscure galaxias complex | 51 | | | 0 | 51 |
| Olive perchlet | 0 | 0 | 0 | 0 | |
| Pouched lamprey | 0 | | 0 | 0 | 0 |
| River blackfish | 0 | 0 | 0 | 0 | 0 |
| Sandy sprat | 0 | | | 0 | |
| Short-finned eel | 0 | 0 | 0 | 0 | 0 |
| Shortheaded lamprey | 0 | 0 | 0 | 0 | 0 |
| Silver perch | 8 | 4 | 4 | 0 | |
| Smallmouthed hardyhead | 0 | | | 0 | |
| Southern purple-spotted gudgeon | 0 | 0 | 0 | 0 | |
| Southern pygmy perch | 19 | 0 | 0 | 0 | 19 |
| Trout cod | 0 | 0 | 0 | 0 | |
| Unspecked hardyhead | 956 | 494 | 379 | 83 | |
| Yarra pygmy perch | 0 | | | 0 | |
| Yelloweyed mullet | 0 | | | 0 | |
| Alien species | | | | | |
| Brown trout | 9 | | | | 9 |
| Common carp | 449 | 120 | 203 | 126 | |
| Gambusia | 2370 | 130 | 9 | | 2231 |
| Goldfish | 40 | 27 | 11 | 2 | |
| Redfin perch | 13 | 3 | 4 | 1 | 5 |

# MURRAY VALLEY - LOWER

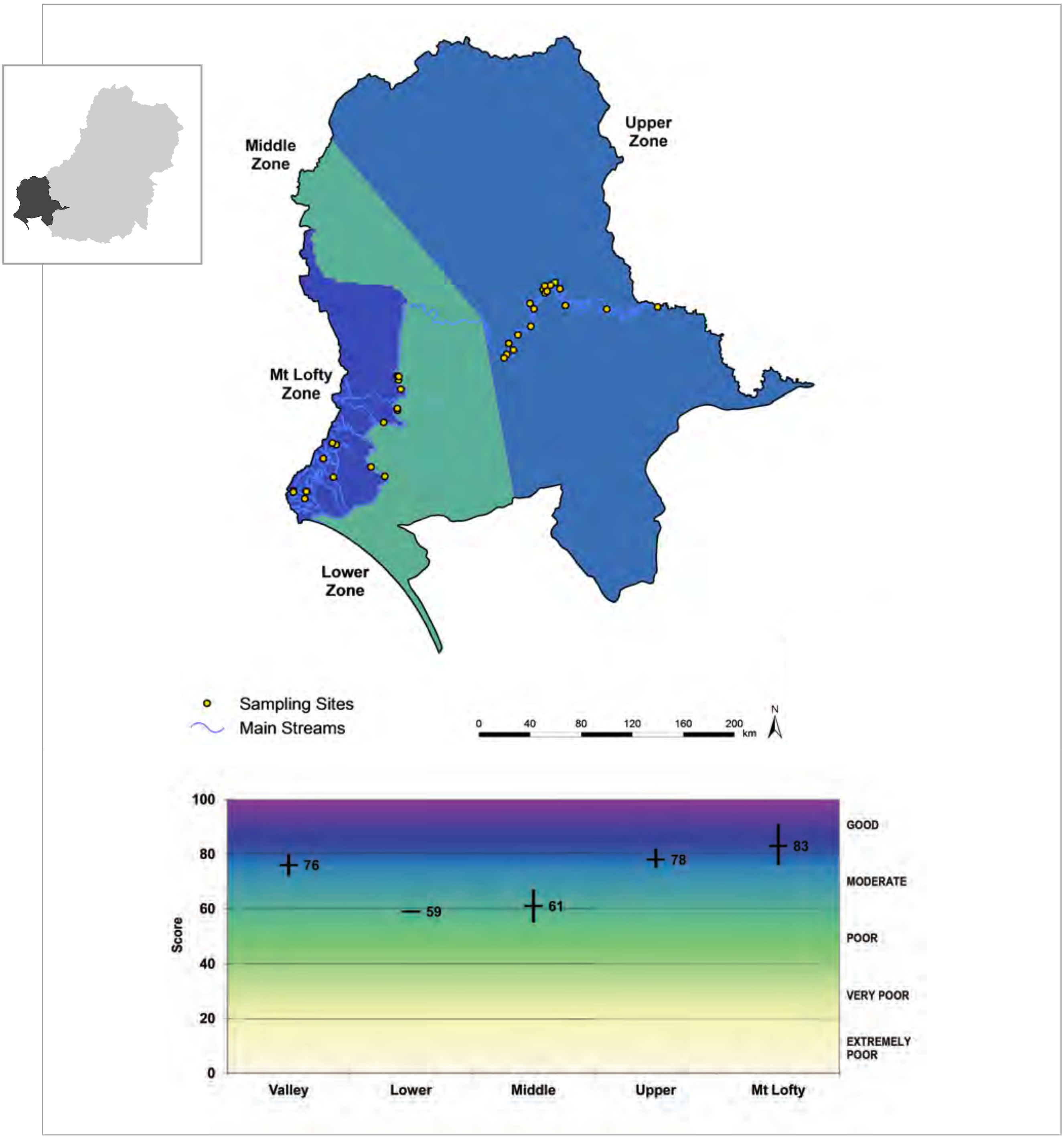



**Figure MLW 3: Lower Murray Valley map with sampling sites and zones coloured by SR Macroinvertebrate Index (SR–MI) scores.**

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

*The Macroinvertebrate community of the Lower Murray Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 76. Upper zone Moderate; Middle zone Moderate; Lower zone Poor; Mt Lofty zone Good. The proportion of sites in Moderate condition was high (51%); ten of the 32 rated sites (31%) were in Good condition (mostly in the Upper zone). Family richness generally was low, and was also low compared to Reference Condition.*

Thirty-five sites were surveyed across the Lower Murray Valley in April–June 2010 yielding 85,269 macroinvertebrates in 50 families (53% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 76 (CL 72–80), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 51 (CL 49–52) 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 (80% overall), with ten of the 32 rated sites (31%) being in Good condition (seven of which were in the Upper zone).
- The number of families found was lowest in the Lower zone (14 families) and highest in the Upper and Mt Lofty zones (36 and 37 families respectively), with these latter zones having the highest average number of families per site (18 and 17).

Figure MLW 3 shows sampling sites, zones and SR–MI values, and Table MLW 5 shows index and metric values. The SR–MI score for the Lower Murray Valley indicated Moderate condition of macroinvertebrate communities, rating 10th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the Upper and Middle zones showed moderate differences from Reference Condition (SR–MI = 78 and 61 respectively) and were rated as in Moderate condition. The Middle and Lower zones were similar in condition, falling close to the boundary between moderate and large differences from Reference Condition (SR–MI 61 and 59 respectively). The Lower zone communities were rated in Poor condition. The communities of the Mt Lofty zone were rated as being in Good condition. Larger confidence intervals (12–15 points) for the Middle and Mt Lofty zone SR–MI values indicates greater spatial variability in condition in those zones, with three of the five sites in the Mt Lofty zone being in Good condition. Expectedness (simOE) was low to moderate and varied by up to 21 points among sites.

Table MLW 6 shows that 80% of sites across all zones had moderate or good SR–MI values. Seven of the 18 sites assessed in the Upper zone (39%) were rated in Good condition, whereas none of the 12 sites assessed in the Middle and Lower zones were rated as Good. Each of the Middle and Lower zones had one site with a low simOE score (<40 points). For the three zones of the River Murray, 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 low (average 16 families per site), with the Upper zone being most diverse at site scale (average 18 families per site). The valley contained 53% of the families found across the Basin (Table MLW 6), with the Lower zone having the lowest representation of Basin-wide fauna. Most (72–74%) of the fauna of the valley was found in each of the Upper and Mt Lofty zones.

**Table MLW 5: Lower Murray 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 | Mt Lofty |
| Index | Macroinvertebrate Condition (SR–MI) | 76 (72–80) | 78 (75–82) | 61 (55–67) | 59 (59–59) | 83 (76–91) |
| Metric | SimOE | 51 (49–52) | 51 (50–53) | 44 (42–46) | 43 (37–49) | 54 (50–58) |

Table MLW 6: Lower Murray Valley: Distribution of sample sites and values of derived variables.

| Number of sites and families sampled | Valley | Zone | | | |
|---|---|---|---|---|---|
| | | Upper | Middle | Lower | Mt Lofty |
| **Sites** | | | | | |
| Number of sites sampled | 35 | 18 | 7 | 2 | 8 |
| Number of sites with index values* | 32 | 18 | 7 | 2 | 5 |
| N sites by SR–MI condition band | | | | | |
| Good (80–100) | 10 | 7 | | | 3 |
| Moderate (60–80) | 18 | 11 | 4 | 1 | 2 |
| Poor (40–60) | 4 | | 3 | 1 | |
| Very or Extremely Poor (0–40) | | | | | |
| Families | | | | | |
| Number of families sampled | 50 | 36 | 21 | 14 | 37 |
| No. families/site (min–max) | 16 (8–22) | 18 (10–22) | 12 (10–15) | 10 (8–11) | 17 (10–21) |
| Percent of families in Basin | 53 | 38 | 22 | 15 | 39 |
| Percent of families in valley | 100 | 72 | 42 | 28 | 74 |

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

# MURRAY VALLEY - LOWER

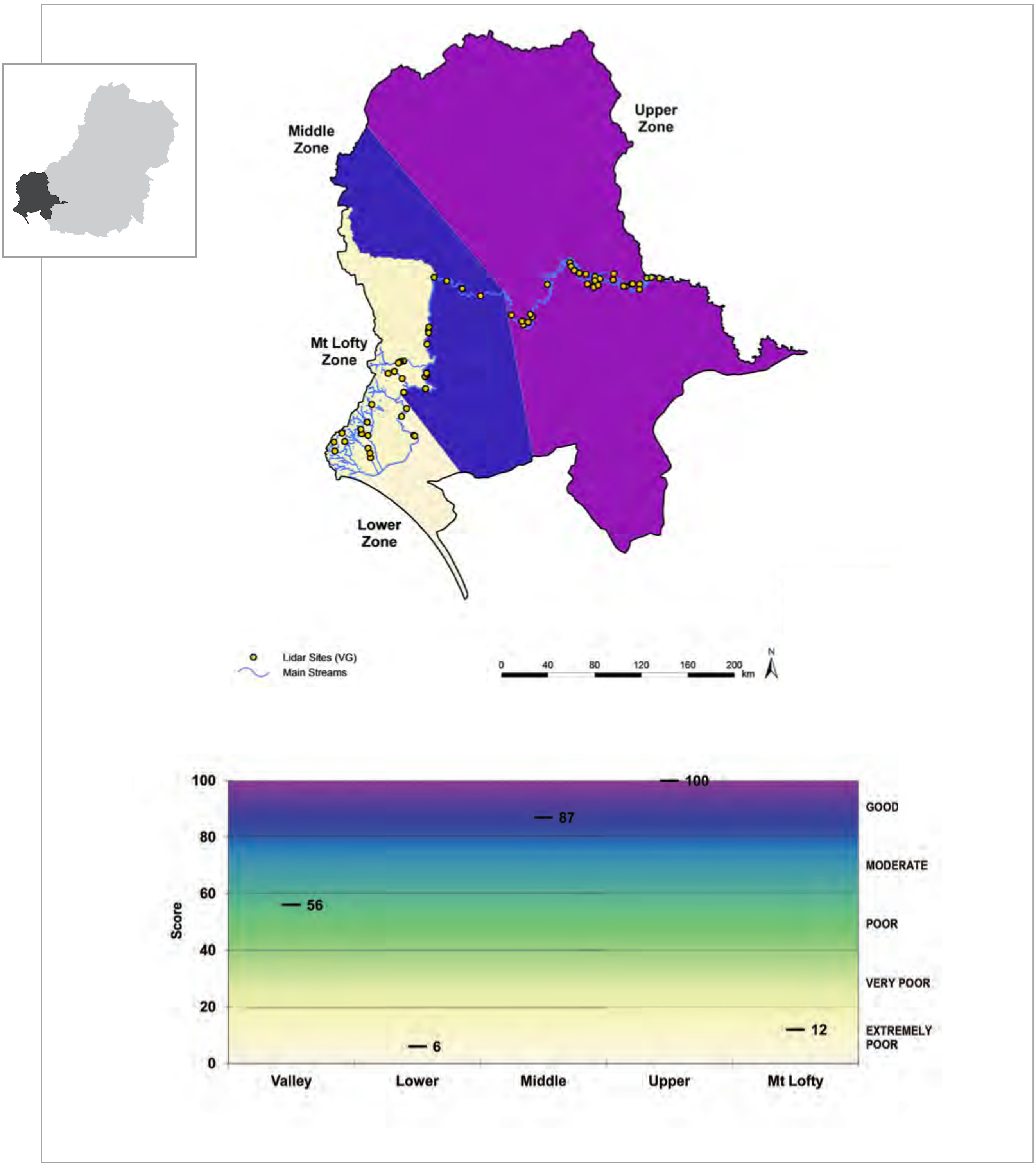



**Figure MLW 4: Lower Murray Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.**

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Lower Murray Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 56. Overall condition for the four zones in this valley was: Upper Good; Mt Lofty Extremely Poor; Middle Good; Lower Extremely Poor.*

*The Abundance and Diversity indicator score was 65 for the valley, indicating a Moderate rating overall. In the four zones in this valley was: Upper Good; Mt Lofty Very Poor; Middle Good; Lower Very Poor.*

*The Quality and Integrity indicator score was 60 for the valley, indicating a Moderate rating overall. In the four zones in this valley was: Upper Good; Mt Lofty Very Poor; Middle Moderate; Lower Extremely Poor.*

The SRA Vegetation assessment for the Lower Murray Valley considers riverine vegetation in two spatial domains: Near Riparian (along 1,950 km of stream) and Lowland Floodplain (for 1,105 km² of flooding land (across the entire valley) which represents a substantial part of the valley's floodplain. Most (39% and 43%) of the stream length is in the Upper and Mt Lofty zones, and the length of stream assessed per zone is as follows: Upper 756 km; Middle 275 km; Mt Lofty 837 km; and Lower 82 km. Similarly, most (84%) of the Lowland Floodplain domain is in the Upper zone: the Middle zone has 14% and the Lower zone has 2%. 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 67 sites set back 50 m from the top of the bank. LiDAR sites are distributed along the stream network and amongst zones as follows: Upper 30 sites; Middle 14 sites; Mount Lofty 19 sites; and Lower four sites. Assessment of the Lowland Floodplain is also based on national vegetation mapping of Major Vegetation Groups but is limited to the Upper and Middle zones. The Lower zone was not assessed, even though it is a Lowland zone, because the vegetation mapping was inadequate (86% of domain affected).

Figure MLW 4 shows values of the Vegetation Index (SR–VI) for the Lower Murray Valley and Table MLW 7 shows the index, indicator and sub-indicator values. Tables MLW 8 and MLW 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 Lower Murray Valley with:

- SRA Vegetation Index (SR–VI) = 56, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 65, 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 relatively little affected by clearing. The abundance and degree of fragmentation of major vegetation groups is near Reference Condition in the sampled area.

The Abundance and Diversity of riverine vegetation is in Moderate condition overall, but quite variable in the valley with the Upper and Middle zones being near Reference Condition, and the Mt Lofty and Lower zones being extremely different from reference. 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 the Lowland Floodplain is near reference. MVG richness is maintained near reference in both the Near Riparian and Lowland Floodplain domains, as no MVG has been completely reduced. Vegetation in the Lowland Floodplain has 83% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, being near Reference Condition in the Upper zone, showing a moderate difference from reference in the Middle zone, a very large difference from reference in the Mt Lofty zone and an extreme difference from reference in the Lower zone. The Quality and Integrity indicator is strongly influenced by nativeness which is the extent of native vegetation, where native vegetation means the MVGs listed in Table MLW 8 as well as other native but non-specific MVGs. Valley nativeness in the Near Riparian domain shows a large difference from reference; and in the Lowland Floodplain domain, nativeness is near reference. 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 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 Good condition overall, but the metrics show high variability between zones and domains. Abundance in the Near Riparian domain is near Reference Condition in the Upper zone, shows a large difference from reference in the Middle zone, and a very large difference in the Mt Lofty and Lower zones; and in the Lowland Floodplain domain, abundance is near reference in the Upper zone and shows a moderate difference from reference in the Middle zone.

***Stability***

- Floodplain area vegetation stability is in Good condition overall, with minor 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 nativeness is highly variable between zones and domains. Nativeness in the Near Riparian domain is near Reference Condition in the Upper zone, shows a moderate difference from reference in the Middle zone and shows a very large difference from reference in the Mt Lofty and Lower zones; and in the Lowland Floodplain domain, nativeness is as in the Near Riparian domain, being near reference in the Upper zone and showing a moderate difference from reference in the Middle zone.

***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 shows a moderate difference from Reference Condition in the Upper, Middle and Mt Lofty zones, and a very large difference from reference in the Lower 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 Good condition overall, and near Reference Condition in the Upper zone and moderately different from reference in the Middle zone largely due to dissection and clearing of one fairly extensive MVG, Chenopod Shrublands, Samphire Shrublands and Forblands. The smaller MVGs have patch numbers and mean patch areas that are close to reference.

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

- Upper zone: The Near Riparian domain was mostly Eucalypt Woodlands (47% of the domain area). Two of the seven other MVGs present were more than 5% of the domain.
- Middle zone: The most extensive MVG in the Near Riparian domain was Mallee Woodlands and Shrublands (32% of domain area). Only one of the four other MVGs mapped was more than 5% of the domain.
- Lower zone: The Near Riparian domain had six MVGs of which only one was more than 5% of the mapped domain area. Mapping is incomplete, with 77% of the area not assigned to any MVG.
- Mt Lofty zone: The Near Riparian domain was mostly Eucalypt Woodland (64% of domain area). Two of the other ten MVGs present were more than 5% of the domain.

- Upper zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (50% of domain area). Three of the seven other MVGs were more than 5% of the domain.

- Middle zone: The most extensive MVGs in the Lowland Floodplain domain are Mallee Woodlands and Shrublands (39% of the mapped domain area) and Chenopod Shrublands, Samphire Shrublands and Forblands (19%). Four other MVGs are present. Mapping is incomplete, with 41% of the area not assigned to any MVG.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has been reduced to various degrees between zones, with variable effects on MVGs.

- Upper zone: In the Near Riparian domain, Eucalypt Woodlands are reduced (37% of the domain area). About 12% is cleared or non-native vegetation. Most of the MVGs are well-retained, with 60–100% of their reference area, but one (Chenopod Shrublands, Samphire Shrubland and Forblands) is just 38% of its reference area.

- Middle zone: In the Near Riparian domain, Mallee Woodlands and Shrublands is reduced to 19% of the domain area. About 20% is cleared or non-native. Most MVGs have areas close to Reference Condition, except for two that are about 60% of their reference area.

- Lower zone: At least 16% of the Near Riparian domain is cleared or non-native. Mapping reliability for this zone is particularly low (77% not assigned to any MVG).

- Mt Lofty zone: In the Near Riparian domain, Eucalypt Woodlands are reduced (9% of the domain area). About 74% of the domain is cleared or non-native. Three MVGs are reduced to less than 15% of their reference area (Eucalypt Open Forest, Eucalypt Woodlands, and Tussock Grasslands) and seven MVGs with areas unchanged from reference are amongst the smallest.

- Upper zone: In the Lowland Floodplain domain, although reduced, Eucalypt Woodlands are still the most extensive MVG (43% of the mapped domain area). About 10% is cleared or non-native vegetation. Most MVGs are affected, but not substantially, and three MVGs have close to the same area as Reference Condition (Eucalypt Open Forests, Eucalypt Woodlands and Other Grasslands, Herblands, Sedgelands and Rushlands).

- Middle zone: In the Lowland Floodplain domain, Mallee Woodlands and Shrublands and Chenopod Shrublands, Samphire Shrublands and Forblands are both reduced (28% and 11% of the mapped domain area respectively). About 19% is cleared or non-native vegetation.

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 2001–2004, whereas the LiDAR was flown in January-February 2010. Mapping content is very low in some zones. Some 77% and 50% of the area in the Near Riparian domain in the Lower and Middle zones does not have an MVG assigned, so the assessment refers to a relatively small area and may not be representative. Mapping content is higher in the Upper and Mt Lofty zones (20% and 7.5% non-assigned, respectively): these are also the two zones with greatest influence on the valley score, based on stream lengths.

Both techniques are used in the Near Riparian domain, therefore 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 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 areas without an assigned MVG are unusually high in this valley. 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 Lower Murray Valley is notable for the Extremely Poor condition of the Mt Lofty and Lower zones, for the contrast in condition between these and the Upper and Middle zones, and for the low abundance of MVGs and low nativeness in the Near Riparian domain.

Only the Upper and Middle zones have a Lowland Floodplain domain and its condition is similar to their Near Riparian domains. In the valley and in these two zones, characterised by a large main channel inset into the landscape, these two domains refer to similar parts of the landscape.

Condition in the four zones is variable and changes down the valley. The Upper zone is in best condition, and is near Reference Condition, with abundance, nativeness and richness near reference, the degree of fragmentation near reference, little evidence of instability or turnover of MVGs, and the vegetation structure in the Near Riparian domain is moderate. The Mt Lofty and Lower zones are the zones in worst condition, both Extremely Poor, with very low scores for abundance and nativeness (although no loss of MVGs) and an unusually low score for Structure in the Lower zone.

# MURRAY VALLEY - LOWER

**Table MLW 7: Lower Murray 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 | Mt Lofty |
| Index | Vegetation Condition (SR–VI) | 56 | 100 | 87 | 6 | 12 |
| Indicator | Abundance and diversity | 65 | 100 | 82 | 32 | 32 |
| Metric | LF stability | 0.83 | 0.89 | 0.68 | | |
| Sub-ind. | NRLF richness | 100 | 100 | 100 | | |
| Metric | NR richness | 1 | 1 | 1 | 1 | 1 |
| Metric | LF richness | 1 | 1 | 1 | | |
| Sub-ind. | NRLF abundance | 90 | 98 | 68 | | |
| Metric | NR abundance | 0.50 | 0.84 | 0.60 | 0.20 | 0.20 |
| Metric | LF abundance | 0.83 | 0.88 | 0.68 | | |
| Indicator | Quality and integrity | 60 | 98 | 70 | 15 | 26 |
| Sub-ind. | NRLF nativeness | 90 | 98 | 68 | | |
| Metric | NR nativeness | 0.50 | 0.84 | 0.60 | 0.20 | 0.20 |
| Metric | LF nativeness | 0.83 | 0.88 | 0.68 | | |
| Sub-ind. | NR structure | 67 (60–74) | 78 (70–84) | 61 (42–78) | 44 (26–63) | 62 (47–73) |
| Sub-ind. | LF fragmentation | 87 | 90 | 78 | | |

**Table MLW 8: The most abundant MVGs in the Near Riparian domain in the Lower Murray 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.

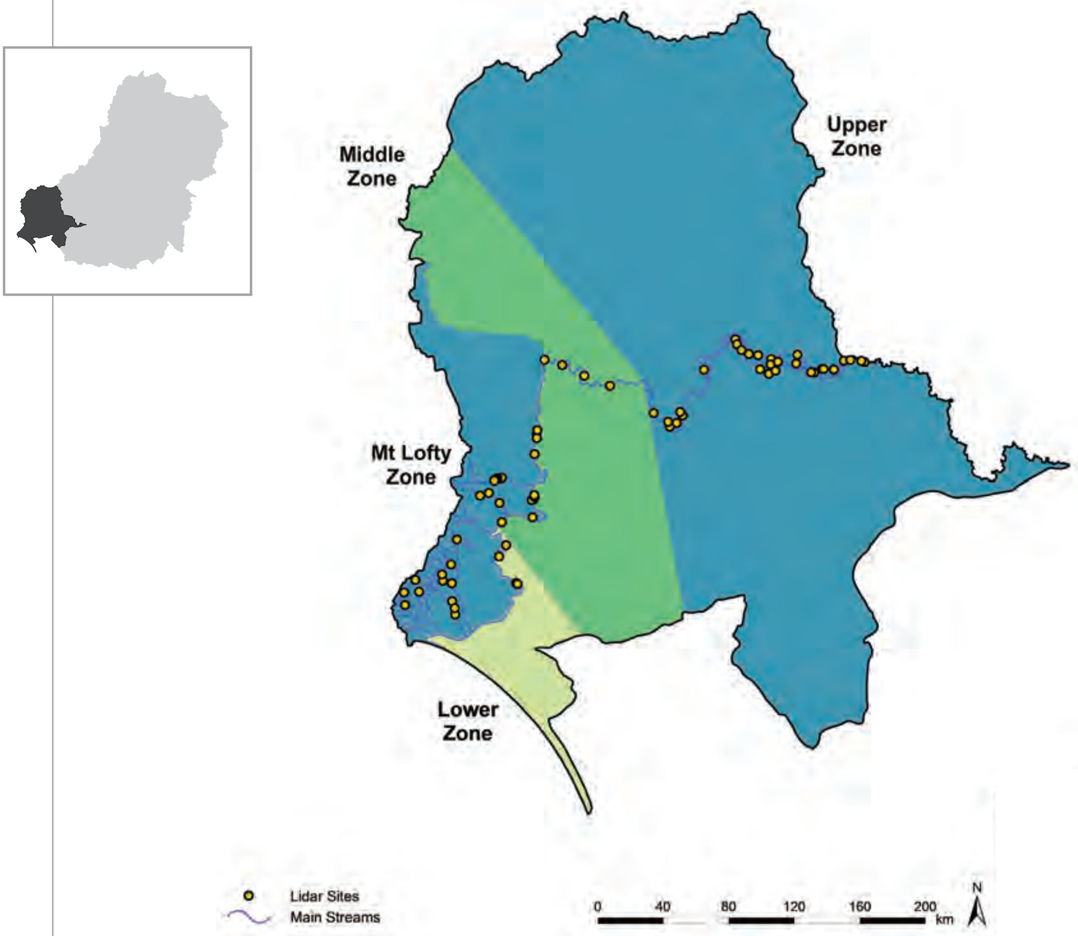
| Major Vegetation Groups | Zone | | | |
|---|---|---|---|---|
| | Upper | Middle | Lower | Mt Lofty |
| MVG | | | | |
| 3. Eucalypt Open Forests | 14 | | | 13 |
| 5. Eucalypt Woodlands | 47 | | | 64 |
| 14. Mallee Woodlands and Shrublands | 7 | 32 | 14 | 8 |
| 22. Chenopod Shrublands, Samphire Shrublands and Forblands | | 17 | | |

# MURRAY VALLEY - LOWER

**Table MLW 9: Most abundant MVGs in Lowland Floodplain domain of the Lower Murray Valley.**
Showing percentage of domain area under Reference Condition in each of the two zones, and metrics for the number of patches and mean patch area: restricted to MVGs that are at least 5% in area of all mapped MVGs. N patches = the ratio of the current to reference number of patches for the MVG.
Note: there is no data for the Lower Murray Lower zone due to the absence of mapped domain data.

| Major Vegetation Groups | % domain | N patches | Mean patch area |
|---|---|---|---|
| MVG | | | |
| Lower Murray (Upper) | | | |
| 3. Eucalypt Open Forests | 11 | 1.04 | 0.97 |
| 5. Eucalypt Woodlands | 50 | 1.12 | 0.77 |
| 14. Mallee Woodlands and Shrublands | 8 | 1.11 | 0.68 |
| 17. Other Shrublands | 11 | 1.00 | 0.99 |
| Lower Murray (Middle) | | | |
| 14. Mallee Woodlands and Shrublands | 39 | 0.93 | 0.78 |
| 22. Chenopod Shrublands, Samphire Shrublands and Forblands | 19 | 1.30 | 0.44 |

# MURRAY VALLEY - LOWER



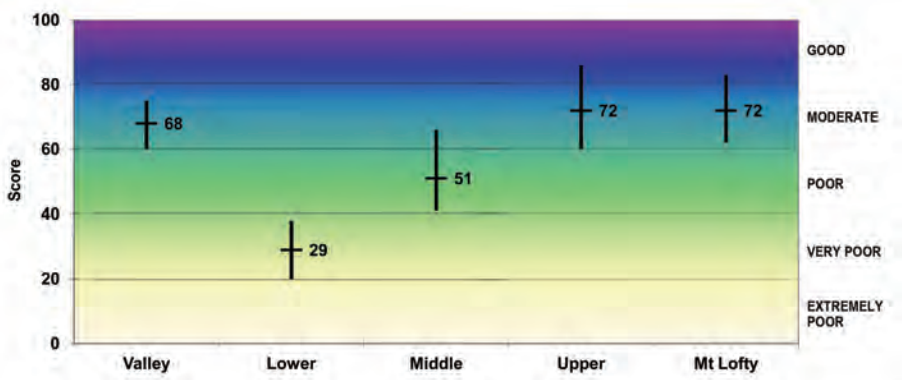




Figure MLW 5: Lower Murray Valley map with LiDAR sites and zones coloured by SRA Physical Form Index scores.

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

*The Physical Form of the Lower Murray Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 68. The condition of Physical Form in the zones was: Mt Lofty and Upper Moderate; Middle Poor; and Lower Very Poor. 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 riverine physical form was characterised by channel enlargement and straightening. There was also indication of elevated sediment loads since European settlement, particularly in the Mt Lofty zone, and associated sedimentation.*

The SRA Physical Form assessment considers physical form and processes along 1,950 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 326 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 MLW 5 shows values of the Physical Form Index (SR–PI) for the Lower Murray Valley and Table MLW 10 shows the index, indicator, sub-indicator and metric values.

Analyses showed a Moderate difference from Reference Condition for the Lower Murray Valley with:

- SRA Physical Form Condition Index (SR–PI) = 68 (CL 60–75), indicating Moderate Physical Form condition
- the Channel Form indicator = 69 (CL 62–75), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 60 (CL 56–65), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 96 (CL 92–98), showing near Reference Condition
- the Floodplain indicator = 74 (CL 68–81), showing a moderate difference from Reference Condition.

***Upper zone***

There were 29 LiDAR survey sites and 154 SedNet river segments in the Upper zone of the Lower Murray Valley. Based on these samples, Channel Depth, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upper zone. At these sites Channel Depth and Channel Sediment Ratio were 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 Width Variability were modified from Reference Condition in more than half of the Upper zone. At these sites Channel

Width was generally increased (a few sites having large increases) and Channel Width Variability was generally reduced (with a large reduction at over half of these sites). Sinuosity, Bank Variability and Channel Sediment Deposition were modified from reference for approximately half of the Upper zone. At these sites Sinuosity was generally reduced, results show both increases and decreases in Bank Variability 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 was modified from reference for less than half of the Upper zone. At these sites Meander Wavelength was generally increased. These results are generally consistent with previous field observations (Rutherfurd pers. comm.).

### *Middle zone*

There were 14 LiDAR survey sites and 101 SedNet river segments in the Middle zone of the Lower Murray Valley. Based on these samples, Channel Width, Channel Depth, Channel Width Variability, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Middle zone. At these sites Channel Width and Channel Depth were generally increased (a few sites having large increases), Channel Width Variability was generally reduced (with a large reduction at over half of these sites), results show both increases and decreases in Channel Sediment Ratio across the zone and there was a moderate increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Sinuosity was modified from reference in more than half of the Middle zone. At these sites Sinuosity was generally reduced. Channel Sediment Deposition was modified from reference for approximately half of the Middle zone. At these sites there was a large increase in Channel Sediment Deposition across 30% of the zone for the post-European period. Meander Wavelength was modified from Reference Condition for less than half of the Middle zone. At these sites Meander Wavelength was generally increased. Bank Variability was largely unmodified from reference in the Middle zone.

### *Lower zone*

There were four LiDAR survey sites and 20 SedNet river segments in the Lower zone of the Lower Murray Valley. Based on these samples, Channel Width, Channel Width Variability, Sinuosity and Channel Sediment Ratio were modified from Reference Condition throughout most of the Lower zone. At these sites Channel Width was generally increased (many sites having large increases), Channel Width Variability and Sinuosity were generally reduced (with a large reduction in Channel Width Variability at over half of these sites) and Channel Sediment Ratio was generally increased. Channel Depth and Floodplain Sediment Deposition were modified from reference in more than half of the Lower zone. At these sites Channel Depth was generally increased and there was a moderate increase in Floodplain Sediment Deposition across 30% of the zone for the post-European period. Meander Wavelength was modified from reference for approximately half of the Lower zone. At these sites results show both increases and decreases in Meander Wavelength across the zone. Channel Sediment Deposition was modified from reference for less than half of the Lower zone. At these sites there was a large increase in Channel Sediment Deposition across 30% of the zone for the post-European period. Bank Variability was largely unmodified from reference in the Lower zone. These results are generally not consistent with previous field observations. Other measurements through these reaches of the Murray indicate some bank erosion, but not much other change in Channel Form in historical times (Thoms 1992). Further field-based validation may be required.

### *Mt Lofty zone*

There were 19 LiDAR survey sites and 51 SedNet river segments in the Mt Lofty zone of the Lower Murray Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Mt Lofty 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 and Sinuosity were modified from reference in more than half of the Mt Lofty zone. At these sites Channel Depth was generally increased and Sinuosity was generally reduced. Channel Width, Meander Wavelength, Bank Variability and Channel Sediment Deposition were modified from reference for approximately half of the Mt Lofty zone. At these sites Channel Width and Meander were generally increased (a few sites having large increases in Channel Width and many sites having large increases in Meander Wavelength), 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 Width Variability was largely unmodified from reference in the Mt Lofty zone.

### *Channel Form*

Assessment of Physical Form relies on modelled Reference Conditions based on valley and catchment environmental characteristics. The lower Murray River presents particular challenges for Reference Condition modelling, with only weak geomorphic influence of the local catchments. This means that this assessment of Channel Form in the Upper, Middle and Lower zones of the Lower Murray Valley has greater uncertainty than elsewhere in the Basin and should be interpreted with caution.

There was substantial 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 100% of sites as a result of channel widening and bed degradation. Channel straightening was indicated at 100% of sites mostly as a result of reduced sinuosity. There was widespread evidence of channel simplification but small deviations from Reference Condition had little influence on scores when aggregated at the zone scale.

There was considerable change from Reference Condition in Channel Form in the Middle zone. The more serious impacts were channel enlargement and channel straightening. An enlarged channel was indicated at 100% of sites as a result of channel widening and bed degradation. Channel straightening was indicated at 90% of sites as a result of both increased meander wavelength and reduced sinuosity. 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 Mt Lofty zone. The more serious impact was channel simplification. Channel simplification was indicated at 70% 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.

There was minor change from Reference Condition in Channel Form in the Upper zone. The more serious impacts were channel enlargement and channel straightening. An enlarged channel was indicated at 90% of sites as a result of channel widening and bed degradation. Channel straightening was indicated at 60% of sites as a result of both increased meander wavelength and reduced sinuosity. There was widespread evidence of 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 no change from Reference Condition in Bank Dynamics in the Lower zone. There was little change from Reference Condition in Bank Dynamics in the Middle, Mt Lofty and Upper zones.

There was minor change from Reference Condition in Bed Dynamics in the Lower 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 Middle and Upper zones as a result of widespread sedimentation (50%-60% of the SedNet river segments) and increased sediment load (50%-100% of the SedNet river segments). There was considerable change from reference in Bed Dynamics in the Mt Lofty zone as a result of widespread sedimentation (50% of the SedNet river segments) and increased sediment load (90% of the SedNet river segments). In the Middle, Mt Lofty and Upper 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.

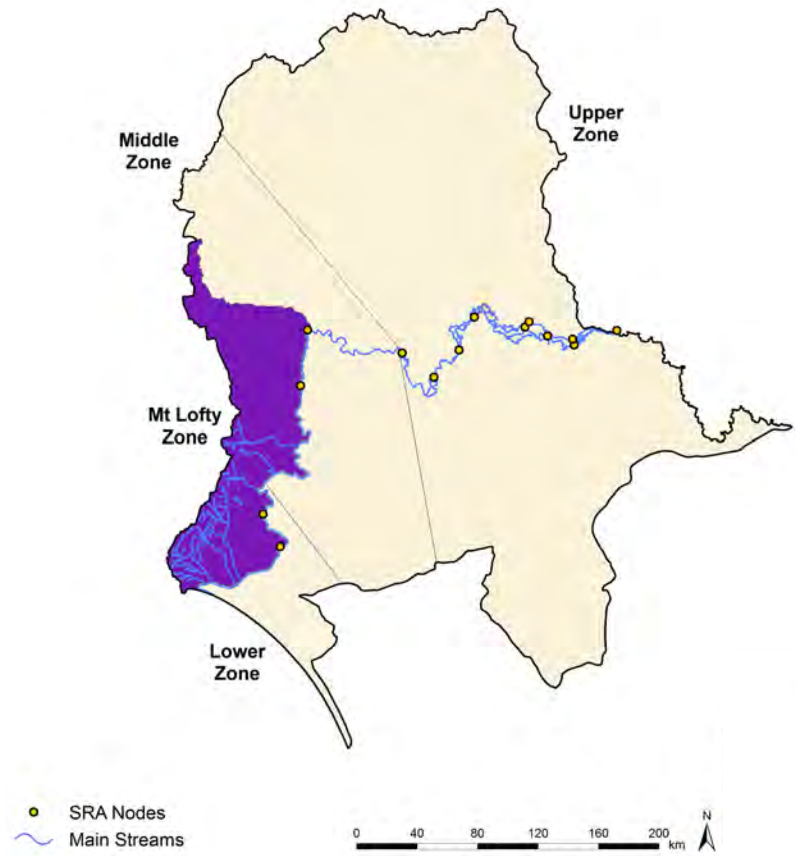
There was minor change from Reference Condition in Floodplain Sedimentation in all four zones as a result of widespread sedimentation (70%-90% of SedNet river segments).

**Table MLW 10: Lower Murray 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 | | | |
|---|---|---|---|---|---|---|
| | | | Upper | Middle | Lower | Mt Lofty |
| Index | Physical Form Condition (SR-PI) | 68 (60–75) | 72 (60–86) | 51 (41–66) | 29 (20–38) | 72 (62–83) |
| Indicator | Channel Form (volume and flow events) | 69 (62–75) | 65 (54–77) | 46 (38–59) | 28 (20–36) | 85 (73–94) |
| Sub-ind. | Cross-section Form | 74 (68–79) | 66 (57–76) | 65 (53–77) | 48 (26–70) | 86 (75–94) |
| Metric | Channel Depth (mean) | 1.45 (1.32–1.55) | 1.59 (1.40–1.78) | 1.84 (1.42–2.00) | 1.12 (1.03–1.27) | 1.23 (1.05–1.44) |
| Metric | Channel Width (mean) | 1.22 (1.16–1.29) | 1.22 (1.13–1.33) | 1.31 (1.19–1.41) | 1.85 (1.64–2.00) | 1.13 (1.03–1.25) |
| Sub-ind. | Cross-section Form (variability) | 71 (64–78) | 65 (49–78) | 27 (12–46) | 0 (0–0) | 98 (95–100) |
| Metric | Channel Width (CV) | 0.82 (0.78–0.86) | 0.79 (0.71–0.86) | 0.55 (0.46–0.66) | 0.36 (0.29–0.45) | 0.98 (0.95–1.00) |
| Sub-ind. | Channel Planform | 87 (81–91) | 92 (88–96) | 95 (92–98) | 88 (76–96) | 79 (66–88) |
| Metric | Sinuosity | 0.97 (0.95–0.99) | 0.99 (0.97–1.02) | 0.97 (0.96–0.98) | 0.92 (0.90–0.95) | 0.96 (0.92–1.00) |
| Metric | Meander Wavelength | 1.00 (0.95–1.04) | 0.98 (0.91–1.03) | 0.98 (0.89–1.04) | 0.90 (0.67–1.03) | 1.04 (0.95–1.14) |
| Indicator | Bed Dynamics | 60 (56–65) | 70 (66–74) | 62 (51–74) | 80 (64–94) | 48 (38–58) |
| Metric | Channel Sediment Ratio | 173 (133–213) | 24 (16–34) | 221 (137–298) | 111 (10–230) | 298 (207–401) |
| Metric | Channel Sediment Depth | 0.004 (0.003–0.006) | 0.002 (0.001–0.002) | 0.008 (0.004–0.01) | 0.003 (0.001–0.006) | 0.006 (0.004–0.008) |
| Indicator | Bank Dynamics | 96 (92–98) | 94 (87–99) | 99 (96–100) | 100 (100–100) | 95 (90–99) |
| Metric | Bank Variability (longitudinal) | 1.00 (0.97–1.04) | 0.97 (0.92–1.02) | 0.99 (0.96–1.00) | 1.00 (1.00–1.00) | 1.03 (0.96–1.10) |
| Indicator | Floodplain | 74 (68–81) | 77 (68–84) | 75 (66–86) | 66 (43–90) | 73 (60–86) |
| Metric | Floodplain Sediment Deposition | 1.77 (1.40–2.00) | 1.75 (1.16–2.00) | 1.84 (1.27–2.00) | 1.82 (0.68–3.00) | 1.75 (1.18–2.00) |

# MURRAY VALLEY - LOWER



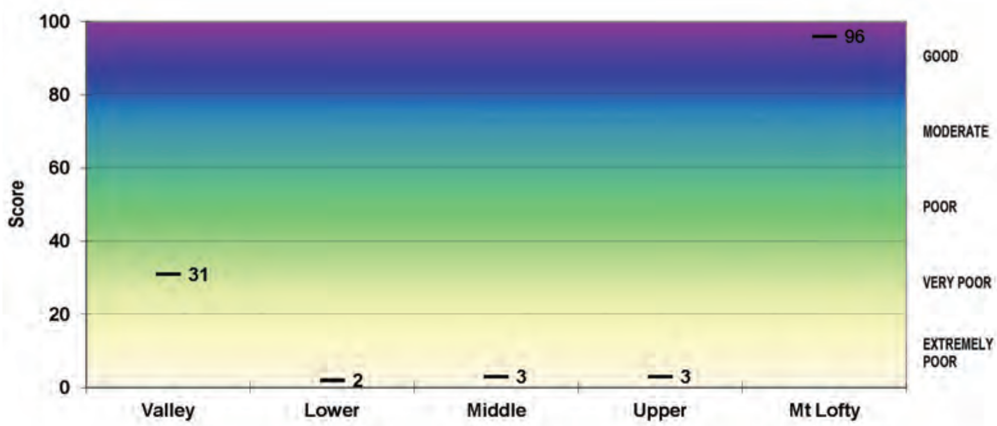




**Figure MLW 6: Lower Murray Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.**
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Lower Murray Valley river system was in Very Poor condition, with an aggregate Hydrology Index (SR–HI) score of 31. The Mt Lofty zone was in Good condition. The Upper, Middle and Lower zones were all in Extremely Poor condition.*

*The mainstem river system of the valley was in Extremely Poor condition. The magnitude of high and mean flows, the amplitude of seasonal flow variations and the frequency of high flow spells were all reduced. The frequency of low flow spells were increased, timing of seasonal flow variations was altered, monthly flow variation and inter-flood durations for Low and High Over Bank Flows were increased. The duration of High and Low Over Bank Flows was reduced throughout all of the mainstem river system. In addition, there was widespread reduction in the magnitude of low flows relative to Reference Condition. The headwater streams were rated in Good condition. Throughout some of the headwater streams high flows were reduced relative to Reference Condition.*

The Lower Murray Valley begins at Lock 10, below the Murray–Darling confluence, and ends with the Murray's entry to Lake Alexandrina then Lake Albert and the Coorong, isolated from the Southern Ocean by barrages that prevent incursions by sea water. It also includes the tributaries of the Mt Lofty zone, draining the eastern slopes of the Mt Lofty Ranges. The Murray flows westward through a broad floodplain from Wentworth to Morgan, where the river turns southward through a limestone gorge extending to about Mannum. The lower-most reaches are flanked by former swamplands, now reclaimed for agriculture by earthen levees. There are Ramsar-listed wetlands at Chowilla, near Renmark, and the Lower Lakes and Coorong. Flows are highly modified by diversions, regulation and inter-valley transfers upstream. There are no major instream storages, but a series of nine low-level weirs that has had profound effects on the river and its floodplain (e.g. Walker 2006). An offstream storage, Lake Victoria (677 GL), regulates flows from the Murray and Darling to meet downstream demand from major irrigation areas, from Adelaide and rural towns and cities in South Australia. The river-mouth barrages maintain high water levels (and low salinity) in the Lower Lakes, supporting local irrigation. Reduced flows over the barrages, intensified by the prevailing drought, have caused major changes to the Coorong.

In the Lower Murray Valley, hydrological condition is assessed using metrics of hydrological alteration available for 6,101 km of mainstem river reaches and headwater streams. There are 821 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 daily 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 Lower Murray Valley there is 5,280 km of headwater stream (45 km in the Lower zone; 1,064 km in the Middle zone; 1,655 km in the Mt Lofty zone; 2,517 km in the Upper zone). In these headwater streams, SRA hydrology metrics quantify the effects of tree cover change since European settlement and of farm dams.

In this assessment, farm dam impacts are assessed based on basin-wide mapping of farm dams and basin-wide modelling of farm impacts. Farm dams are of particular concern for water and catchment

# MURRAY VALLEY - LOWER

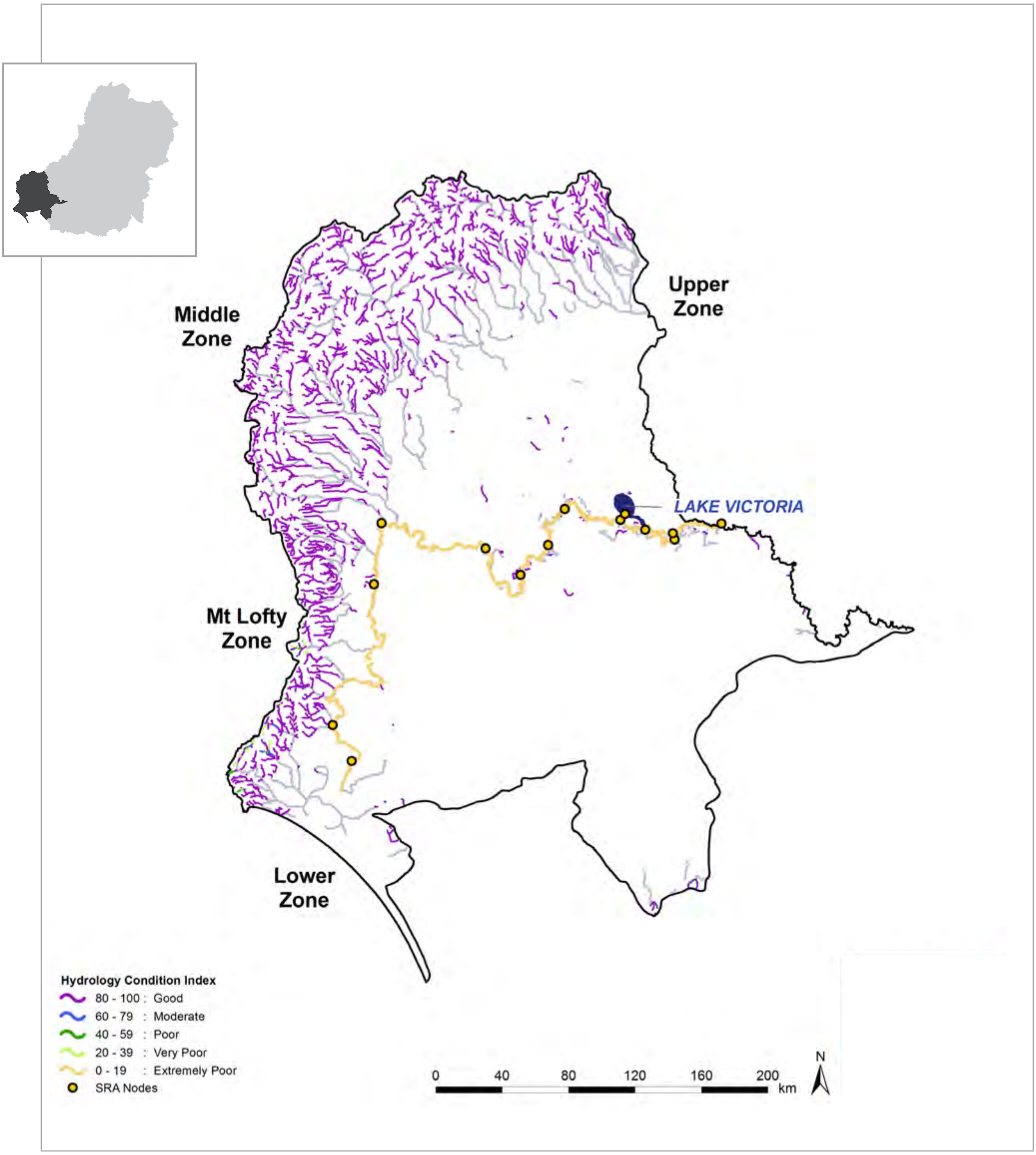



Figure MLW 7: Lower Murray Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

management in the Mt Loft Ranges and local studies of their distribution and hydrological impact are available. Local management and planning should be based on such local studies because they are targeted for local condition, and will generally be more accurate than a basin-wide assessment.

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 Lower Murray Valley there is 3,652 km of these mid-size tributaries (153 km in the Lower zone; 612 km in the Middle zone; 2,203 km in the Upper zone; 684 km in the Mt Lofty 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 MLW 6 and MLW 7 show values of the Hydrology Condition Index (SR–HI) for the Lower Murray Valley and its river network, and Table MLW 11 and MLW 12 show the index, sub-index, indicator and metric values. Analyses showed a very large difference from Reference Condition for the Lower Murray Valley with:

- The Hydrology Condition Index for the whole valley = 31, indicating Very Poor hydrological condition.
- The Hydrology Condition Index for the Murray mainstem (Lower, Middle and Upper zones) = 2, 3 and 3, indicating Extremely Poor condition throughout.
- The Hydrology Condition Index for the Mt Lofty zone = 96 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) = 3, indicating Extremely Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 4, indicating Extremely Poor condition and an extreme difference from Reference Condition for the flow regime within the channels.
- The Over Bank Flow Regime sub-index in the mainstem river reaches = 9, indicating Extremely Poor condition and an extreme 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.

# MURRAY VALLEY - LOWER

In the mainstem rivers, the Flow Gross Volume sub-indicator showed and extreme difference from Reference Condition. Results for the Flow Duration metric showed a significant alteration from Reference Condition in 5% 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 Upper zone. Results for the Mean Annual 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 a small portion 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 (associated with both increased and reduced 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 large difference from Reference Condition. Results for the High 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 a small portion 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 100% 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 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 very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with increased 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 a small proportion in the Lower zone, some in the Middle zone, a small proportion in the Mt Lofty zone and some in the Upper 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 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 24% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 71% 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 Lower zone, some in the Middle zone and some in the Upper zone. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 5% 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 Upper zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 99% 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 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 a significant alteration from reference in 3% of the headwater 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 Lower zone and most in the Mt Lofty 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 100% of the mainstem river length (mostly reduced amplitude). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Lower zone, some in the Middle zone and some in the Upper zone. Results for the Seasonal Period metric showed a significant alteration from reference in 100% of the mainstem river length. These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Lower zone, some in the Middle zone and some in the Upper 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 7% 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 Lower zone, a small proportion in the Middle zone, most in the Mt Lofty zone and a small proportion in the Upper zone. Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

# MURRAY VALLEY - LOWER

***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 very large difference from Reference Condition. Results for the Flow Variation metric showed a very significant alteration from Reference Condition in 80% of the mainstem river length (mostly associated with increased variability) and a significant alteration from reference in 20% 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 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 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 most in the Mt Lofty 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 the reference flow regime. 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 large difference from Reference Condition. Results for the Low Over Bank Flow Duration 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 a small portion 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 100% 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 Lower zone, some in the Middle zone and some 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 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 the reference flow regime. 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 an extreme difference from Reference Condition. Results for the High Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 85% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 15% 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 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 100% 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 Upper zone.

***Summary: mainstem rivers***

The mainstem river system of the Lower Murray Valley was in Extremely Poor condition. The magnitude of High and Mean Flows were reduced, the frequency of High Flow Spells were reduced, the frequency of Low Flow Spells were increased, the amplitude of Seasonal Flow Variations was reduced, timing of Seasonal Flow Variations was altered, monthly flow variation was increased, inter-flood durations for Low and High Over Bank flows were increased, the duration of High and Low Over Bank flows was reduced throughout all of the mainstem river system. In addition, there was widespread reduction in the magnitude of Low Flows relative to Reference Condition.

***Summary: headwater streams***

The headwater streams of the Lower Murray 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 high flows were reduced.

**Table MLW 11: Lower Murray 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 | Mt Lofty |
| Hydrology Condition SR–HI | 31 | 3 | 3 | 2 | 96 |

# MURRAY VALLEY - LOWER

Table MLW 12: Lower Murray 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-HIm, headwater: SR-HIh)** | **3 (0–33)** | **99 (18–100)** |
| Sub-index | In-Channel Flow Regime | 4 (0–16) | 99 (18–100) |
| **Indicator** | **In-Channel Flow Regime A (volume and flow events)** | **24 (4–32)** | **100 (50–100)** |
| Sub-ind. | Flow Gross Volume | 7 (4–20) | 100 (33–100) |
| Metric | Mean Annual Flow | 0.23 (0.11–2.00) | 1.00 (0.35–1.18) |
| Metric | Flow Duration | 0.95 (0.89–1.21) | 0.97 (0.63–1.18) |
| Sub-ind. | High Flow Events | 42 (29–44) | 97 (9–100) |
| Metric | High Flow | 0.34 (0.21–1.96) | 0.91 (0.10–1.90) |
| Metric | High Flow Spells | 0.36 (0.30–0.39) | |
| Sub-ind. | Low and Zero Flow Events | 66 (8–97) | 98 (65–99) |
| Metric | Zero Flows Proportion | 1.03 (0.90–2.00) | 0.99 (0.95–1.00) |
| Metric | Low Flow | 0.56 (0.38–1.00) | 1.00 (0.32–1.55) |
| Metric | Low Flow Spells | 0.49 (0.33-2.00) | |
| **Indicator** | **In-Channel Flow Regime B (seasonality & variability)** | **16 (5–34)** | **98 (15–100)** |
| Sub-ind. | Flow Seasonality | 34 (26–47) | 97 (57–100) |
| Metric | Flow Seasonal Amplitude | 0.38 (0.20–1.91) | 1.04 (0.89–1.80) |
| Metric | Flow Seasonal Period | 0.71 (0.63–0.78) | 0.98 (0.66–1.00) |
| Sub-ind. | Flow Variability | 29 (0–55) | 92 (0–100) |
| Metric | Flow Variation | 1.52 (0.51–1.67) | 0.93 (0.11–1.00) |
| Sub-index | Over Bank Flow Regime | 9 (8–68) | |
| **Indicator** | **Over Bank Floods Low** | **40 (0–47)** | |
| Metric | OB Flow Duration (ARI 1) | 0.44 (0.33–2.00) | |
| Metric | OB Flow Spells (ARI 1) | 0.39 (0.17–2.00) | |
| **Indicator** | **Over Bank Floods High** | **3 (0–78)** | |
| Metric | OB Flow Duration (ARI 8) | 0.47 (0–2.00) | |
| Metric | OB Flow Spells (ARI 8) | 0.15 (0–1.81 | |

| | Zone | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mainstem rivers | | | Headwater streams | | | |
| | Upper | Middle | Lower | Upper | Middle | Lower | Mt Lofty |
| | **3** | **3** | **2** | **100** | **100** | **99** | **96** |
| | 5 | 3 | 2 | 100 | 100 | 99 | 96 |
| | **23** | **25** | **24** | **100** | **100** | **98** | **100** |
| | 8 | 7 | 6 | 100 | 100 | 99 | 99 |
| | 0.32 | 0.13 | 0.12 | 1.00 | 1.00 | 1.02 | 1.01 |
| | 0.95 | 0.94 | 0.92 | 0.97 | 0.96 | 1.02 | 0.97 |
| | 40 | 44 | 42 | 96 | 96 | 94 | 97 |
| | 0.41 | 0.25 | 0.25 | 0.87 | 0.85 | 1.11 | 1.01 |
| | 0.36 | 0.36 | 0.35 | | | | |
| | 65 | 68 | 66 | 99 | 99 | 97 | 98 |
| | 1.04 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 | 0.99 |
| | 0.58 | 0.56 | 0.50 | 1.00 | 1.00 | 1.04 | 0.99 |
| | 0.58 | 0.38 | 0.39 | | | | |
| | **18** | **13** | **12** | **100** | **100** | **98** | **93** |
| | 27 | 28 | 40 | 99 | 99 | 92 | 93 |
| | 0.51 | 0.22 | 0.20 | 0.99 | 1.00 | 1.18 | 1.15 |
| | 0.72 | 0.69 | 0.72 | 0.99 | 0.98 | 1.00 | 0.96 |
| | 29 | 30 | 30 | 96 | 94 | 99 | 85 |
| | 1.44 | 1.59 | 1.65 | 0.95 | 0.93 | 0.99 | 0.89 |
| | 9 | | | | | | |
| | **36** | **46** | **43** | | | | |
| | 0.52 | 0.36 | 0.35 | | | | |
| | 0.44 | 0.34 | 0.30 | | | | |
| | **3** | | | | | | |
| | 0.47 | 0.47 | 0.46 | | | | |
| | 0.15 | | | | | | |

# MURRUMBIDGEE VALLEY

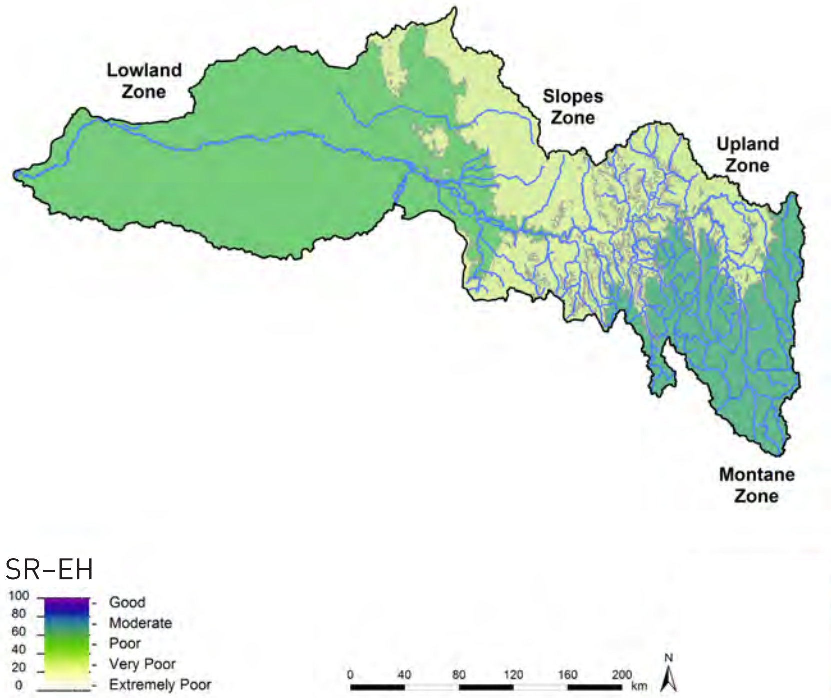



**Figure MBG 1: Murrumbidgee Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure MBG 1 shows the Ecosystem Health ratings for the Murrumbidgee Valley and Tables MBG 1 and MBG 2 also show the index values and ratings for each Theme. Ecosystem health shows a large difference from Reference Condition for the Murrumbidgee Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Extremely Poor, Moderate and Moderate 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 Murrumbidgee Valley river system. River Ecosystem Health was rated as Poor (Lowland zone: Poor; Slopes and Upland zones: Very Poor and Montane zone: Poor).

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

*The Murrumbidgee Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Montane and Lowland Poor, Upland and Slopes Very Poor. The Fish community was in Extremely Poor condition. Most expected species were absent. Fish species counts, abundance and biomass were dominated by aliens; and recruitment levels among the remaining native species were Very to Extremely Poor. 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 low abundance and nativeness and reduced structural integrity in the Near Riparian domain, but little 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 to high levels of floodplain sediment deposition. The river system's Hydrology was in Poor condition, with mainstem river reaches generally characterised by considerable alteration from Reference Condition in flow variability, flow seasonality, low and zero flow events, high flow events and flow gross volume. There was minor alteration in high and low over bank floods.*

### *Ecosystem health*

The Murrumbidgee Valley ranked 17th out of 23 SRA valleys in terms of Ecosystem Health, and was the lowest of the 15 valleys rated as being in Poor condition (see Table 5.2). It ranked 19th in terms of hydrological condition and equal 8th (with the Castlereagh and Lachlan) for Physical Form. It ranked 9th, 12th and equal 18th (with the Goulburn) for Vegetation, Macroinvertebrates, and Fish respectively.

The Murrumbidgee supports a substantial irrigation industry in its Lowland zone and forestry and grazing in the Slopes and Upland zones, whereas much of the Montane zone is dedicated to conservation and catchment protection. Flow is highly regulated through major storages which influence the hydrology of the Upland, Slopes and Lowland zones. Inter-valley transfers from the Snowy Catchment are also significant. Assessment of hydrological condition reflects this scenario with Index values indicating Good condition in the Montane zone, declining to Very Poor in the Lowland zone.

The Lowland zone also has the lowest macroinvertebrate score, rated as Poor; all other zones being rated as Moderate to Good. Fish condition scored lowly throughout the valley, even in the Montane zone, above the influence of regulation and river management. The Index (SR–FI) was lowest in the Upland and Slopes zones (zero in both cases) which lie between major in-stream storages and the downstream reached from which irrigation water is diverted. Fish were sampled in early 2010, just prior to the breaking of the extended drought. It is possible that drought effects are more severe on the fish communities of small catchment streams than on the fish of the larger lowland streams which are likely to be somewhat buffered from drought effects by river regulation and infrastructure. This hypothesis needs investigation in the future.

### *Fish Theme*

The Fish Condition Index SR–FI = 15, indicating Extremely Poor condition (Lowland zone: Very Poor; Slopes zone: Extremely Poor; Upland zone: Extremely Poor; Montane zone: Very Poor). The Expectedness indicator = 27, indicating Very Poor condition, and a very large difference from Reference Condition. The Nativeness indicator = 29, indicating Very Poor condition, and a very large difference from Reference Condition. The Recruitment indicator = 19, indicating Extremely Poor condition, and an extreme difference from Reference Condition.

# MURRUMBIDGEE VALLEY

The Fish community of the Murrumbidgee had reduced numbers of expected native species, low numbers of native fish, and low native biomass. The valley had lost most of its native fish species richness and alien species dominated the community, contributing 84% of fish biomass overall. Native fish recruitment was Very Poor to Extremely Poor, across all zones.

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 71, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Good; Upland zone: Good; Montane zone: Moderate). The simOE metric = 49 (CL 47–51) 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 site communities in Moderate to Good condition was high across both zones (77% overall), with 16 of the 35 rated sites in Good condition (12 of which were in the Upland and Montane zones).

Family richness generally was moderate, but was reduced compared to Reference Condition.

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 64, indicating Moderate condition (Lowland zone: Good; Slopes zone: Extremely Poor; Upland zone: Very Poor; Montane zone: Good). The Vegetation Abundance and Diversity indicator = 66, indicating Moderate condition and a moderate difference from Reference Condition for the abundance, richness and stability of vegetation major groups in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 62, 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 has been slightly affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the floodplain sampled area is 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 = 88 and the Bank Dynamics indicator = 96, both indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 71 and the Floodplain Form indicator = 65, 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 within the river channel and floodplains of the Lowland and Slopes zones.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 56, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Moderate; Upland zone: Poor; Montane zone: Good). The In-Channel Flow Regime sub-index = 21, 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 = 82, indicating Good condition and near Reference Condition for the wetting regime in riparian and floodplain areas.

The hydrology of the Murrumbidgee Valley river system was characterised by a mainstem river in Very Poor condition and headwater streams in Good condition. The mainstem river reaches were generally characterised by considerable alteration from Reference Condition in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume and minor alteration in High Over Bank Floods and Low Over Bank Floods. The headwater streams were generally characterised by little or no alteration in any of these indicators.

**Table MBG 1: Murrumbidgee 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 | Very Poor | Very Poor | Poor |

| THEME | | VALLEY | ZONE | | | |
|---|---|---|---|---|---|---|
| | | | MONTANE | UPLAND | SLOPES | LOWLAND |
| Fish | SCORE RATING | 15 (10–20) Ext' Poor | 26 (16–44) Very Poor | 0 (0–1) Ext' Poor | 0 (0–2) Ext' Poor | 24 (11–32) Very Poor |
| Macro-invertebrates | SCORE RATING | 71 (67–75) Moderate | 79 (69–88) Moderate | 80 (71–87) Good | 81 (77–86) Good | 50 (41–57) Poor |
| Vegetation | SCORE RATING | 64 Moderate | 98 Good | 37 Very Poor | 13 Ext' Poor | 93 Good |

**Table MBG 2: Murrumbidgee 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 (82–90) Good | 95 (92–98) Good | 85 (69–92) Good | 85 (82–88) Good | 83 (67–91) Good |
| Hydrology | SCORE RATING | 56 Poor | 100 Good | 43 Poor | 64 Moderate | 36 Very Poor |

# MURRUMBIDGEE VALLEY

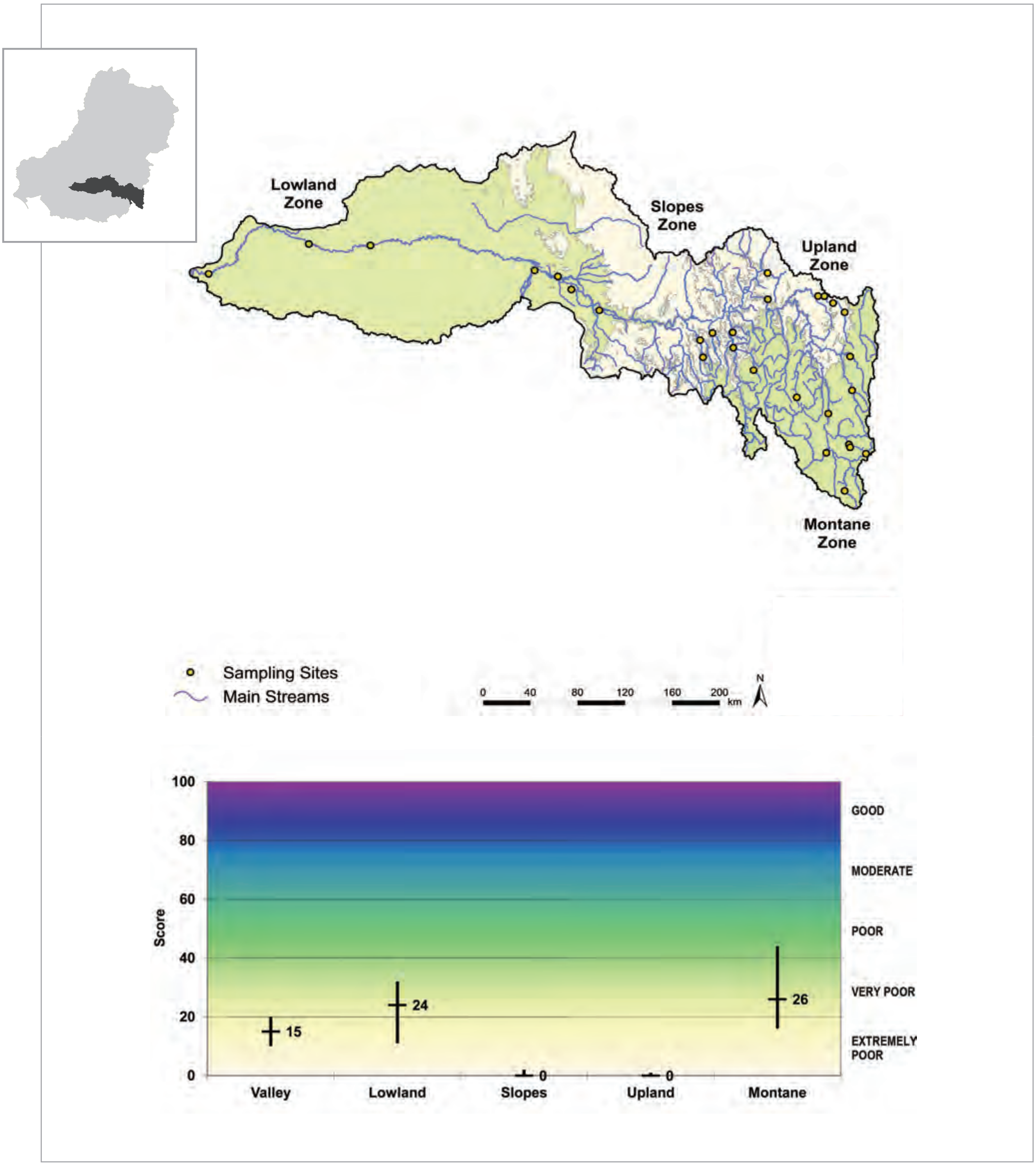



Figure MBG 2: Murrumbidgee Valley map with sampling sites and zones coloured by SR Fish Index scores.

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

*The Fish community of the Murrumbidgee 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: Montane zone Very Poor; Upland zone Extremely Poor; Slopes zone Extremely Poor and Lowland zone Very Poor. The Fish community was characterised by a Very Poor score for expected native fish species, a Very Poor score for nativeness and an Extremely Poor score for native fish recruitment. The Upland and Slopes zones in particular had few fish and lacked 67% and 72% of the predicted native species respectively. The valley had lost much of its native species richness and alien species contributed 84% of the biomass in samples. Native fish recruitment was Very Poor, Extremely Poor, Extremely Poor and Very Poor in the Montane, Upland, Slopes, and Lowland zones respectively.*

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

- SRA Fish Index (SR–FI) = 15 (CL 10–20), indicating Extremely 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 55% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 29 (CL 22–38), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 19 (CL 11–31), indicating Extremely Poor condition, and an extreme difference from Reference Condition. Evidence of recruitment was observed for 10 of the 12 native species observed in the valley.

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

SR–FI for the Murrumbidgee Valley was fifth lowest for all valleys, and close to that for the Goulburn and Kiewa valleys. The Upland and Slopes zone communities were in much worse condition (SR–FI = 0 in both cases) than that in the Montane and Slopes zones (SR–FI = 26 and 24 respectively).

Expectedness varied amongst zones, the Upland and Slopes zones being rated as Extremely Poor, the Montane zone as Poor and the Lowland zone as Very Poor. The Upland zone had four native species of an expected 12 and the Slopes zone had five of 18 expected species.

Nativeness followed a similar pattern amongst zones. The Upland zone yielded a total of 10 native fish from its seven sites, whereas 413 fish belonging to five alien species were captured. The Slopes zone yielded 20 native fish and 1,227 alien specimens. Native fish outnumbered alien fish in both the Montane and Lowland zones—2.4 to 1 in the Montane zone and over 4 to 1 in the Lowland zone.

# MURRUMBIDGEE VALLEY

Table MBG 4 shows native species abundances in the Murrumbidgee Valley compared with Reference Condition. Those native species present were mostly caught in low numbers, with Mountain galaxias being the only native species to yield more than 100 individuals in total; almost all from the Montane zone, Australian smelt was the only other native species to exceed 10 individuals per site in any zone. Large-bodied native species including golden perch, Macquarie perch, Murray cod, and silver perch appeared in samples—mostly in low numbers. Trout cod and freshwater catfish were expected but not caught. Gambusia was the most numerous alien species and common carp was well represented in all four zones.

The Murrumbidgee Valley yielded the eighth highest biomass of fish per site amongst the 23 valleys, but only 16.2% of this was contributed by native species; the sixth lowest proportion of fish biomass that was native, and similar to the Wimmera and Broken valleys. Golden perch averaging 1.3 kg per fish and Murray cod at 1.4 kg per fish were the only large native fish caught. The total native fish catch from the 28 sites weighed just under 41 kg. Common carp captured at the same time weighed over 202 kg.

Recruitment was variable amongst zones. All three native species caught in the Montane zone—mountain galaxias, Macquarie perch and two-spined blackfish— were deemed to have recruited. Only one of the four native species in the Upland zone showed evidence of recruitment. Golden perch, present in three zones, showed no evidence of recruitment. All alien species were recorded as recruiting in all or almost all zones in which they were found.

In general, the fish community of the Murrumbidgee had reduced numbers of expected native species, low numbers of native fish, and low native biomass.

**Table MBG 3: Murrumbidgee 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) | 15 (10–20) | 26 (16–44) | 0 (0–1) | 0 (0–2) | 24 (11–32) |
| Indicator | Expectedness | 27 (23–31) | 51 (42–61) | 8 (8–13) | 5 (5–10) | 30 (18–41) |
| Metric | O/E | 0.25 (0.18–0.32) | 0.37 (0.21–0.53) | 0.10 (0.03–0.21) | 0.11 (0.04–0.22) | 0.33 (0.17–0.48) |
| Metric | O/P (Zone level) | 0.43 (0.43–0.43) | 0.60 (0.60–0.60) | 0.33 (0.33–0.33) | 0.28 (0.28–0.28) | 0.42 (0.42–0.42) |
| Indicator | Nativeness | 29 (22–38) | 40 (22–63) | 0 (0–2) | 3 (0–12) | 59 (41–76) |

Continued/...

| Indexes Indicators Metrics | Description | Valley | Zone | | | |
|---|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes | Lowland |
| Metric | Proportion biomass native | 0.22 (0.12–0.33) | 0.28 (0.06–0.55) | 0.01 (0.00–0.03) | 0.08 (0.00–0.22) | 0.42 (0.19–0.65) |
| Metric | Proportion abundance native | 0.37 (0.26–0.48) | 0.57 (0.27–0.84) | 0.02 (0.00–0.06) | 0.08 (0.00–0.21) | 0.63 (0.37–0.83) |
| Metric | Proportion species native | 0.38 (0.28–0.48) | 0.46 (0.26–0.66) | 0.13 (0.04–0.26) | 0.25 (0.10–0.42) | 0.57 (0.35–0.75) |
| Indicator | Recruitment | 19 (11–31) | 26 (6–60) | 2 (0–20) | 12 (0–26) | 31 (14–44) |
| Metric | Proportion of sites with native recruits | 0.24 (0.13–0.35) | 0.36 (0.07–0.66) | 0.05 (0.00–0.15) | 0.12 (0.00–0.29) | 0.33 (0.20–0.46) |
| Metric | Proportion of native taxa with recruits | 0.69 (0.47–0.82) | 1.00 (0.5–1.00) | 0.25 (0.00–1.00) | 0.60 (0.00–1.00) | 0.75 (0.5–0.86) |
| Metric | Proportion of abundance as recruits | 0.37 (0.22–0.51) | 0.22 (0.00–0.43) | 0.25 (0.00–1.00) | 0.50 (0.00–0.90) | 0.52 (0.43–0.62) |
| Variables | | | | | | |
| | Number of sites sampled | 28 | 7 | 7 | 7 | 7 |
| | Total number of species | 18 | 8 | 9 | 9 | 12 |
| | Number of native species | 12 | 3 | 4 | 5 | 8 |
| | Number of predicted species | 22 | 5 | 12 | 18 | 19 |
| | Number of alien species | 6 | 5 | 5 | 4 | 4 |
| | Mean number of fish per site | 85 | 74 | 60 | 178 | 29 |
| | Biomass/site all species (g) | 8994 | 6322 | 17175 | 4021 | 8458 |
| | Mean native biomass/fish (g) | 73 | 9 | 92 | 347 | 180 |
| | Mean alien biomass/fish (g) | 115 | 270 | 289 | 17 | 740 |

**Table MBG 4: Murrumbidgee 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 | 86 | | 0 | 10 | 76 |
| Bony herring | 31 | | | 0 | 31 |
| Dwarf flathead gudgeon | 0 | | | 0 | |
| Flathead gudgeon | 0 | | | 0 | 0 |
| Freshwater catfish | 0 | | | 0 | 0 |
| Golden perch | 17 | | 1 | 4 | 12 |
| Gudgeon | 20 | | 3 | 3 | 14 |
| Macquarie perch | 10 | 8 | 2 | 0 | 0 |
| Mountain galaxias | 327 | 322 | 4 | 1 | |
| Murray cod | 9 | | 0 | 0 | 9 |
| Murray hardyhead | 0 | | | | 0 |
| Murray jollytail | 0 | | | 0 | 0 |
| Murray–Darling rainbowfish | 5 | | | 0 | 5 |
| Olive perchlet | 0 | | | | 0 |
| River blackfish | 2 | 0 | 0 | 2 | 0 |
| Shortheaded lamprey | 0 | | | | 0 |
| Silver perch | 1 | | 0 | 0 | 1 |

Continued/...

| Fish species | Valley | Zone | | | |
|---|---|---|---|---|---|
| | | Montane | Upland | Slopes | Lowland |
| Southern purple-spotted gudgeon | 0 | | 0 | 0 | 0 |
| Southern pygmy perch | 0 | | 0 | 0 | 0 |
| Trout cod | 0 | 0 | 0 | 0 | 0 |
| Two-spined blackfish | 34 | 34 | 0 | | |
| Unspecked hardyhead | 16 | | | 0 | 16 |
| Alien species | | | | | |
| Brown trout | 15 | 14 | | 1 | |
| Common carp | 300 | 48 | 129 | 91 | 32 |
| Gambusia | 1276 | 6 | 149 | 1120 | 1 |
| Goldfish | 104 | 49 | 50 | | 5 |
| Rainbow trout | 44 | 34 | 10 | | |
| Redfin perch | 92 | | 75 | 15 | 2 |

# MURRUMBIDGEE VALLEY

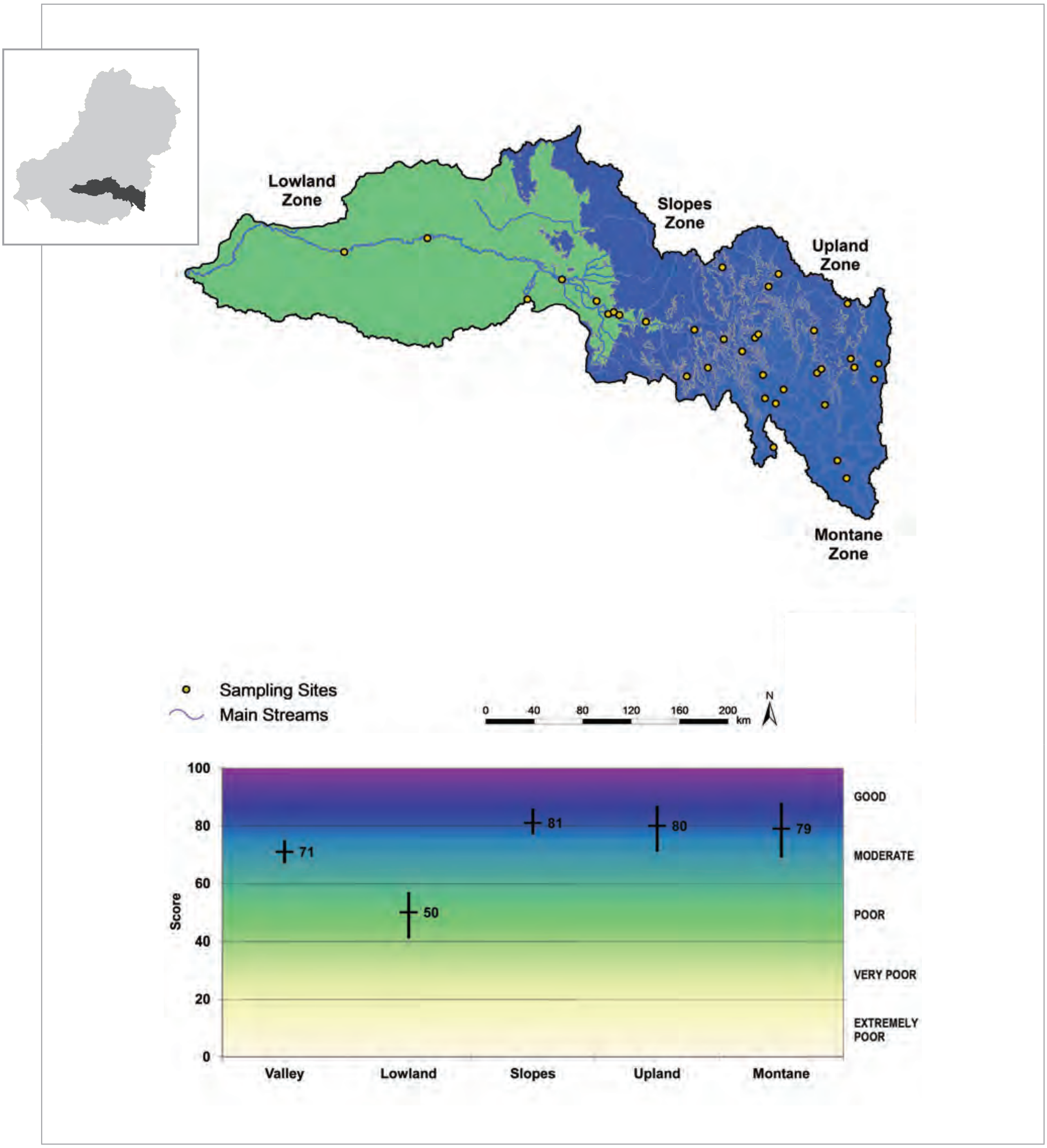



Figure MBG 3: Murrumbidgee Valley map with sampling sites and zones coloured by SR Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Murrumbidgee Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 71. The condition of the Macroinvertebrate community in the zones was as follows: Montane Moderate; Upland Good; Slopes Good; Lowland Poor. The proportion of sites in Moderate to Good condition was high (77%); 13 of the 35 rated sites (37%) were in Good condition. Family richness generally was Moderate, but was reduced compared to Reference Condition.*

Thirty-five sites were surveyed across the Murrumbidgee Valley in September–October 2008 yielding 7,275 macroinvertebrates in 73 families (78% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 71 (CL 67–75), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 49 (CL 47–51) indicating a moderate to 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 site communities in Moderate to Good condition was high across both zones (77% overall), with 13 of the 35 rated sites (37%) in Good condition (10 of which were in the Upland and Montane zones).
- The number of families found was lowest in the Lowland zone (31 families) and highest in the Montane and Upland zones (58–59 families), with the three upper zones all having an equally high average number of families per site (25–26).

Figure MBG 3 shows sampling sites, zones and SR–MI values, and Table MBG 5 shows index and metric values. The SR–MI score for the Murrumbidgee Valley indicated Moderate condition of macroinvertebrate communities, rating 12th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Upland and Slopes zones showed minor differences from Reference Condition (SR–MI = 80 and 81, respectively), while the Montane zone fell just below these (SR–MI = 79). A wider confidence interval (19 points) for the Montane zone SR–MI value indicates more spatial variability there, with sites ranging from Moderate to Good condition. Expectedness (simOE) was generally moderate and varied by up to 21 points among sites.

# MURRUMBIDGEE VALLEY

Table MBG 6 shows that most sites above the Lowland zone had SR–MI values indicating Moderate to Good condition. Most sites in these zones had slightly lower than expected diversities of macroinvertebrates, though coupled with reductions in frequency of occurrence of the families present. Only the Lowland zone had sites with a low simOE score (<40 points), comprising 22% of sites in that zone. Sites in this zone had substantially lower than expected macroinvertebrate diversities.

Overall, family richness generally was reduced compared to Reference Condition. Diversity was moderate (average 23 families per site), with all three upper zones being most diverse at site scale (average 25 – 26 families per site). The valley contained 78% of the families found across the Basin (Table MBG 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (79–81%) of the fauna of the valley was found in the Montane and Upland zones.

**Table MBG 5: Murrumbidgee 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) | 71 (67–75) | 79 (69–88) | 80 (71–87) | 81 (77–86) | 50 (41–57) |
| Metric | SimOE | 49 (47–51) | 53 (48–58) | 53 (48–57) | 53 (51–56) | 40 (37–43) |

Table MBG 6: Murrumbidgee 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 | 10 | 8 | 8 | 9 |
| Number of sites with index values* | 35 | 10 | 8 | 8 | 9 |
| N sites by SR–MI condition band | | | | | |
| Good (80–100) | 13 | 5 | 5 | 3 | |
| Moderate (60–80) | 14 | 4 | 2 | 5 | 3 |
| Poor (40–60) | 6 | 1 | 1 | | 4 |
| Very or Extremely Poor (0–40) | 2 | | | | 2 |
| Families | | | | | |
| Number of families sampled | 73 | 58 | 59 | 45 | 31 |
| No. families/site (min-max) | 23 (7–36) | 25 (14–34) | 26 (17–36) | 26 (19–30) | 16 (7–23) |
| Percent of families in Basin | 78 | 62 | 63 | 48 | 33 |
| Percent of families in valley | 100 | 79 | 81 | 62 | 42 |

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

# MURRUMBIDGEE VALLEY

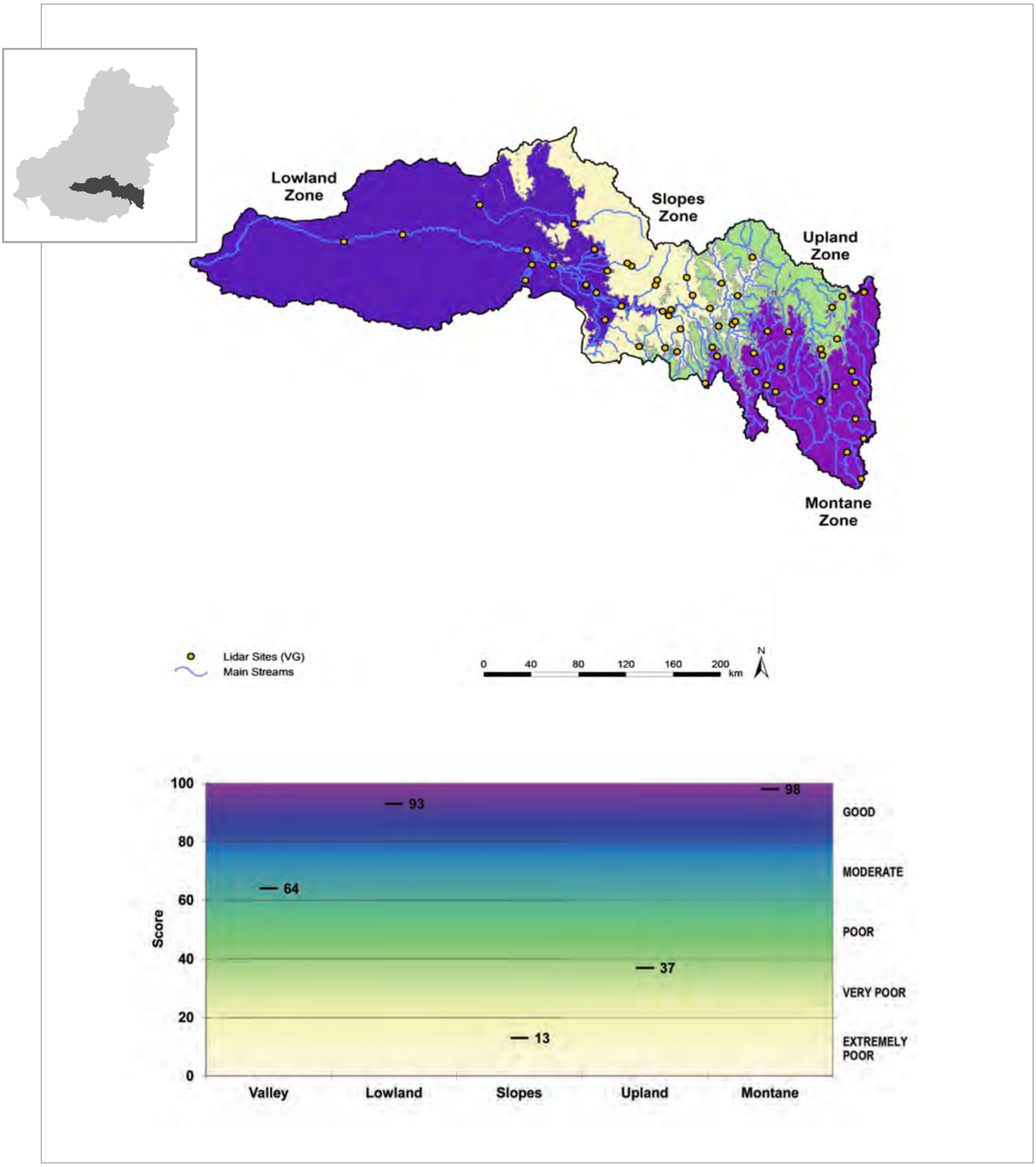



**Figure MBG 4: Murrumbidgee Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.**

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Murrumbidgee Valley river system was in Moderate condition, with an aggregate Vegetation Index score (SR–VI) of 64. Overall condition for the four zones in this valley was: Montane Good; Upland Very Poor; Slopes Extremely Poor; Lowland Good.*

*The Abundance and Diversity indicator score was 66 for the valley, indicating a Moderate rating overall. In the four zones it was: Montane Good; Upland Poor; Slopes Very Poor; Lowland Good.*

*The Quality and Integrity indicator score was 62 for the valley, indicating a Moderate rating overall. In the four zones in this valley it was: Montane Good; Upland Poor; Slopes Very Poor; Lowland Moderate.*

The SRA Vegetation assessment of the Murrumbidgee Valley considers riverine vegetation in two spatial domains: Near Riparian, along 6,553 km of stream across the valley, and Lowland Floodplain, for 1,821 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. The length of stream assessed per zone is as follows: Montane 1,765 km; Upland 1,149 km; Slopes 1,690 km; and Lowland 1,949 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 61 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, 16 sites; Upland, 10 sites; Slopes, 17 sites; and Lowland, 18 sites. The assessment of the Near Riparian domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure MBG 4 shows values of the Vegetation Index (SR–VI) for the Murrumbidgee Valley and Table MBG 7 shows the index, indicator and sub-indicator values. Tables MBG 8 and MBG 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 Murrumbidgee Valley with:

- SRA Vegetation Index (SR–VI) = 64, indicating Moderate condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 66, 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 = 62, 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 slightly affected by clearing.  The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with MVGs being near Reference Condition in the Montane zone, and showing a large difference from reference in the Upland zone, 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 is near reference in the Lowland Floodplain domain. MVG richness is maintained near reference in both the Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 91% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Moderate condition overall, being near reference in the Montane zone, and showing a large difference from reference for the Upland zone, a very large difference from reference in the Slopes zone and a moderate difference 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 MBG 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 is near reference in the Lowland Floodplain domain. The degree of MVG fragmentation in the Lowland Floodplain 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 in Upland, Slopes and Lowland 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 considerable variability between zones and domains. Abundance in the Near Riparian domain shows a moderate difference from Reference Condition in the Montane zone, a large difference in the Upland zone, an extreme difference in the Slopes zone and a large difference in the Lowland zone; and in the Lowland Floodplain domain, it 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 Moderate condition overall, and the metrics show high variability between zones and domains. Nativeness in the Near Riparian domain shows a moderate difference from reference in the Montane zone, a large difference in the Upland zone, an extreme difference in the Slopes zone and a large difference in the Lowland zone; and in the Lowland Floodplain domain, it is near 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 some differences between zones. Structure is moderately different from Reference Condition in the Montane zone, near reference in the Upland and Slopes zones, 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 Good condition, due to Eucalypt Open Forests and Other Shrublands having a patch number and mean patch area in near Reference Condition. Under Reference Conditions, these were two of the most extensive MVGs in the Lowland Floodplain domain, and so have a strong influence on the Fragmentation sub-indicator.

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

- Montane zone: The Near Riparian domain was mostly (61% of domain area) Eucalypt Open Forests. Only two of the eight other MVGs present were more than 5%.
- Upland zone: The Near Riparian domain was mostly Eucalypt Woodlands (51%) with Eucalypt Open Forests (35%) and another seven MVGs, all less than 5% of the domain.
- Slopes zones: The Near Riparian domain was mostly (72%) Eucalypt Woodlands. One of the other two MVGs present (Eucalypt Open Forests) was more than 5%.
- Lowland zone: The Near Riparian domain was mostly (53%) Eucalypt Woodlands with Eucalypt Open Forests (36%) and six other MVGs, none of which was more than 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Open Forests (42%) with Eucalypt Woodlands (24%), and eight other MVGs of which only two 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 reduced in all domains but particularly in the Slopes zones. The effects on individual MVGs vary between zones.

- Montane zone: In the Near Riparian domain, although reduced, Eucalypt Open Forests are still the most extensive MVG (47% of the domain area). About 26% is either cleared or non-native vegetation. MVGs are variously affected: one (Casuarina Forests and Woodlands) is completely reduced, four are reduced to 15–30% of their reference area, another four are reduced to 70–94% of their reference area, and three are unchanged.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands are reduced (currently 10% of domain area) and Eucalypt Open Forests are now the most extensive MVG (23%). About 54% of the domain is either cleared or non-native vegetation. Three MVGs are reduced to less than 30% of their reference area, three are reduced to 60–70% of their reference area, and three are unchanged.

- Slopes zones: In the Near Riparian domain, Eucalypt Woodlands are reduced to 4% of the domain area. About 80% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands and Eucalypt Open Forests, previously the most extensive MVGs, are reduced to 6% and 17% of their reference area; in contrast, two MVGs are 80–90% of their reference area, and one is unchanged.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are reduced and occupy only 10% of the domain area and Eucalypt Open Forests are now the most extensive MVG (31%). About 49% of the domain is either cleared or non-native vegetation. Three MVGs are substantially affected, being reduced to less than 20% of their reference area, however other MVGs are much less affected and four of the smallest have areas the same as under Reference Condition.

- Lowland zone: In the Lowland Floodplain domain, about 10% is either cleared or non-native vegetation. The effect on MVGs is quite variable: three MVGs, though all originally quite small in area, appear substantially affected, while in contrast six MVGs—including Eucalypt Open Forests—have the same area as under Reference Conditions.

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 current NVIS 3.0 mapping may range from 1997 to 2004, whereas the LiDAR was flown February–March 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 in quality. About 6% and 9% of the Near Riparian domain in the Upland and Slopes zones respectively has no MVG assigned. 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 Murrumbidgee Valley is notable for the range of condition amongst the zones, for the Slopes zone being in Extremely Poor condition with extremely low abundance of MVGs and nativeness in the Near Riparian domain, and the Lowland Floodplain domain being in better condition than the Near Riparian domain in the Lowland zone.

The zones with riverine vegetation in the best condition are the Montane and Lowland, both rated as near reference. The zone with the lowest rating in the valley is the Slopes zone, with abundance and nativeness scores that are Extremely Poor, but near reference scores for richness and structure.

In the Lowland zone, the Lowland Floodplain domain is in better condition than the Near Riparian domain: abundance and nativeness are near reference, the degree of fragmentation is low, and there is little evidence of MVG turnover. In the Near Riparian domain, abundance and nativeness have low scores and structure is in Moderate condition. These two domains assess differing parts of the Lowland zone: the Lowland Floodplain domain is land that floods beside the main river and parts of the broader floodplain, whereas the Near Riparian is a strip centred on all channels, and smaller in area.

**Table MBG 7: Murrumbidgee 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) | 64 | 98 | 37 | 13 | 93 |
| Indicator | Abundance and diversity | 66 | 94 | 52 | 30 | 82 |
| Metric | LF stability | 0.91 | | | | 0.91 |
| Sub-ind. | NRLF richness | 100 | | | | 100 |
| Metric | NR richness | 0.98 | 0.92 | 1 | 1 | 1 |
| Metric | LF richness | 1 | | | | 1 |
| Sub-ind. | NRLF abundance | 62 | | | | 62 |
| Metric | NR abundance | 0.44 | 0.74 | 0.42 | 0.09 | 0.48 |
| Metric | LF abundance | 0.90 | | | | 0.90 |

Continued....

# MURRUMBIDGEE VALLEY

| Indexes Indicators Metrics | Description | Valley | Zone | | | |
|---|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes | Lowland |
| Indicator | Quality and integrity | 62 | 82 | 51 | 30 | 78 |
| Sub-ind. | NRLF nativeness | 62 | | | | 62 |
| Metric | NR nativeness | 0.44 | 0.74 | 0.42 | 0.09 | 0.48 |
| Metric | LF nativeness | 0.90 | | | | 0.90 |
| Sub-ind. | NR structure | 78 (73–82) | 64 (51–76) | 80 (68–87) | 90 (82–94) | 79 (70–87) |
| Sub-ind. | LF fragmentation | 95 | | | | 95 |

**Table MBG 8: The most abundant MVGs in the Near Riparian domain in the Murrumbidgee 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 | 61 | 35 | 19 | 36 |
| 5. Eucalypt Woodlands | 17 | 51 | 72 | 53 |
| 21. Other Grasslands, Herblands, Sedgelands and Rushlands | 13 | | | |

**Table MBG 9: Most abundant MVGs in the Lowland Floodplain domain of the Murrumbidgee Valley.**

Showing percentage of domain area under Reference Condition in the Murrumbidgee 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 | 42 | 0.99 | 0.99 |
| 5. Eucalypt Woodlands | 24 | 0.74 | 1.01 |
| 17. Other Shrublands | 20 | 1 | 1 |
| 22. Chenopod Shrublands, Samphire Shrublands and Forblands | 8 | 0.54 | 1.27 |

# MURRUMBIDGEE VALLEY

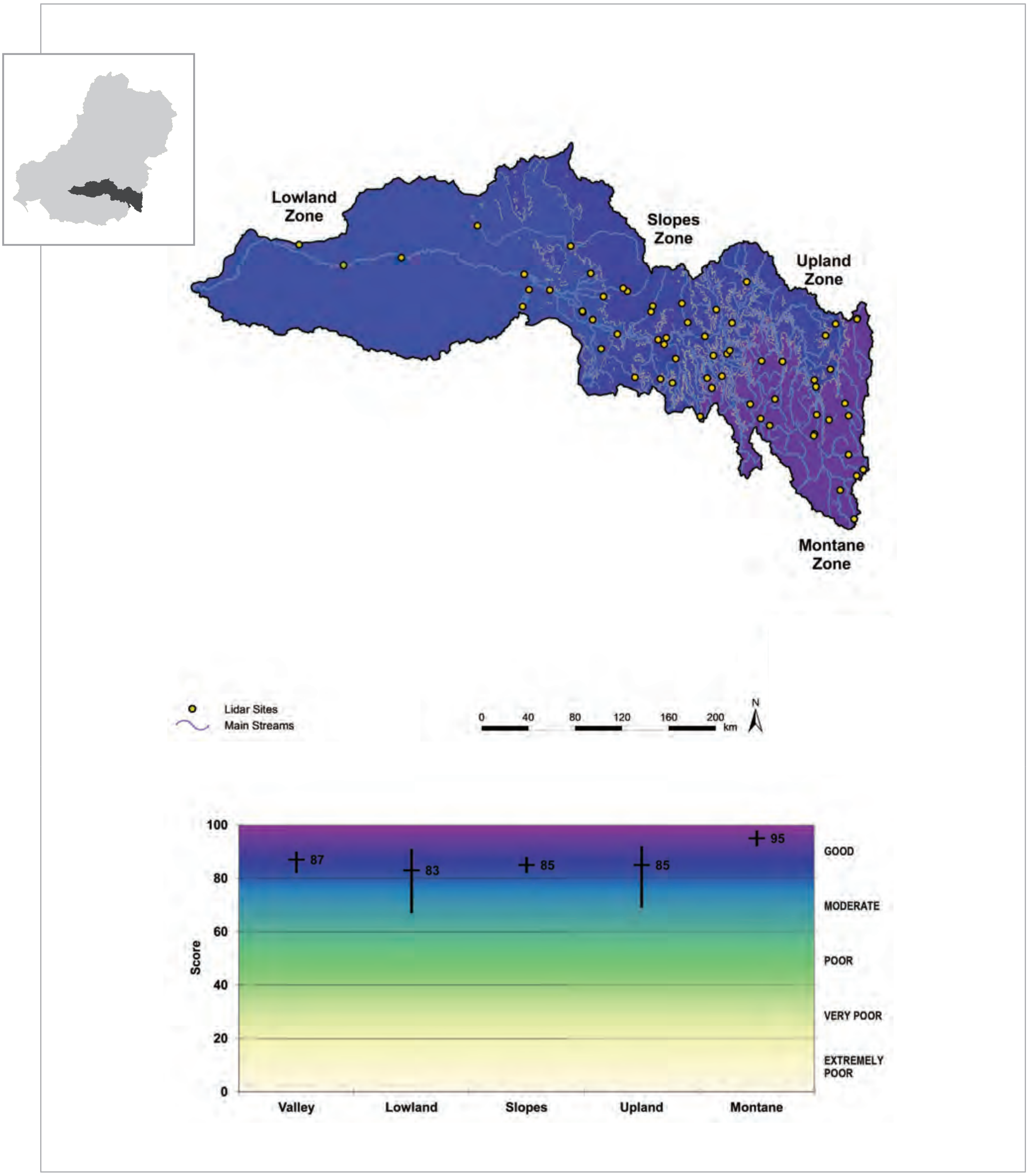



**Figure MBG 5: Murrumbidgee Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.**

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

*The Physical Form of the Murrumbidgee 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 elevated sediment loads since European settlement and associated sedimentation within the river channel and floodplains of the Lowland and Slopes zones.*

The SRA Physical Form assessment considers physical form and processes along 6,553 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 536 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 MBG 5 shows values of the Physical Form Index (SR–PI) for the Murrumbidgee Valley and Table MBG 10 shows the index, indicator, sub-indicator and metric values.

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

- the SRA Physical Form Condition Index (SR–PI) = 87 (CL 82–90), indicating Good Physical Form condition
- the Channel Form indicator = 88 (CL 83–92), showing near Reference Condition
- the Bed Dynamics indicator = 71 (CL 69–73), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 96 (CL 91–99), showing near Reference Condition
- the Floodplain indicator = 65 (CL 61–69), showing a moderate difference from Reference Condition.

These SRA assessment results are generally inconsistent with assessment results made using the River Styles Geomorphic Condition Sub-index of the NSW River Condition Index (GHD 2012b). The results for the Montane zone are in general agreement with the River Styles assessment, but River Styles assessment shows areas within the Slopes, Upland and Lowland zones that are in moderate and poor condition, while this SRA assessment indicates Good condition throughout. These differences could be explained by fundamental differences in the method. For example, River Styles takes riparian vegetation condition and bed particle size into account, while the SRA method does not. Other field investigations also suggest that Physical Form is in a more altered state in this valley than indicated by this SRA assessment, in particular in the Montane and Upland zones (M. Thoms pers. comm.).

# MURRUMBIDGEE VALLEY

***Montane zone***

There were 17 LiDAR survey sites and 85 SedNet river segments in the Montane zone of the Murrumbidgee Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from reference 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 in more than half of the Montane zone. At these sites results show both increases and decreases in Channel Depth across the zone. Channel Width, Sinuosity and Meander Wavelength were modified from reference for approximately half of the Montane zone. At these sites Channel Width and Sinuosity were generally increased (a few sites having large increases in Sinuosity) and results show both increases and decreases in Meander Wavelength across the zone. Bank Variability was modified from reference for less than half of the Montane zone. At these sites Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability and Channel Sediment Deposition were largely unmodified from reference in the Montane zone.

***Upland zone***

There were 10 LiDAR survey sites and 96 SedNet river segments in the Upland zone of the Murrumbidgee 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 10% of the zone for the post-European period. 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, 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, Sinuosity and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

***Slopes zone***

There were 18 LiDAR survey sites and 150 SedNet river segments in the Slopes zone of the Murrumbidgee 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 10% of the zone for the post-European period. Channel Width and Bank Variability were modified from reference for approximately half of the Slopes zone. At these sites Channel Width and Bank Variability were generally increased. Channel Depth, Channel Width Variability, Meander Wavelength and Channel Sediment Deposition were modified from reference for less than half of the Slopes zone. At these sites results show both increases and decreases in Channel Depth across the zone, Channel Width Variability was generally reduced, 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. Sinuosity was largely unmodified from reference in the Slopes zone.

### *Lowland zone*

There were 19 LiDAR survey sites and 205 SedNet river segments in the Lowland zone of the Murrumbidgee Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from reference 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 Width was modified from reference in more than half of the Lowland zone. At these sites results show both increases and decreases in Channel Width across the zone. Channel Depth and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites Channel Depth was generally increased (a few sites having large increases) and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Channel Width Variability, Sinuosity, Meander Wavelength and Bank Variability were modified from reference for less than half of the Lowland zone. At these sites Channel Width Variability and Bank Variability were generally reduced and both Sinuosity and Meander Wavelength were generally increased (a few sites having large increases in Meander Wavelength).

### *Channel Form*

There was little change from Reference Condition in Channel Form in the Montane zone. 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 Upland zone. 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 Slopes zone. 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. There was widespread evidence of changes in channel size 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, Upland, Slopes and Lowland zones. Bank variability exceeded Reference Conditions at 30% of sites in the Slopes zone. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result.

There was minor change from Reference Condition in Bed Dynamics in the Montane, Upland, Slopes and Lowland zones, mostly as a result of widespread elevated sediment load (90%-100% of the SedNet river segments). There was also widespread sedimentation (40% of the SedNet river segments) in the Lowland zone affecting Bank Dynamics. 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.

# MURRUMBIDGEE VALLEY

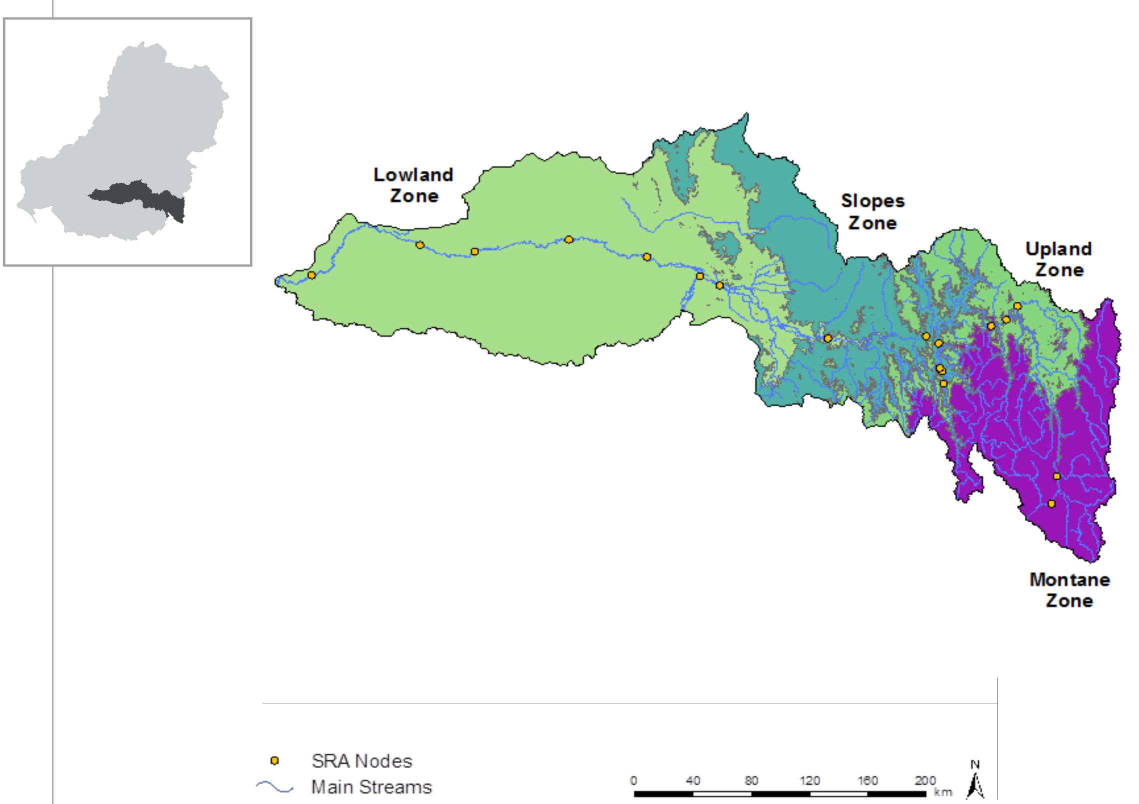
Unlike the other aspects of the Physical Form Theme, Bed Dynamics and Floodplain Sedimentation are assessed entirely using modelling, with no direct observations. These components are assessed using output from the SedNet model based on simulation of mean sediment budgets since European settlement. They 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 (90% 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 MBG 10: Murrumbidgee 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 (82–90) | 95 (92–98) | 85 (69–92) | 85 (82–88) | 83 (67–91) |
| Indicator | Channel Form (volume and flow events) | 88 (83–92) | 92 (84–98) | 83 (64–95) | 90 (82–98) | 86 (78–95) |
| Sub-ind. | Cross-section Form | 87 (82–92) | 85 (72–92) | 84 (64–97) | 91 (86–95) | 88 (80–94) |
| Metric | Channel Depth (mean) | 1.06 (0.99–1.12) | 1.06 (0.94–1.22) | 1.10 (0.94–1.36) | 0.99 (0.89–1.09) | 1.09 (0.93–1.23) |
| Metric | Channel Width (mean) | 1.09 (1.06–1.16) | 1.18 (1.09–1.34) | 1.12 (1.00–1.34) | 1.04 (0.99–1.08) | 1.05 1.00–1.11) |
| Sub-ind. | Cross-section Form (variability) | 93 (88–97) | 99 (98–100) | 87 (67–100) | 97 (92–100) | 89 (77–97) |
| Metric | Channel Width (CV) | 0.96 (0.93–1.00) | 1.03 (0.99–1.11) | 0.94 (0.83–1.02) | 0.97 (0.94–1.00) | 0.91 (0.84–0.96) |
| Sub-ind. | Channel Planform | 90 (85–94) | 88 (81–94) | 95 (87–99) | 88 (78–98) | 91 (81–98) |
| Metric | Sinuosity | 1.05 (1.01–1.11) | 1.18 (1.02–1.38) | 1.00 (1.00–1.00) | 1.01 (1.00–1.03) | 1.01 1.00–1.03) |
| Metric | Meander Wavelength | 1.03 (1.00–1.07) | 0.97 (0.90–1.06) | 1.03 (1.00–1.08) | 1.06 (1.01–1.11) | 1.06 (1.01–1.12) |
| Indicator | Bed Dynamics | 71 (69–73) | 75 (72–78) | 69 (62–73) | 65 (62–68) | 75 (71–78) |
| Metric | Channel sediment ratio | 37 (33–42) | 30 (24–37) | 51 (41–63) | 47 (39–55) | 26 (18–36) |
| Metric | Channel sediment depth | 0.002 (0.001–0.003) | 0.0003 (0–0.001) | 0.002 (0–0.004) | 0.005 (0.002–0.009) | 0.002 (0.001–0.003) |
| Indicator | Bank Dynamics | 96 (91–99) | 100 (100–100) | 98 (93–100) | 96 (93–99) | 91 (77–99) |
| Metric | Bank Variability (longitudinal) | 1.02 (0.98–1.05) | 1.03 (1.00–1.06) | 0.99 (0.93–1.04) | 1.06 (0.98–1.13) | 0.98 (0.90–1.04) |
| Indicator | Floodplain | 65 (61–69) | 78 (69–86) | 59 (49–71) | 63 (55–71) | 59 (51–68) |
| Metric | Floodplain Sediment Deposition | 4 (3–5) | 1.57 (1.03–2.00) | 3 (2–5) | 4 (2–8) | 6 (4–8) |



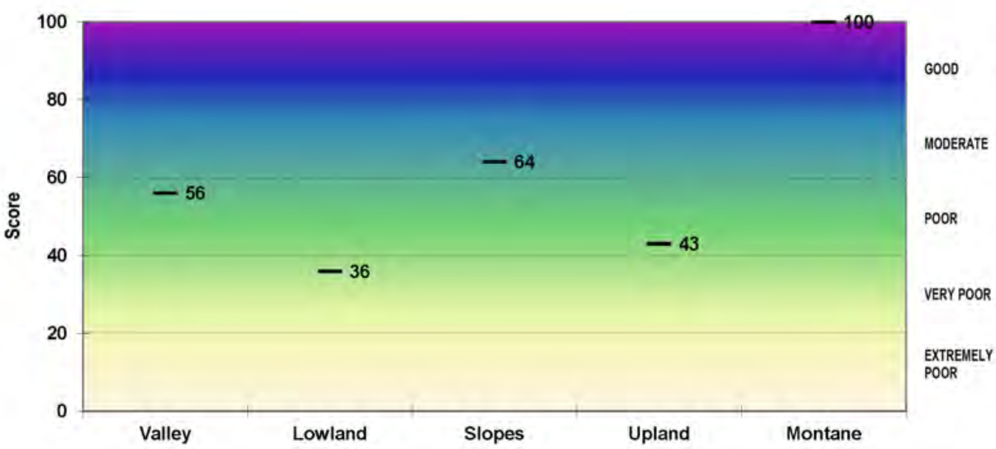




Figure MBG 6: Murrumbidgee Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Murrumbidgee Valley river system was in Poor condition, with an aggregate Hydrology Index (SR–HI) score of 56. The Montane zone was in Good condition. The Slopes zone was in Moderate condition. The Upland zone was in Poor condition. The Lowland zone was in Very Poor condition. The mainstem river system of the Murrumbidgee Valley was rated in Very Poor condition. Throughout all of the mainstem river system the duration and frequency of high flow spells were reduced, the amplitude of seasonal flow variations was reduced, and the timing of seasonal flow variations was altered relative to Reference Condition. Throughout most of the mainstem river system the magnitude, frequency and duration of low flows spells were altered. There was also a widespread increase in the duration of inter-flood periods and a reduction in flood durations. The headwater streams of the Murrumbidgee Valley were rated in Good condition.*

The Murrumbidgee Valley in southern New South Wales has one major tributary, the Tumut River, in the south-west, and several lesser tributaries including the Queanbeyan, Yass and Cotter rivers in the upper reaches and Tarcutta and Mirrool creeks downstream of the Tumut junction. At this point the river enters a broad floodplain and flows westward. In big floods, water from the Lachlan River can enter the lower Murrumbidgee via the Great Cumbung Swamp. The Murrumbidgee is intensively regulated and supports major irrigation areas, with perennial horticulture in the mid-reaches and rice and other annual crops to the west. Major dams are Burrinjuck on the Murrumbidgee (1,025 GL) and Blowering on the Tumut (1,631 GL). Four smaller dams (Googong, Corin, Bendoura, Cotter) supply Canberra and the Australian Capital Territory, and there is another on the upper Tumut River. Inter-valley transfers occur as part of the Snowy Mountains Scheme. Diversions to Blowering Dam cause flows in the Tumut to be about double the modelled natural annual flows. Water is transferred from the Murrumbidgee via Yanco Creek to Billabong Creek and the Murray via the Edward River.

In the Murrumbidgee Valley, hydrological condition is assessed using metrics of hydrological alteration available for 9,025 km of mainstem rivers and headwater streams. There are 1,262 km of mainstem river extending across the Lowland, Slopes, Upland and Montane zones. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily water resource modelling. In the Murrumbidgee Valley there is 7,763 km of headwater stream (2,020 km in the Montane zone; 1,413 km in the Upland zone; 3,100 km in the Slopes zone; 1,230 km in the Lowland zone). 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 Murrumbidgee Valley there is 6,050 km of these mid-size tributaries (623 km in the Montane zone; 533 km in the Upland zone; 1,093 km in the Slopes zone; 3,802 km in the Lowland zone) which is 0.7 times the stream length for which metrics are available.

# MURRUMBIDGEE VALLEY

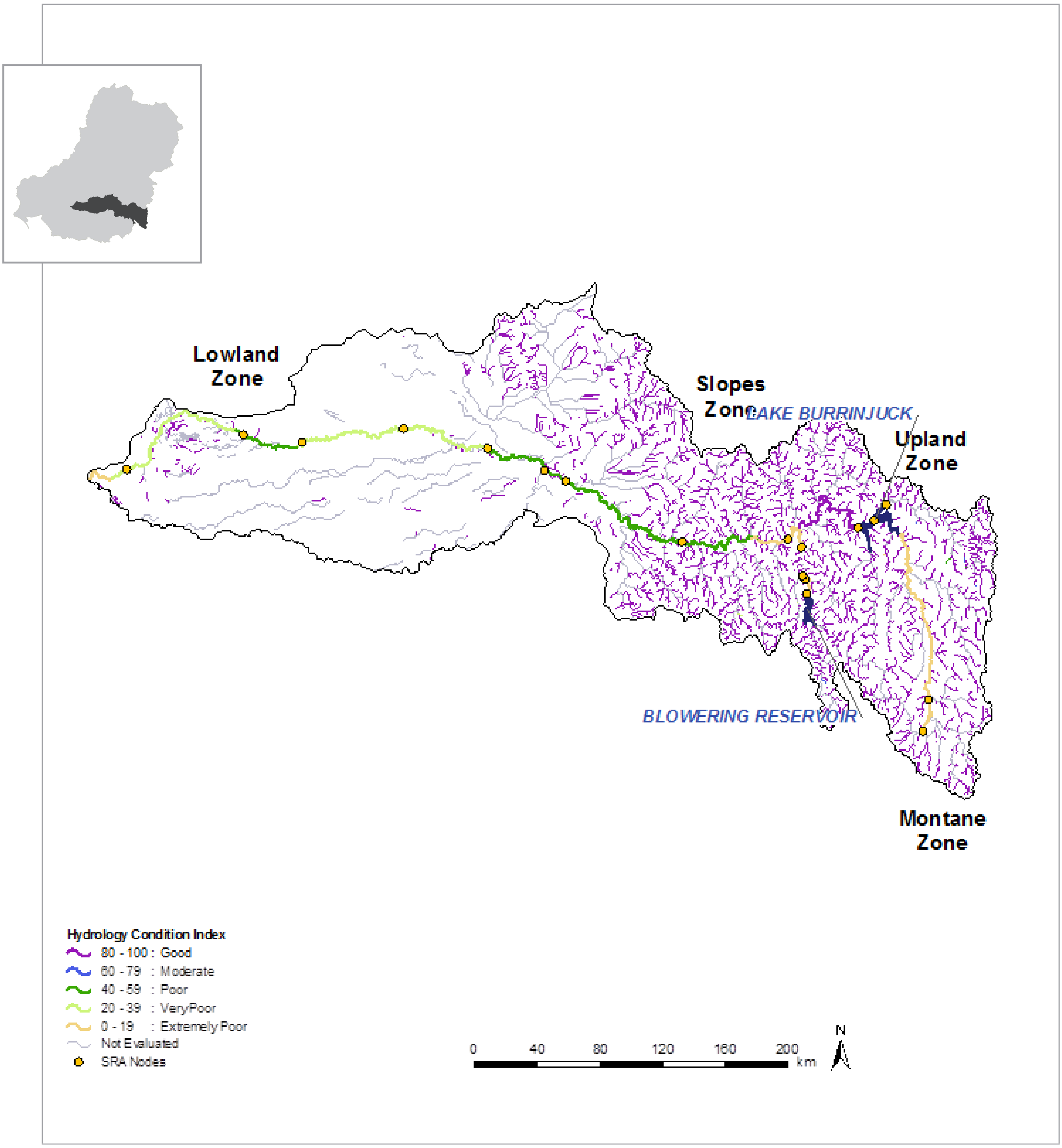



Figure MBG 7: Murrumbidgee Valley map with reaches coloured by SRA Hydrology Index (SR-HI) scores.

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 MBG 6 and MBG 7 show values of the Hydrology Condition Index (SR–HI) for the Murrumbidgee Valley and its river network, and Table MBG 11 and MBG 12 show the index, sub-index, indicator and metric values. Analyses showed a large difference from Reference Condition for the Murrumbidgee Valley, with:

- The Hydrology Condition Index for the whole valley = 56, indicating Poor hydrological condition.
- The Hydrology Condition Index for the Montane, Upland, Slopes and Lowland zones = 100, 43, 64 and 36 indicating Good, Poor, Moderate 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) = 37, indicating Very Poor hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 21, 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 = 82, 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 a combination of the Flow Duration metric and the Mean Annual Flow metric. The Flow Duration metric quantifies change in the distribution of flows relative to Reference Condition. The Mean Annual Flow metric quantifies change in annual flows relative to reference.

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 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 Slopes zone. Results for the Mean Annual Flow metric showed a very significant alteration from Reference Condition in 61% 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 a small proportion in the Montane zone, a small proportion in the Upland zone, some in the Slopes zone and some in the Lowland zone.

# MURRUMBIDGEE VALLEY

In the headwater streams, the Flow Gross Volume sub-indicator showed near Reference Condition. Results for the Flow Duration metric showed only small variations from reference throughout the headwater river length (mostly associated with increased flows). Results for the Mean Annual Flow 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 large difference from Reference Condition. Results for the High Flow metric showed a very significant alteration from Reference Condition in 58% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 15% 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 Montane zone, 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 66% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 33% 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 Montane zone, 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 significant alteration from reference in 8% 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 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 36% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 50% 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 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 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 Slopes zone. Results for the Low Flow Spells metric showed a very significant alteration from Reference Condition in 53% of the mainstem river length (mostly associated with increased 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 a small proportion in the Montane zone, 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 significant alteration from reference in 22% 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, 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. 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 large difference from Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 55% 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 a small proportion 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 Seasonal Period metric showed a very significant alteration from Reference Condition in 16% of the mainstem river length and a significant alteration from reference in 81% 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 in 17% 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 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.

# MURRUMBIDGEE VALLEY

***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 26% of the mainstem river length (mostly associated with increased variability) and a significant alteration from reference in 48% 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 Montane zone, a small proportion in the Upland zone, 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 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.

***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 70% 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 a small proportion 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 Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 11% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 58% 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 Montane zone, 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 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 8% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 75% 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 Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 8% 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.

***Summary: mainstem rivers***

The mainstem river system of the Murrumbidgee Valley was generally characterised by considerable alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume and minor alteration in High Over Bank Floods and Low Over Bank Floods relative to Reference Condition. Throughout all of the mainstem river system the duration and frequency of high flow spells were reduced, the amplitude of seasonal flow variations was reduced, and the timing of seasonal flow variations was altered relative to Reference Conditions. Throughout most of the mainstem river system the magnitude, frequency and duration of low flows spells were altered. There was also a widespread increase in the duration of inter-flood periods and a reduction in flood durations.

***Summary: headwater streams***

The headwater streams of the Murrumbidgee 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.

**Table MBG 11: Murrumbidgee 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 | 56 | 100 | 43 | 64 | 36 |

# MURRUMBIDGEE VALLEY

**Table MBG 12: Murrumbidgee 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*)** | **37 (0–100)** | **100 (7–100)** |
| Sub-index | In-Channel Flow Regime | 21 (0–100) | 100 (7–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 37 (3–100) | 100 (29–100) |
| Sub-ind. | Flow Gross Volume | 51 (1–100) | 99 (61–100) |
| Metric | Mean Annual Flow | 0.62 (0.03–1.83) | 1.03 (0.54–1.21) |
| Metric | Flow Duration | 1.01 (0.93–1.16) | 0.99 (0.73–1.90) |
| Sub-ind. | High Flow Events | 54 (1–99) | 99 (32–100) |
| Metric | High Flow | 0.49 (0–1.70) | 1.02 (0.37–1.90) |
| Metric | High Flow Spells | 0.38 (0.03–1.00) | |
| Sub-ind. | Low and Zero Flow Events | 59 (20–98) | 97 (23–99) |
| Metric | Zero Flows Proportion | 1.00 (0–1.06) | 0.99 (0.96–1.00) |
| Metric | Low Flow | 1.25 (0.18–2.00) | 0.92 (0.01–1.90) |
| Metric | Low Flow Spells | 1.33 (0.35–2.00) | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 33 (1–100) | 99 (20–100) |
| Sub-ind. | Flow Seasonality | 40 (11–100) | 96 (62–100) |
| Metric | Flow Seasonal Amplitude | 0.46 (0–1.37) | 1.09 (0.89–1.72) |
| Metric | Flow Seasonal Period | 0.64 (0.07–1.00) | 0.96 (0.77–1.00) |
| Sub-ind. | Flow Variability | 47 (0–100) | 92 (0–100) |
| Metric | Flow Variation | 1.11 (0.47–1.66) | 0.92 (0.40–1.00) |
| Sub-index | Over Bank Flow Regime | 82 (0–100) | |
| Indicator | Over Bank Floods Low | 71 (6–99) | |
| Metric | OB Flow Duration (ARI 1) | 0.43 (0–1.00) | |
| Metric | OB Flow Spells (ARI 1) | 0.75 (0–1.14) | |
| Indicator | Over Bank Floods High | 77 (58–98) | |
| Metric | OB Flow Duration (ARI 8) | 0.53 (0.32–0.60) | |
| Metric | OB Flow Spells (ARI 8) | 0.69 (0.52–1.00) | |

| | Zone | | | | | |
|---|---|---|---|---|---|---|
| | Mainstem rivers | | | Headwater streams | | |
| | Upland | Slopes | Lowland | Montane | Upland | Slopes |
| | **19** | **49** | **37** | **100** | **100** | **100** |
| | 2 | 40 | 19 | 100 | 100 | 100 |
| | 19 | 48 | 37 | 100 | 100 | 100 |
| | 7 | 49 | 60 | 99 | 99 | 99 |
| | 0.13 | 0.75 | 0.66 | 1.03 | 1.04 | 1.03 |
| | 0.94 | 1.02 | 1.02 | 1.01 | 1.00 | 0.99 |
| | 4 | 55 | 63 | 99 | 99 | 98 |
| | 0 | 0.61 | 0.54 | 1.06 | 1.06 | 1.01 |
| | 0.15 | 0.42 | 0.41 | | | |
| | 77 | 65 | 53 | 97 | 97 | 97 |
| | 1.01 | 0.93 | 1.02 | 0.99 | 0.99 | 0.99 |
| | 0.58 | 1.03 | 1.46 | 0.93 | 0.93 | 0.92 |
| | 0.57 | 1.15 | 1.54 | | | |
| | 15 | 37 | 37 | 99 | 98 | 99 |
| | 31 | 37 | 44 | 97 | 95 | 95 |
| | 0.23 | 0.53 | 0.48 | 1.08 | 1.11 | 1.10 |
| | 0.77 | 0.55 | 0.64 | 0.97 | 0.96 | 0.96 |
| | 30 | 52 | 49 | 96 | 91 | 89 |
| | 1.65 | 1.04 | 1.02 | 0.96 | 0.92 | 0.90 |
| | 92 | 98 | 76 | | | |
| | 77 | 83 | 68 | | | |
| | 0.65 | 0.44 | 0.39 | | | |
| | 0.69 | 0.95 | 0.71 | | | |
| | 95 | 92 | 71 | | | |
| | | | 0.53 | | | |
| | | | 0.69 | | | |

# NAMOI VALLEY

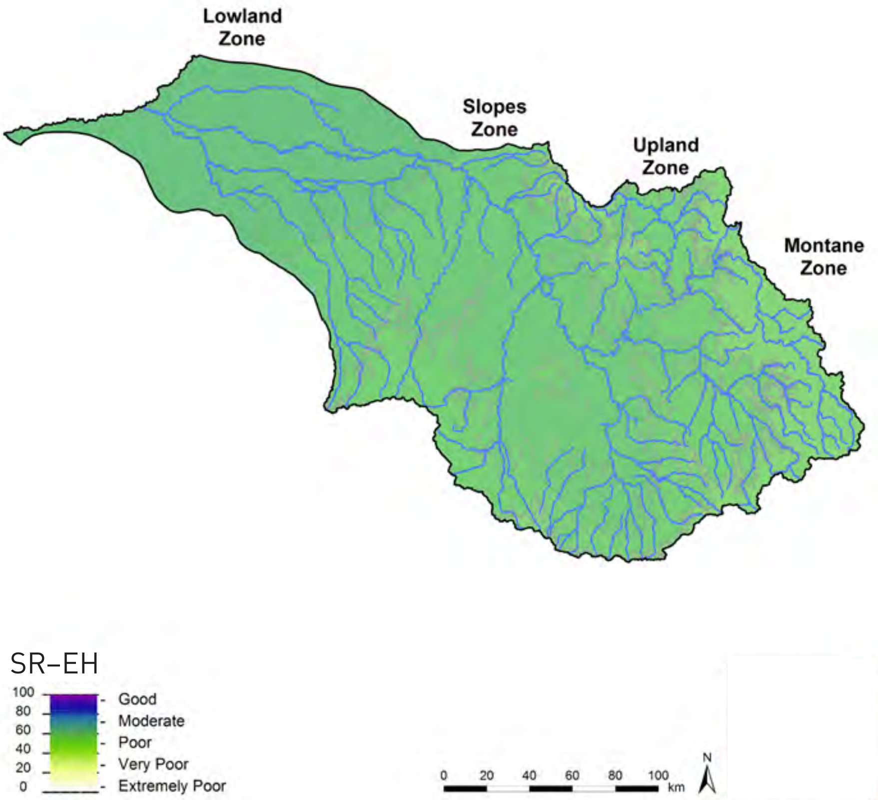



**Figure NAM 1: Namoi Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure NAM 1 shows the Ecosystem Health ratings for the Namoi Valley and Tables NAM 1 and NAM 2 also show the index values and ratings for each Theme. Ecosystem health shows a large difference from Reference Condition for the Namoi 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 Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River EcosystemHealth of the Namoi 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 Namoi 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 Very 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 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, nativeness and structural integrity in the Near Riparian and Lowland Floodplain domains; and little increase in fragmentation in the Lowland Floodplain domain. 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 high levels of floodplain sediment deposition. The river system's Hydrology was in Good condition, with minor changes from Reference Condition for variability and low and zero flows; and little change in magnitudes of annual flow volumes, seasonality and high flows.*



***Ecosystem Health***

The Namoi Valley ranks 13th amongst the 23 SRA Valleys in terms of River Ecosystem Health, midway among the 15 valleys as rated as being in Poor condition (see Table 5.2). It had a similar ranking with regard to the three biotic Themes; 15th for riverine Vegetation, 13th for Macroinvertebrates, and 11th for fish. In terms of condition of Physical Form the Namoi ranked 18th due mainly to changes in channel morphology and floodplain form, and was ninth highest in Hydrological Condition.

Flows in the Namoi are regulated through in-stream storages (capacity = 882 GL) in the upper reaches. There are also large weirs for irrigation diversions and low-level weirs to ensure urban, stock, and domestic supplies. The Namoi is characterized by a number of tributaries, usually episodic, that join the system at points along the full length of the valley. Above average rainfall in 2004 and 2008 would have re-established connectivity throughout these networks.

Fish and macroinvertebrate sampling took place in the first quarter of 2009 immediately following a wet year. No trends were observed in macroinvertebrate or fish data that would constitute a potential response in these communities to the rainfall. Responses at a community level and on the SRA spatial scale could be expected to have a considerable lag time. There are also questions regarding the nature of flow events that should have resulted from the rainfall and their significance to the biota.

***Fish Theme***

The Fish Condition Index SR–FI = 35, indicating Very Poor condition (Lowland zone: Very Poor; Slopes zone: Poor; Upland zone: Very Poor; Montane zone: Extremely Poor). The Expectedness indicator = 51, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 50, indicating Poor condition, and a large difference from Reference Condition. The Recruitment indicator = 38, indicating Very Poor condition, and a very large difference from Reference Condition.

The valley had reduced native fish species richness, the spatial distribution of most native species was more restricted than predicted under Reference Condition and alien species contributed over 67% of fish biomass. Native fish recruitment was Poor to Extremely Poor across all zones.

# NAMOI VALLEY

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 70, indicating Moderate condition (Lowland zone: Poor; Slopes zone: Moderate; Upland zone: Moderate; Montane zone: Good). The simOE metric = 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 site communities in Moderate or Good condition was high (71% overall). Twelve of the 35 rated sites (34%) were in Good condition (seven of which were in the Upland and Montane zones).

Family richness generally was Moderate, and was reduced or low relative to Reference Condition.

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 50, indicating Poor condition (Lowland zone: Good; Slopes zone: Very Poor; Upland zone: Very Poor; Montane zone: Poor). The Vegetation Abundance and Diversity indicator = 63, 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 = 59, indicating Poor condition and a 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 little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled floodplain area is near Reference Condition.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 72, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate; Upland zone: Moderate; Montane zone: Good). The Bank Dynamics indicator = 95, indicating Good condition and near Reference Condition. The Channel Form indicator = 76 and the Bed Dynamics indicator = 62, both indicating Moderate condition and showing a minor difference from Reference Condition. The Floodplain Form indicator = 43, indicating Poor condition and showing a large difference from Reference Condition.

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation of floodplain areas. There was also evidence of widespread channel enlargement and channel simplification.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 94, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good; Montane zone: Good). The In-Channel Flow Regime indicator = 85, indicating Good condition and near Reference Condition for the flow regime within the channels. The Over Bank Flow Regime Sub-index = 97, 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 changes from Reference Condition in Flow Variability and Low and Zero Flow Events and little or no alteration in High Over Bank Floods, Low Over Bank Floods, Flow Seasonality, High Flow Events and Flow Gross Volume. The headwater streams were generally characterised by little or no alteration in these indicators.

**Table NAM 1: Namoi 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 | 35 (25–40) Very Poor | 19 (14–27) Ext' Poor | 30 (14–43) Very Poor | 44 (27–56) Poor | 28 (17–37) Very Poor |
| Macro-invertebrates | SCORE RATING | 70 (66–75) Moderate | 81 (78–85) Good | 79 (71–86) Moderate | 71 (65–78) Moderate | 49 (34–62) Poor |
| Vegetation | SCORE RATING | 50 Poor | 47 Poor | 34 Very poor | 38 Very poor | 100 Good |

**Table NAM 2: Namoi 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 | 72 (66–78) Moderate | 91 (75–95) Good | 67 (60–80) Moderate | 72 (63–76) Moderate | 67 (49–89) Moderate |
| Hydrology | SCORE RATING | 94 Good | 100 Good | 94 Good | 98 Good | 84 Good |

# NAMOI VALLEY

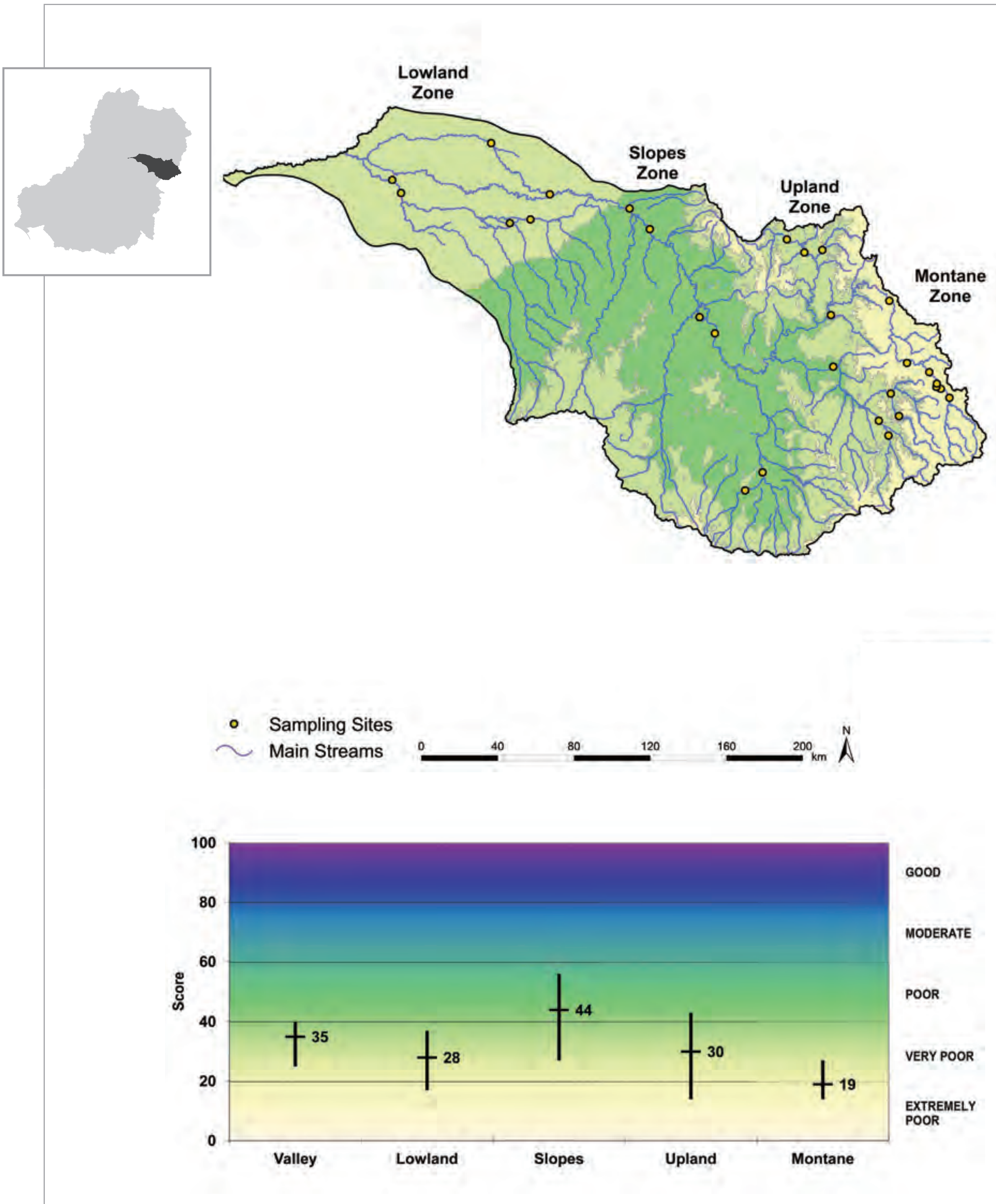



Figure NAM 2: Namoi Valley map with sampling sites and zones coloured by SR Fish Index (SR–FI) scores.

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

*The Fish community of the Namoi Valley river system was in Very Poor condition, with an aggregate Fish Index score (SR–FI) of 35. The condition of the Fish community in the zones was as follows: Montane Extremely Poor; Upland Very Poor; Slopes Poor; and Lowland Very Poor. The fish community was characterised by a 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 few fish and lacked three out of six predicted native species. The valley had reduced native species richness and alien species contributed over 67% of the biomass in samples. Native fish recruitment was Extremely Poor, Poor, Poor, and Very Poor in the Montane, Upland, Slopes, and Lowland zones respectively.*

Twenty-eight sites were surveyed across the Namoi Valley in January – March 2009, yielding 1,708 fish. Analyses showed a very large difference from Reference Condition for the Namoi Valley, with:

- SRA Fish Index (SR–FI) = 35 (CL 25–40), indicating Very Poor condition of the fish community.
- The Expectedness indicator = 51 (CL 43–60), indicating Poor condition, and a large difference from Reference Condition. 73% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 50 (CL 41–59), indicating Poor condition, and a large difference from Reference Condition.
- The Recruitment indicator = 38 (CL 23–43), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for nine of the 11 native species observed in the valley.

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

SR–FI for the Namoi Valley was ranked eleventh out of all 23 Basin valleys, and close to that for the Castlereagh Valley. The Montane zone community was in a worse condition (SR–FI = 19) than that in the Upland, Slopes and Lowland zones (SR–FI = 30, 44, and 28 respectively).

Expectedness was rated as Poor in the Namoi Valley and in the Montane, Upland, and Lowland zones. It was moderate in the Slopes zone, in which eight of the 13 expected species were caught in samples.

Nativeness varied amongst zones, ranging from good in the Montane zone to Very Poor in the Upland zone. Although three of the expected six native species were captured in Montane zone samples, three alien species were caught and these numbered only 12 specimens. Alien fish were much more numerous in the Upland zone numbering 663 individuals and constituting 83% of the total fish biomass in that zone.

# NAMOI VALLEY

Fish biomass was variable amongst zones, as was the relative contribution of native and alien species. Total fish biomass ranged from over 20 kg/site in the Slopes zone to 1.8 kg/site in the Montane zone. In the Montane, Upland, Slopes, and Lowland zones alien fish contributed 15%, 83%, 67%, and 61% of their respective fish biomass.

Table NAM 4 shows native species abundances in the Namoi Valley compared with Reference Condition. In the Montane zone, five Murray cod of mixed sizes were captured in total, though the species is not predicted to occur in this zone under Reference Condition. Murray cod were also caught in the other three zones. Freshwater catfish and golden perch were caught in small numbers but silver perch, expected in three zones, was not caught. Southern purple-spotted gudgeon, a threatened species, was not caught, though expected throughout the valley. Bony herring and gudgeon at lower altitudes, and river blackfish in the Montane zone, were the most numerous native fish. Four alien species were caught in the Namoi Valley, gambusia and goldfish were recorded from all four zones.  Common carp and gambusia were the most numerous.

Recruitment scores ranged from Extremely Poor in the Montane zone to Poor in the Upland and Slopes zones.  In the Montane zone, one of the two expected native species (river blackfish) was recorded as recruiting but only three of the 117 individuals caught were recruits (all found at one site). Nine of the 11 native species observed were recorded as recruiting in the Namoi Valley, including freshwater catfish and Murray cod.  No golden perch recruits were caught in the three zones in which the species occurred.   All four alien species had recruited in at least one zone.

In general, the fish community of the Namoi had some reduction in numbers of expected native species and the spatial distribution of most native species was more restricted than predicted under Reference Condition.

**Table NAM 3: Namoi 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) | 35 (25–40) | 19 (14–27) | 30 (14–43) | 44 (27–56) | 28 (17–37) |
| Indicator | Expectedness | 51 (43–60) | 40 (31–50) | 47 (31–64) | 61 (46–80) | 43 (33–52) |
| Metric | O/E | 0.47 (0.35–0.58) | 0.58 (0.47–0.76) | 0.46 (0.23–0.69) | 0.50 (0.26–0.74) | 0.40 (0.27–0.53) |
| Metric | O/P (Zone level) | 0.54 (0.54–0.54) | 0.33 (0.33–0.33) | 0.50 (0.50–0.50) | 0.62 (0.62–0.62) | 0.50 (0.50–0.50) |
| Indicator | Nativeness | 50 (41–59) | 86 (72–97) | 25 (8–43) | 46 (30–62) | 59 (47–71) |
| Metric | Proportion biomass native | 0.35 (0.25–0.45) | 0.69 (0.47–0.89) | 0.13 (0.01–0.27) | 0.32 (0.16–0.51) | 0.42 (0.24–0.58) |
| Metric | Proportion abundance native | 0.52 (0.40–0.64) | 0.85 (0.71–0.95) | 0.32 (0.10–0.57) | 0.49 (0.26–0.69) | 0.60 (0.40–0.78) |
| Metric | Proportion species native | 0.55 (0.45–0.65) | 0.64 (0.55–0.76) | 0.46 (0.26–0.64) | 0.54 (0.33–0.70) | 0.60 (0.49–0.73) |
| Indicator | Recruitment | 38 (23–43) | 5 (0–15) | 46 (17–67) | 48 (21–56) | 30 (12–43) |
| Metric | Proportion of sites with native recruits | 0.43 (0.30–0.48) | 0.10 (0–0.31) | 0.55 (0.26–0.65) | 0.50 (0.29–0.60) | 0.35 (0.20–0.50) |
| Metric | Proportion of native taxa with recruits | 0.70 (0.50–0.74) | 0.50 (0.00–0.50) | 0.71 (0.43–1.00) | 0.75 (0.50–0.86) | 0.67 (0.40–0.67) |
| Metric | Proportion of abundance as recruits | 0.46 (0.35–0.50) | 0.01 (0.00–0.02) | 0.43 (0.30–0.68) | 0.53 (0.35–0.59) | 0.50 (0.29–0.57) |

Continued/...

# NAMOI VALLEY

| 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 | 6 | 10 | 11 | 9 |
| | Number of native species | 11 | 3* | 7 | 8 | 6 |
| | Number of predicted species | 15 | 6 | 14 | 13 | 12 |
| | Number of alien species | 4 | 3 | 3 | 3 | 3 |
| | Mean number of fish per site | 61 | 21 | 102 | 66 | 54 |
| | Biomass/site all species (g) | 8378 | 1754 | 6430 | 20390 | 4939 |
| | Mean native biomass/fish (g) | 103 | 75 | 145 | 156 | 49 |
| | Mean alien biomass/fish (g) | 166 | 157 | 56 | 587 | 201 |

*Includes one native species (Murray cod) not expected to occur in this zone under Reference Condition.

**Table NAM 4: Namoi 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 | 15 | | 15 | 0 | 0 |
| Bony herring | 284 | | 9 | 147 | 128 |
| Darling River hardyhead | 0 | 0 | 0 | 0 | |
| Freshwater catfish | 6 | 0 | 4 | 2 | 0 |
| Golden perch | 10 | | 1 | 5 | 4 |
| Gudgeon | 222 | 0 | 16 | 84 | 122 |
| Mountain galaxias | 17 | 16 | 1 | | |
| Murray cod | 45 | [5] | 6 | 26 | 8 |
| Murray–Darling rainbowfish | 34 | | 0 | 33 | 1 |
| Olive perchlet | 0 | | | 0 | 0 |
| River blackfish | 117 | 117 | 0 | | |
| Silver perch | 0 | | 0 | 0 | 0 |
| Southern purple-spotted gudgeon | 0 | 0 | 0 | 0 | 0 |
| Spangled perch | 13 | | 0 | 3 | 10 |
| Unspecked hardyhead | 1 | | 0 | 1 | 0 |
| Alien species | | | | | |
| Common carp | 255 | | 113 | 85 | 57 |
| Gambusia | 616 | 5 | 503 | 60 | 48 |
| Goldfish | 68 | 2 | 47 | 18 | 1 |
| Rainbow trout | 5 | 5 | | | |

# NAMOI VALLEY

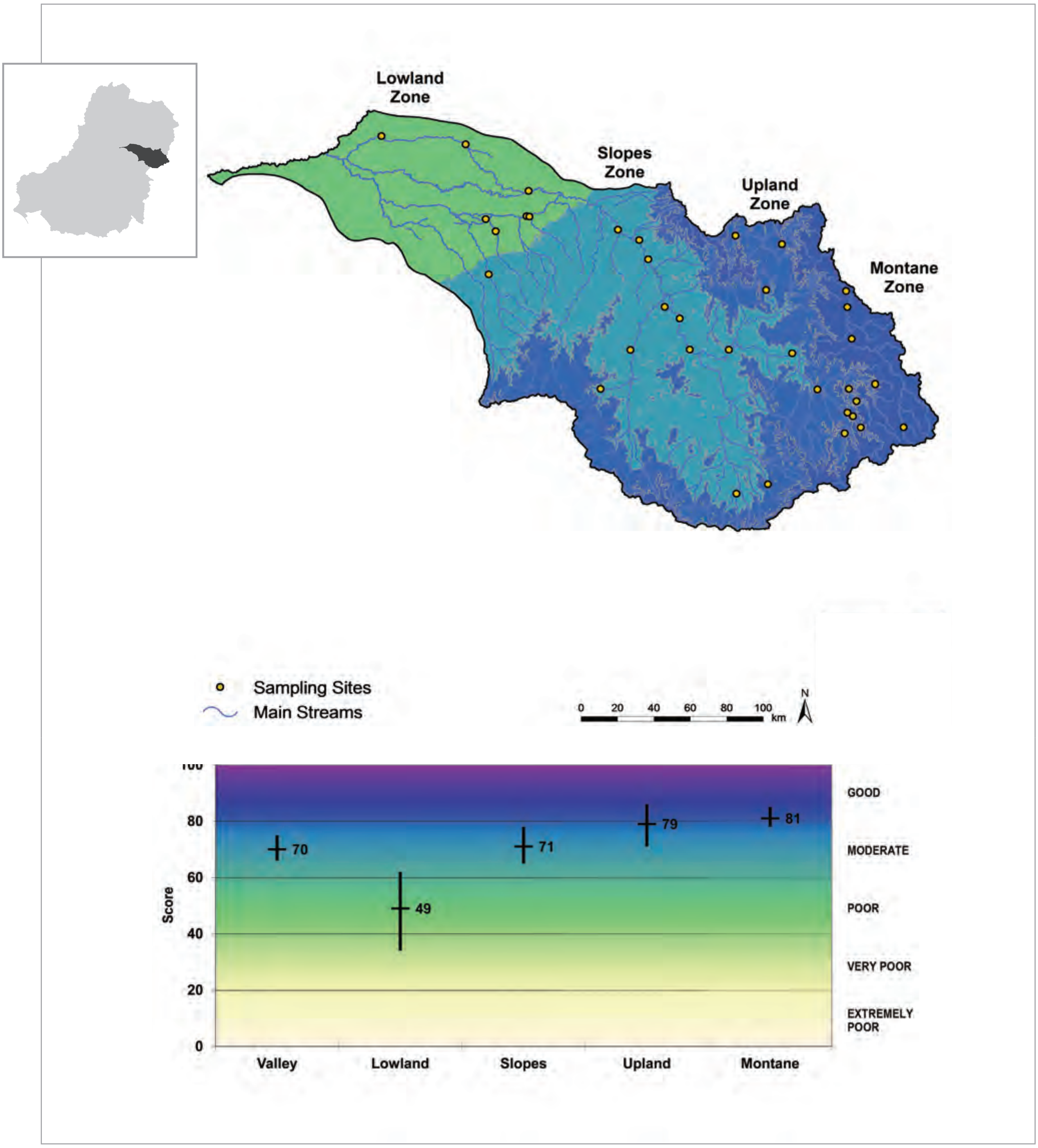



Figure NAM 3: Namoi Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Namoi Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 70. The condition of the Macroinvertebrate community in the zones was as follows: Montane Good; Upland Moderate; Slopes Moderate; Lowland Poor. The proportion of sites in Moderate or Good condition was high (71%); 12 of the 35 rated sites (34%) were in Good condition. Family richness generally was Moderate, and was reduced or low relative to Reference Condition.*

Thirty-five sites were surveyed across the Namoi Valley in March–May 2009 yielding 5,201 macroinvertebrates in 67 families (71% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 70 (CL 66–75), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 48 (CL 46–50) indicating a moderate to 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 site communities in moderate or Good condition was high (71% overall). Twelve of the 35 rated sites (34%) were in Good condition (seven of which were in the Upland and Montane zones).
- The number of families found was lowest in the Lowland zone (34 families) and highest in the Upland zone (55 families), though both the Montane and Upland zones had the highest average number of families per site (29, 30 respectively).

Figure NAM 3 shows sampling sites, zones and SR–MI values, and Table NAM 5 shows index and metric values. The SR–MI score for the Namoi Valley indicated Moderate condition of macroinvertebrate communities, rating 13th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the Montane and Upland zones showed minor to moderate differences from Reference Condition (SR–MI = 81 and 79, respectively), while a moderate and very large differences from Reference Condition were observed for the Slopes and Lowland zones (SR–MI = 71 and 49, respectively). A narrow confidence interval (7 points) for the Montane zone SR–MI value indicates less variability there, with most sites showed a minimal difference from Reference Condition. Expectedness (simOE) was Moderate to high for the upper two zones and low to moderate for the Slopes and Lowland zones, and varied by up to 33 points among sites.

# NAMOI VALLEY

Table NAM 6 shows that most sites in the Lowland to Upland zones had low to moderate SR–MI values, though 12 sites (34%) were in Good condition (five and two of which were in the Upland and Montane zones respectively). The Lowland zone had three sites 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.

Family richness generally was reduced or low relative to Reference Condition. Diversity was moderate (average 23 families per site), with the Montane and Upland zones being most diverse at site scale (average of 29 and 30 families per site respectively). The valley contained 71% of the families found across the Basin (Table NAM 6), with the Lowland zone having the lowest representation of Basin-wide fauna (36%). Most (67 – 82%) of the fauna of the valley was found in each of the Slopes, Upland and Montane zones.

**Table NAM 5: Namoi 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.

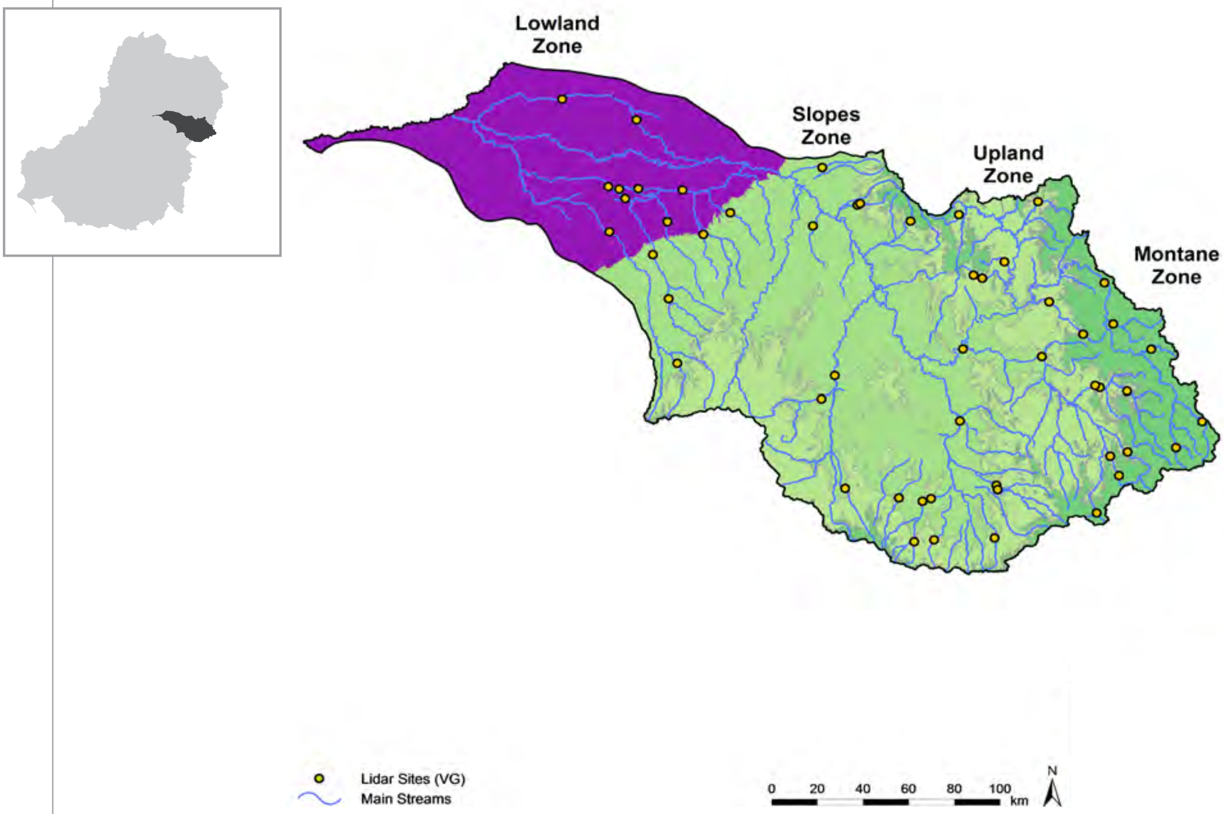
| Indexes Metrics | Description | Valley | Zone | | | |
|---|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes | Lowland |
| Index | Macroinvertebrate Condition (SR–MI) | 70 (66–75) | 81 (78–85) | 79 (71–86) | 71 (65–78) | 49 (34–62) |
| Metric | SimOE | 48 (46–50) | 52 (51–55) | 52 (48–56) | 48 (45–51) | 39 (34–44) |

Table NAM 6: Namoi 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 | 9 | 15 | 7 |
| Number of sites with index values* | 35 | 4 | 9 | 15 | 7 |
| N sites by SR–MI condition band | | | | | |
| Good (80–100) | 12 | 2 | 5 | 5 | |
| Moderate (60–80) | 13 | 2 | 3 | 6 | 2 |
| Poor (40–60) | 7 | | 1 | 4 | 2 |
| Very or Extremely Poor (0–40) | 3 | | | | 3 |
| Families | | | | | |
| Number of families sampled | 67 | 45 | 55 | 45 | 34 |
| No. families/site (min-max) | 23 (9–37) | 29 (21–35) | 30 (23–37) | 21 (12–28) | 16 (9–30) |
| Percent of families in Basin | 71 | 48 | 59 | 48 | 36 |
| Percent of families in valley | 100 | 67 | 82 | 67 | 51 |

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

# NAMOI VALLEY



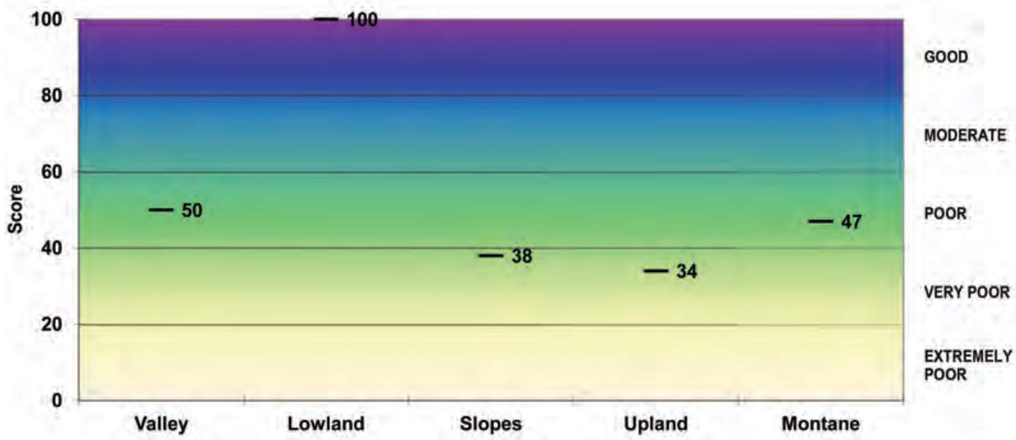




Figure NAM 4: Namoi Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Namoi Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 50. Overall condition for the four zones in this valley was: Montane Poor; Upland Very Poor; Slopes Very Poor; Lowland Good.*

*The Abundance and Diversity indicator score was 63 for the valley, indicating a Moderate rating overall. In the four zones it was: Montane Poor; Upland Poor; Slopes Poor; Lowland Good.*

*The Quality and Integrity indicator score was 59 for the valley, indicating a Poor rating overall. In the four zones it was: Montane Poor; Upland Poor; Slopes Poor; Lowland Good.*

The SRA Vegetation assessment for the Namoi Valley considers riverine vegetation in two spatial domains: Near Riparian, along 11,165 km of stream, and Lowland Floodplain, for 352 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. Much (41%) of the stream length is in the Slopes zone, and the length of stream assessed per zone is as follows: Montane 1,329 km; Upland 3,083 km; Slopes 4,599 km; and Lowland 2,154 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, distributed amongst the four zones as follows: Montane seven sites; Upland 14 sites; Slopes 21 sites; and Lowland 10 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure NAM 4 shows values of the Vegetation Index (SR–VI) for the Namoi Valley and Table NAM 7 shows the index, indicator and sub-indicator values. Tables NAM 8 and NAM 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 Namoi Valley with:

- SRA Vegetation Index (SR–VI) = 50, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 63, 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 = 59, 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 little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with a large difference from reference in the Montane, Upland and Slopes zones and is 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 shows a large difference from reference in the Near Riparian domain and is near reference in the Lowland Floodplain domain. MVG richness is maintained near reference in both Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 88% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Poor condition overall, and shows a large difference from reference in the Montane, Upland and Slopes zones, 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 NAM 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 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 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 Good 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 in the Lowland Floodplain domain it is near reference.

***Stability***

- Floodplain areas of 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, with 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 in the Lowland Floodplain domain it is near 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 some zones. Structure is near reference in the Montane and Upland zones, and moderately different from reference in the Slopes and Lowland zones. 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. The sub-indicator is influenced by the most extensive MVGs, most of which are near reference: only two, Eucalypt Open Woodland and Callitris Forests and Woodlands, show dissection and removal relative to reference.

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

- Montane zone: The Near Riparian domain was mostly (55% of the domain area) Eucalypt Open Forests and Eucalypt Woodlands (37%), with eight other MVGs present, all small in area.
- Upland zone: The Near Riparian domain was mostly Eucalypt Woodlands (75%), with nine other MVGs of which only Eucalypt Open Forests was more than 5%.
- Slopes zone: The Near Riparian domain was mainly (59%) Eucalypt Woodlands with nine other MVGs, of which four covered more than 5% of the domain.
- Lowland zone: The Near Riparian domain was a mix of Eucalypt Open Forests (28% of the domain), Eucalypt Open Woodlands (27%) and Eucalypt Woodlands (19%) with six other MVGs present of which two covered more than 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was a mix of Acacia Forests and Woodlands (31%), Eucalypt Open Woodlands (25%) and seven other MVGs of which two covered more than 5% of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation has been reduced in most of the zones. The effect of this is concentrated on Eucalypt Woodlands and Eucalypt Open Forests which were generally the most extensive MVGs in the Near Riparian domain, with most of the other MVGs having areas that are close to their reference.

- Montane zone: In the Near Riparian domain, Eucalypt Open Forests and Eucalypt Woodlands are still the most extensive MVGs (26% and 12% respectively of the domain area) although reduced in area. About 54% of the domain is either cleared or non-native vegetation. Eucalypt Open Forests and Eucalypt Woodlands are the most reduced MVGs, down to 47% and 34% of their reference areas: all other MVGs have areas close to their reference.

# NAMOI VALLEY

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands is still the most extensive MVGs (now 22% of the domain) although reduced in area. About 58% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands are the most affected MVG, reduced to 29% of its reference area then Eucalypt Open Forests, reduced to 62% of its reference area: eight of the other MVGs have areas close to their reference.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG though much reduced (now 19% of the domain area). About 54% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands are reduced to 31% of their reference area: in contrast, nine of the other MVGs, generally the smallest ones present, have areas the same as reference.

- Lowland zone: The Near Riparian domain is still a mix of Eucalypt Open Forests (28% of the domain), Eucalypt Open Woodlands (19%) and Eucalypt Woodlands (19%), with little change in individual MVG area. About 12% of the area is either cleared or non-native vegetation. Most MVGs are fairly well retained and near reference in area, except Eucalypt Open Woodlands which is now 68% of its reference area.

- Lowland zone: Lowland Floodplain domain is still a mix of Acacia Forests and Woodlands (31%) and Eucalypt Open Woodlands (15%) although reduced in area. About 13% of the domain is either cleared or non-native vegetation. Seven of the MVGs have same area as reference, but Eucalypt Open Woodlands are now reduced to 59% of their reference area.

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 2008–2009. 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 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 vary in quality. About 1–2% of the Near Riparian domain in the Montane and Upland zones is not assigned. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of any of the four zones and of valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Namoi Valley is notable for the marked contrast in condition between the Lowland zone and zones further up the valley, for the low abundance of MVGs and low nativeness in the Near Riparian domain in the Montane, Upland and Slopes zones, and for the contrast between this and the Lowland Floodplain domain which has moderate scores for abundance, stability, nativeness, fragmentation and structure, and is in better condition.

The condition of riverine vegetation ranges from Very Poor in the Upland and Slopes zones to near reference in the Lowland zone. The Slopes zone has low scores for abundance and nativeness, and a moderate but variable score for structure indicative of some clearing. With more stream length than other zones, the Slopes zone has more influence on the valley score.

The Lowland zone has near reference scores for MVG abundance, nativeness, richness, a moderate score for structure, shows little evidence of MVG turnover, and has a degree of fragmentation that is little different from reference. The Near Riparian and Lowland Floodplain domains are in similar condition, with high scores for abundance and nativeness. These two domains assess differing but overlapping parts of the Lowland zone: the Lowland Floodplain domain is land that floods beside the main river channel, whereas the Near Riparian domain is a continuous strip centred on all channels, major and minor, and larger in area.

***Stability***

- Floodplain areas of 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, with 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 in the Lowland Floodplain domain it 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 some zones. Structure is near reference in the Montane and Upland zones, and moderately different from reference in the Slopes and Lowland zones. 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. The sub-indicator is influenced by the most extensive MVGs, most of which are near reference: only two, Eucalypt Open Woodland and Callitris Forests and Woodlands, show dissection and removal relative to reference.

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

- Montane zone: The Near Riparian domain was mostly (56% of the domain area) Eucalypt Open Forests and Eucalypt Woodlands (37%), with eight other MVGs present, all small in area.

- Upland zone: The Near Riparian domain was mostly Eucalypt Woodlands (75%), with nine other MVGs of which only Eucalypt Open Forests was more than 5%.

- Slopes zone: The Near Riparian domain was mainly (59%) Eucalypt Woodlands with nine other MVGs, of which four covered more than 5% of the domain.

- ˙Lowland zone: The Near Riparian domain was a mix of Eucalypt Open Forests (28% of the domain), Eucalypt Open Woodlands (28%) and Eucalypt Woodlands (19%) with six other MVGs present of which two covered more than 5% of the domain.

- Lowland zone: The Lowland Floodplain domain was a mix of Acacia Forests and Woodlands (31%), Eucalypt Open Woodlands (25%) and seven other MVGs of which two covered more than 5% of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation has been reduced in most of the zones. The effect of this is concentrated on Eucalypt Woodlands and Eucalypt Open Forests which were generally the most extensive MVGs in the Near Riparian domain, with most of the other MVGs having areas that are close to their reference.

- Montane zone: In the Near Riparian domain, Eucalypt Open Forests and Eucalypt Woodlands are still the most extensive MVGs (26% and 12% respectively of the domain area) although reduced in area. About 54% of the domain is either cleared or non-native vegetation. Eucalypt Open Forests and Eucalypt Woodlands are the most reduced MVGs, down to 47% and 34% of their reference areas: all other MVGs have areas close to their reference.

- Upland zone: In the Near Riparian domain, Eucalypt Woodlands is still the most extensive MVGs (now 22% of the domain) although reduced in area. About 58% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands are the most affected MVG, reduced to 29% of its reference area then Eucalypt Open Forests, reduced to 62% of its reference area: eight of the other MVGs have areas close to their reference.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG though much reduced (now 19% of the domain area). About 54% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands are reduced to 31% of their reference area: in contrast, nine of the other MVGs, generally the smallest ones present, have areas the same as reference.

- Lowland zone: The Near Riparian domain is still a mix of Eucalypt Open Forests (28% of the domain), Eucalypt Open Woodlands (19%) and Eucalypt Woodlands (19%), with little change in individual MVG area. About 12% of the area is either cleared or non-native vegetation. Most MVGs are fairly well retained and near reference in area, except Eucalypt Open Woodlands which are now 68% of their reference area.

- Lowland zone: Lowland Floodplain domain is still a mix of Acacia Forests and Woodlands (31%) and Eucalypt Open Woodlands (15%) although reduced in area. About 13% of the domain is either cleared or non-native vegetation. Seven of the MVGs have same area as reference, but Eucalypt Open Woodlands are now reduced to 59% of their reference area.

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 2008–2009. 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 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 vary in quality. About 1–2% of the Near Riparian domain in the Montane and Upland zones is not assigned. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of any of the four zones and of valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Namoi Valley is notable for the marked contrast in condition between the Lowland zone and zones further up the valley, for the low abundance of MVGs and low nativeness in the Near Riparian domain in the Montane, Upland and Slopes zones, and for the contrast between this and the Lowland Floodplain domain which has moderate scores for abundance, stability, nativeness, fragmentation and structure, and is in better condition.

The condition of riverine vegetation ranges from Very Poor in the Upland and Slopes zones to near reference in the Lowland zone. The Slopes zone has low scores for abundance and nativeness, and a moderate but variable score for structure indicative of some clearing. With more stream length than other zones, the Slopes zone has more influence on the valley score.

The Lowland zone has near Reference Condition scores for MVG abundance, nativeness, richness, a moderate score for structure, shows little evidence of MVG turnover, and has a degree of fragmentation that is little different from reference. The Near Riparian and Lowland Floodplain domains are in similar condition, with high scores for abundance and nativeness. These two domains assess differing but overlapping parts of the Lowland zone: the Lowland Floodplain domain is land that floods beside the main river channel, whereas the Near Riparian domain is a continuous strip centred on all channels, major and minor, and larger in area.

# NAMOI VALLEY

**Table NAM 7: Namoi 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) | 50 | 47 | 34 | 38 | 100 |
| Indicator | Abundance and diversity | 63 | 57 | 50 | 57 | 100 |
| Metric | LF stability | 0.88 | | | | 0.88 |
| Sub-ind. | NRLF richness | 100 | | | | 100 |
| Metric | NR richness | 1 | 1 | 1 | 1 | 1 |
| Metric | LF richness | 1 | | | | 1 |
| Sub-ind. | NRLF abundance | 99 | | | | 99 |
| Metric | NR abundance | 0.52 | 0.45 | 0.40 | 0.45 | 0.88 |
| Metric | LF abundance | 0.88 | | | | 0.88 |
| Indicator | Quality and integrity | 59 | 57 | 49 | 47 | 98 |
| Sub-ind. | NRLF nativeness | 99 | | | | 99 |
| Metric | NR nativeness | 0.52 | 0.45 | 0.40 | 0.45 | 0.88 |
| Metric | LF nativeness | 0.88 | | | | 0.88 |
| Sub-ind. | NR structure | 75 (66–83) | 94 (91–96) | 86 (77–93) | 61 (42–78) | 78 (57–91) |
| Sub-ind. | LF fragmentation | 86 | | | | 86 |

**Table NAM 8: The most abundant MVGs in the Near Riparian domain in the Namoi 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 | | | | 8 |
| 3. Eucalypt Open Forests | 55 | 13 | 5 | 28 |
| 5. Eucalypt Woodlands | 37 | 75 | 59 | 19 |
| 6. Acacia Forests and Woodlands | | | | 10 |
| 7. Callitris Forests and Woodlands | | | 6 | |
| 11. Eucalypt Open Woodlands | | | 12 | 27 |
| 19. Tussock Grasslands | | | 12 | |

**Table NAM 9: Most abundant MVGs in the Lowland Floodplain domain of the Namoi Valley.**

Showing percentage of domain area under Reference Condition in the Namoi 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 | 18 | 1 | 1 |
| 5. Eucalypt Woodlands | 17 | 1 | 1 |
| 6. Acacia Forests and Woodlands | 31 | 1 | 1 |
| 11. Eucalypt Open Woodlands | 25 | 1.29 | 0.46 |

# NAMOI VALLEY

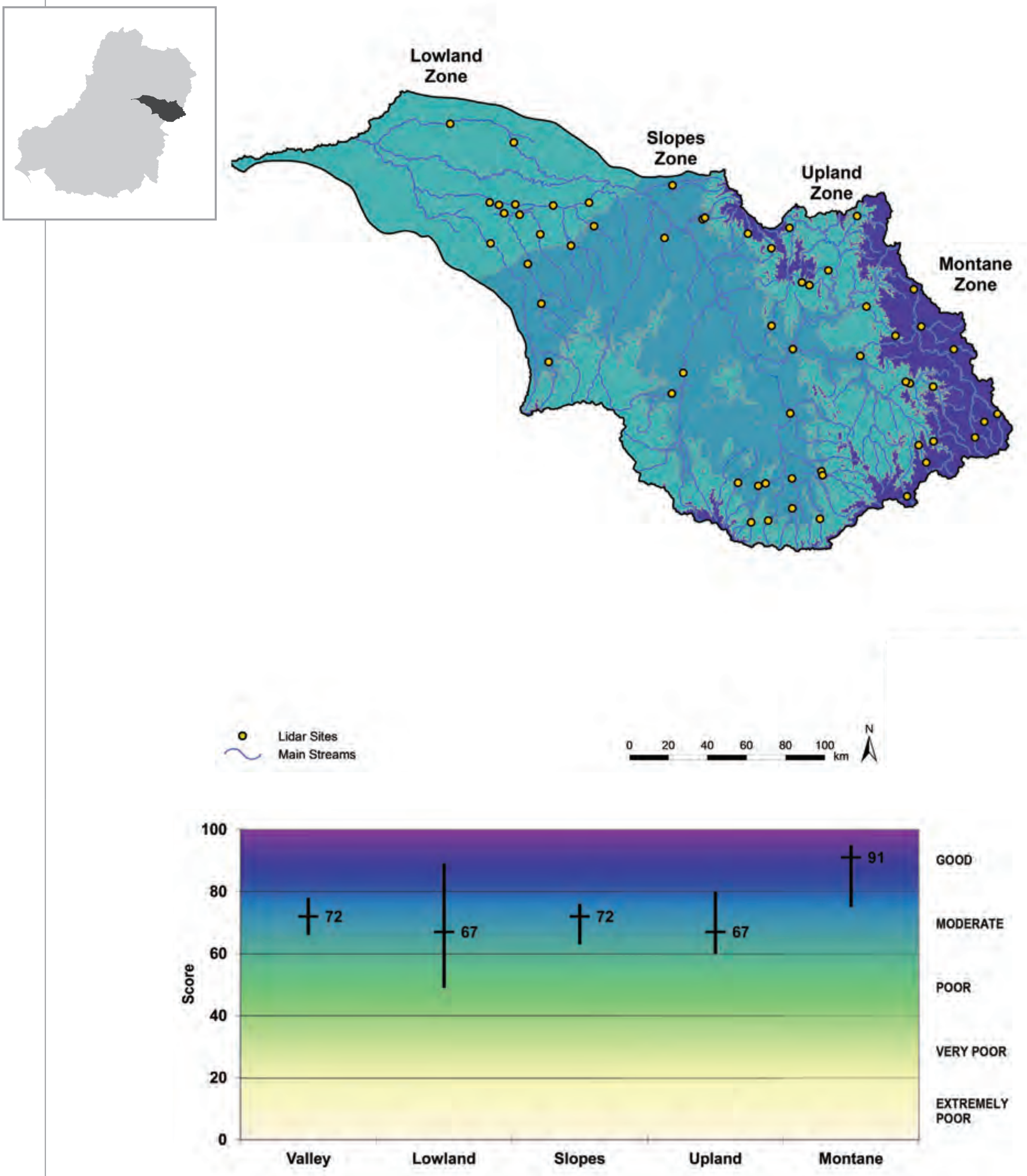



Figure NAM 5: Namoi Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

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

*The Physical Form of the Namoi Valley river system was in Moderate condition, with an aggregate Physical Form Index score (SR–PI) of 72. 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. Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation of floodplain areas. There was also evidence of widespread channel enlargement and channel simplification.*

The SRA Physical Form assessment considers physical form and processes along 11,165 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 373 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 NAM 5 shows values of the Physical Form Index (SR–PI) for the Namoi Valley and Table NAM 10 shows the index, indicator, sub-indicator and metric values.

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

- SRA Physical Form Condition Index (SR–PI) = 72 (CL 66–78), indicating Moderate Physical Form condition
- the Channel Form indicator = 76 (CL 69–82), showing a moderate difference from Reference Condition
- the Bed Dynamics indicator = 62 (CL 60–65), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 95 (CL 93–98), showing near Reference Condition
- the Floodplain indicator = 43 (CL 37–49), showing a large difference from Reference Condition.

These SRA assessment results show some inconsistency with assessments using the River Styles Geomorphic Condition Sub-index of the NSW River Condition Index (Lampert and Short 2004). The results for the Montane and Lowland zones are in general agreement, but River Styles assessment shows areas within the Slopes and Upland zones (i.e. Mooki River, Peel River and Coxs Creek) that are in Poor condition, while this SRA assessment indicates Moderate condition. These differences in results could be explained by fundamental differences in the method. For example, River Styles takes riparian vegetation condition and bed particle size into account, while the SRA assessment does not.

# NAMOI VALLEY

### *Montane zone*

There were 8 LiDAR survey sites and 16 SedNet river segments in the Montane zone of the Namoi 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 large increase in Floodplain Sediment Deposition across 10% of the zone for the post-European period. Channel Width, Meander Wavelength and Bank Variability were modified from reference in more than half of the Montane zone. At these sites Channel Width and Meander Wavelength were generally increased (a few sites having large increases) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Depth and Sinuosity were modified from reference for less than half of the Montane zone. At these sites Channel Depth was generally increased and results show both increases and decreases in Sinuosity across the zone. Channel Width Variability and Channel Sediment Deposition were largely unmodified from reference in the Montane zone.

### *Upland zone*

There were 15 LiDAR survey sites and 91 SedNet river segments in the Upland zone of the Namoi Valley. Based on these samples, Channel Width, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Upland zone. At these sites Channel Width and Channel Sediment Ratio were 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, Meander Wavelength and Bank Variability were modified from reference for approximately half of the Upland zone. At these sites Channel Depth and Meander Wavelength were generally increased (a few sites having large increases in Channel Depth and many sites having large increases in Meander Wavelength) and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability was modified from reference for less than half of the Upland zone. At these sites Channel Width Variability was generally reduced. Sinuosity and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

### *Slopes zone*

There were 23 LiDAR survey sites and 182 SedNet river segments in the Slopes zone of the Namoi 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 50% 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 Channel Width and Meander Wavelength were generally increased (a few sites having large increases Channel Width and 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 results show both increases and decreases in Channel Depth across the zone, Channel Width Variability was generally reduced, 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 30% of the zone for the post-European period.

***Lowland zone***

There were 12 LiDAR survey sites and 84 SedNet river segments in the Lowland zone of the Namoi Valley. Based on these samples, Meander Wavelength, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from Reference Condition throughout most of the Lowland zone. At these sites Meander Wavelength and Channel Sediment Ratio were 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 and Bank Variability were generally increased. Sinuosity was modified from reference for approximately half of the Lowland zone. At these sites Sinuosity was generally increased (a few sites having large increases). Channel Width Variability 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 and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Channel Width 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. 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.

There was minor change from Reference Condition in Channel Form in the Upland zone. The more serious impacts were channel enlargement and channel simplification. An enlarged channel was indicated at 90% of sites as a result of channel widening and bed degradation. Channel simplification was indicated at 70% of sites mostly as a result of channel straightening. There was widespread evidence of 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 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 impacts were channel enlargement and channel simplification. An enlarged channel was indicated at 60% of sites as a result of channel widening and bed degradation. Channel simplification was indicated at 80% of sites mostly as a result of channel straightening. There was widespread evidence of channel straightening 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, Upland, Slopes and Lowland zones. Bank Variability exceeded Reference Conditions at 50%-60% of sites in all zones except the Slopes zone. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result.

There was minor change from Reference Condition in Bed Dynamics in the Montane, Upland and Lowland zones mostly as a result of widespread elevated sediment load (90%-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 (30% 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.

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.

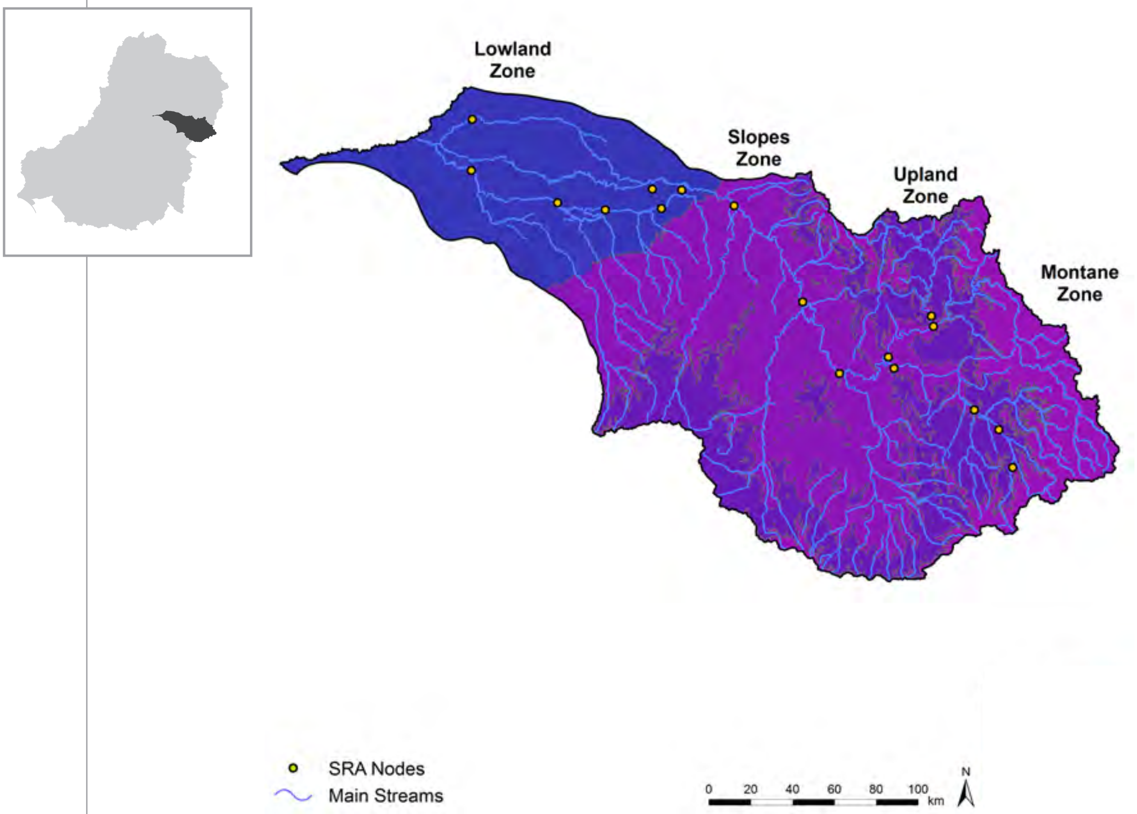
There was considerable change from Reference Condition in Floodplain Sedimentation in the Slopes and Lowland zones as a result of widespread sedimentation (100% of SedNet river segments).

**Table NAM 10: Namoi 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) | 72 (66–78) | 91 (75–95) | 67 (60–80) | 72 (63–76) | 67 (49–89) |
| Indicator | Channel Form (volume and flow events) | 76 (69–82) | 84 (64–98) | 66 (52–78) | 84 (74–92) | 70 (55–87) |
| Sub-ind. | Cross-section Form | 81 (75–87) | 89 (78–97) | 73 (61–85) | 85 (75–93) | 79 (63–92) |
| Metric | Channel Depth (mean) | 1.04 (0.98–1.09) | 1.07 (1.00–1.19) | 1.16 (1.07–1.28) | 0.96 (0.90–1.01) | 1.02 (0.82–1.16) |
| Metric | Channel Width (mean) | 1.39 (1.23–1.59) | 1.26 (1.08–1.42) | 1.58 (1.33–1.89) | 1.30 (1.07–1.62) | 1.38 (0.99–1.86) |
| Sub-ind. | Cross-section Form (variability) | 92 (85–97) | 100 (99–100) | 86 (66–100) | 95 (91–99) | 87 (68–99) |
| Metric | Channel Width (CV) | 0.95 (0.91–0.98) | 0.99 (0.98–1.00) | 0.92 (0.83–1.00) | 0.97 (0.92–1.01) | 0.91 (0.80–0.99) |
| Sub-ind. | Channel Planform | 74 (66–82) | 72 (52–91) | 68 (54–84) | 82 (72–93) | 65 (53–81) |
| Metric | Sinuosity | 1.04 (1.01–1.08) | 1.14 (1.10–1.41) | 1.01 (1.00–1.03) | 1.02 (1.00–1.05) | 1.07 (1.01–1.14) |
| Metric | Meander Wavelength | 1.19 (1.12–1.26) | 1.19 (1.01–1.42) | 1.19 (1.08–1.30) | 1.13 (1.04–1.24) | 1.31 (1.13–1.50) |
| Indicator | Bed Dynamics | 62 (60–65) | 73 (71–77) | 63 (56–68) | 53 (48–57) | 76 (72–81) |
| Metric | Channel Sediment Ratio | 68 (61–75) | 32 (21–46) | 86 (70–103) | 86 (73–99) | 26 (21–32) |
| Metric | Channel Sediment Depth | 0.004 (0.002–0.005) | 0 (0–0) | 0.003 (0.001–0.005) | 0.006 (0.004–0.009) | 0.001 (0–0.002) |
| Indicator | Bank Dynamics | 95 (93–98) | 99 (98–100) | 94 (88–98) | 94 (89–98) | 98 (96–100) |
| Metric | Bank Variability (longitudinal) | 1.16 (1.10–1.25) | 1.11 (1.03–1.20) | 1.27 (1.11–1.40) | 1.15 (1.02–1.28) | 1.08 (1.00–1.16) |
| Indicator | Floodplain | 43 (37–49) | 54 (32–80) | 31 (21–42) | 41 (32–49) | 58 (42–73) |
| Metric | Floodplain Sediment Deposition | 8 (6–10) | 3.00 (1.28–6.00) | 7 (5–10) | 10 (7–13) | 9 (4–14) |

# NAMOI VALLEY



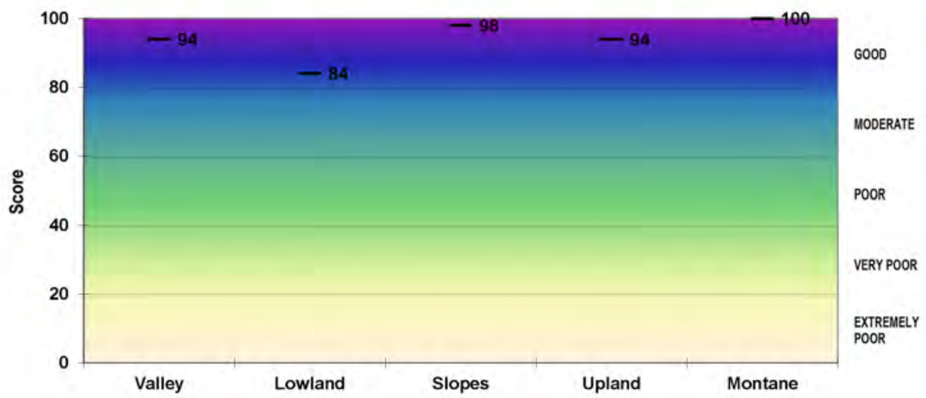




Figure NAM 6: Namoi Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.

Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Namoi Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 94. The Lowland, Slopes, Upland and Montane zones were in Good condition. The mainstem river system of the Namoi Valley was rated in Good condition. However, throughout much of the mainstem river system low flows were increased and high flows were reduced relative to Reference Condition. These changes were associated with altered timing of seasonal flow variations. The headwater streams of the Namoi Valley were rated in Good condition.*

The Namoi River rises in the Great Dividing Range and flows westward to join the Barwon River near Walgett. Its main tributary is the Peel River, joining the Namoi at Gunnedah. Other tributaries include the Manilla and McDonald rivers and Cox's Creek. Smaller episodic tributaries meet the Namoi over much of its length. From Wee Waa to Walgett, the channel branches across a broad floodplain. There are major instream storages in the upper catchment, namely Keepit Dam on the Namoi (423 GL), Split Rock Dam at the junction of the Manilla and McDonald (397 GL) and Chaffey Dam on the Peel (62 GL). Weirs on the Namoi provide urban, stock and domestic supplies, and larger structures such as Mollee Weir and Gunidgera Weir provide irrigation water. Irrigation, mainly for cotton, occurs throughout the valley.

In the Namoi Valley, hydrological condition is assessed using metrics of hydrological alteration available for 6,853 km of mainstem rivers and headwater streams. There are 683 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 Namoi Valley there is 6,170 km of headwater stream (701 km in the Montane zone; 2,124 km in the Upland zone; 2,978 km in the Slopes zone; 367 km in the Lowland zone). 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 Namoi Valley there is 3,507 km of these mid-size tributaries (197 km in the Montane zone; 520 km in the Upland zone; 1,760 km in the Slopes zone; 1,030 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 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.

# NAMOI VALLEY

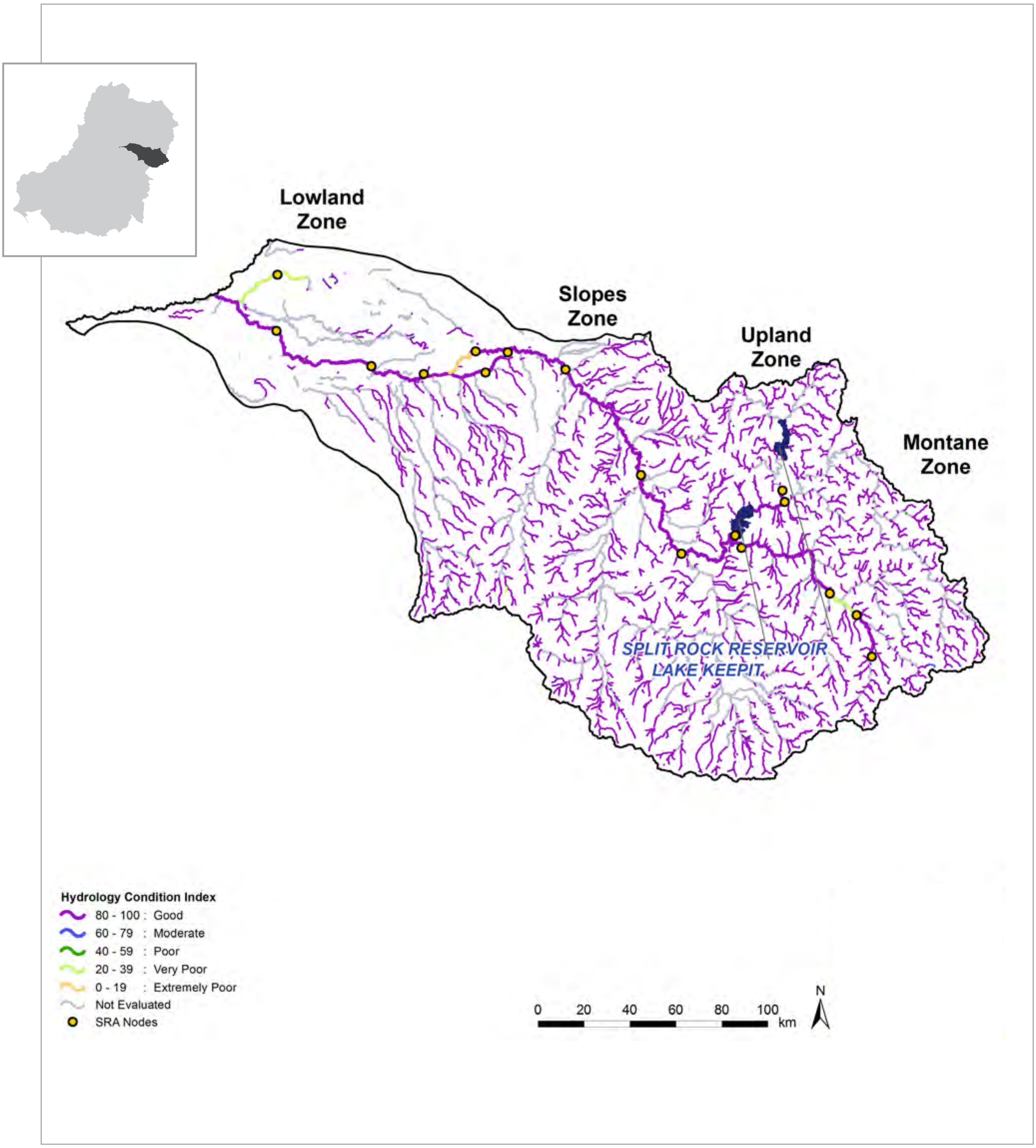



Figure NAM 7: Namoi Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

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

- The Hydrology Condition Index for the whole valley = 94, indicating Good hydrological condition.
- The Hydrology Condition Index for the Montane, Upland, Slopes and Lowland zones = 100, 94, 98 and 84 indicating Good, Good, Good and Good 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) = 91, indicating Good hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 85, 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 = 97, 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 20% 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 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. 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 Condition flow regime. The High Flow Spells metric quantifies change in the frequency of high flow events relative to Reference Condition.

# NAMOI VALLEY

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) and a significant alteration from reference in 45% 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, a small proportion in the Slopes zone and most in the Lowland zone. Results for the High Flow Spells metric showed a very significant alteration from Reference Condition in 3% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 66% 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 1% of the headwater river length (mostly associated with increased flows) and a significant alteration from reference in 12% 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 Condition 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 moderate difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 2% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 49% 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 3% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 6% 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 53% of the mainstem river length (mostly associated with increased flows) and a significant alteration from reference in 31% 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.

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 21% 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 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 9% of the mainstem river length (associated with both increased and reduced flows). 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 1% of the mainstem river length and a significant alteration from reference in 55% 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 2% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 15% 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 moderate difference from Reference Condition. Results for the Flow Variation metric showed a significant alteration from reference in 39% 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 1% 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 Montane zone, some in the Slopes zone and a small proportion in the Lowland 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 near Reference Condition. Results for the Low Over Bank Flow Duration metric showed a very significant alteration from Reference Condition in 10% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from reference in 12% 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 Slopes zone and most in the Lowland zone. Results for the Low Over Bank Flow Spells metric showed a very significant alteration from Reference Condition in 9% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from reference in 11% 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.

### *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 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 3% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 27% 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 4% 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 some in the Lowland zone.

### *Summary: mainstem rivers*

The mainstem river system of the Namoi Valley was generally characterised by moderate alteration in Flow Variability and Low and Zero Flow Events relative to Reference Condition and little or no alteration in High Over Bank Floods, Low Over Bank Floods, Flow Seasonality, High Flow Events and Flow Gross Volume. However, throughout much of the mainstem river system low flows were increased and high flows were reduced relative to Reference Condition. These changes were associated with altered timing of seasonal flow variations.

### *Summary: headwater streams*

The headwater streams of the Namoi 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.

**Table NAM 11: Namoi 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 | 94 | 100 | 94 | 98 | 84 |

# NAMOI VALLEY

**Table NAM 12: Namoi 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*)** | **91 (2–100)** | **100 (22–100)** |
| Sub-index | In-Channel Flow Regime | 85 (2–100) | 100 (22–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 82 (20–100) | 100 (55–100) |
| Sub-ind. | Flow Gross Volume | 94 (64–100) | 99 (82–100) |
| Metric | Mean Annual Flow | 0.94 (0.63–1.47) | 1.04 (0.77–1.28) |
| Metric | Flow Duration | 1.00 (0.94–1.04) | 1.00 (0.83–1.27) |
| Sub-ind. | High Flow Events | 88 (42–99) | 98 (32–100) |
| Metric | High Flow | 0.87 (0.49–1.44) | 1.04 (0.64–1.90) |
| Metric | High Flow Spells | 0.73 (0.05–1.00) | |
| Sub-ind. | Low and Zero Flow Events | 71 (20–98) | 97 (46–99) |
| Metric | Zero Flows Proportion | 1.07 (0.98–2.00) | 0.99 (0.96–1.00) |
| Metric | Low Flow | 1.07 (0.65–1.61) | 0.95 (0.18–1.52) |
| Metric | Low Flow Spells | 1.41 (0.24–2.00) | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 84 (14–100) | 100 (20–100) |
| Sub-ind. | Flow Seasonality | 87 (54–100) | 96 (65–100) |
| Metric | Flow Seasonal Amplitude | 0.95 (0.60–1.47) | 1.08 (0.89–1.65) |
| Metric | Flow Seasonal Period | 0.77 (0.49–1.00) | 0.97 (0.83–1.00) |
| Sub-ind. | Flow Variability | 78 (12–100) | 96 (6–100) |
| Metric | Flow Variation | 1.01 (0.59–1.34) | 0.95 (0.56–1.00) |
| Sub-index | Over Bank Flow Regime | 97 (64–100) | |
| Indicator | Over Bank Floods Low | 90 (37–99) | |
| Metric | OB Flow Duration (ARI 1) | 0.90 (0.27–2.00) | |
| Metric | OB Flow Spells (ARI 1) | 1.01 (0.46–1.51) | |
| Indicator | Over Bank Floods High | 90 (40–98) | |
| Metric | OB Flow Duration (ARI 8) | 0.91 (0.02–1.26) | |
| Metric | OB Flow Spells (ARI 8) | 0.96 (0.69–1.22) | |

| Zone | | | | | |
|---|---|---|---|---|---|
| Mainstem rivers | | | Headwater streams | | |
| Upland | Slopes | Lowland | Montane | Upland | Slopes |
| **91** | **97** | **84** | **100** | **100** | **100** |
| 91 | 92 | 78 | 100 | 100 | 100 |
| 92 | 83 | 81 | 100 | 100 | 100 |
| 99 | 99 | 87 | 97 | 99 | 99 |
| 0.98 | 0.96 | 0.92 | 1.10 | 1.05 | 1.02 |
| 1.01 | 1.02 | 0.98 | 1.03 | 1.02 | 0.99 |
| 98 | 96 | 79 | 96 | 99 | 98 |
| 0.97 | 0.93 | 0.81 | 1.18 | 1.08 | 1.00 |
| 0.98 | 0.83 | 0.61 | | | |
| 88 | 68 | 73 | 98 | 97 | 97 |
| 1.00 | 1.04 | 1.11 | 0.99 | 1.00 | 0.99 |
| 1.08 | 1.19 | 0.95 | 0.97 | 1.01 | 0.93 |
| 1.14 | 1.63 | 1.20 | | | |
| 100 | 97 | 69 | 99 | 100 | 100 |
| 98 | 88 | 85 | 92 | 96 | 97 |
| 0.98 | 0.91 | 0.99 | 1.19 | 1.10 | 1.05 |
| 0.97 | 0.77 | 0.74 | 0.95 | 0.97 | 0.98 |
| 100 | 93 | 59 | 94 | 97 | 96 |
| 1.00 | 0.95 | 1.07 | 0.93 | 0.96 | 0.95 |
| 100 | 100 | 95 | | | |
| 98 | 94 | 84 | | | |
| 0.98 | 0.85 | 0.95 | | | |
| 1.02 | 1.05 | 0.98 | | | |
| 98 | 87 | 93 | | | |
| | | 0.91 | | | |
| | | 0.96 | | | |

# OVENS VALLEY

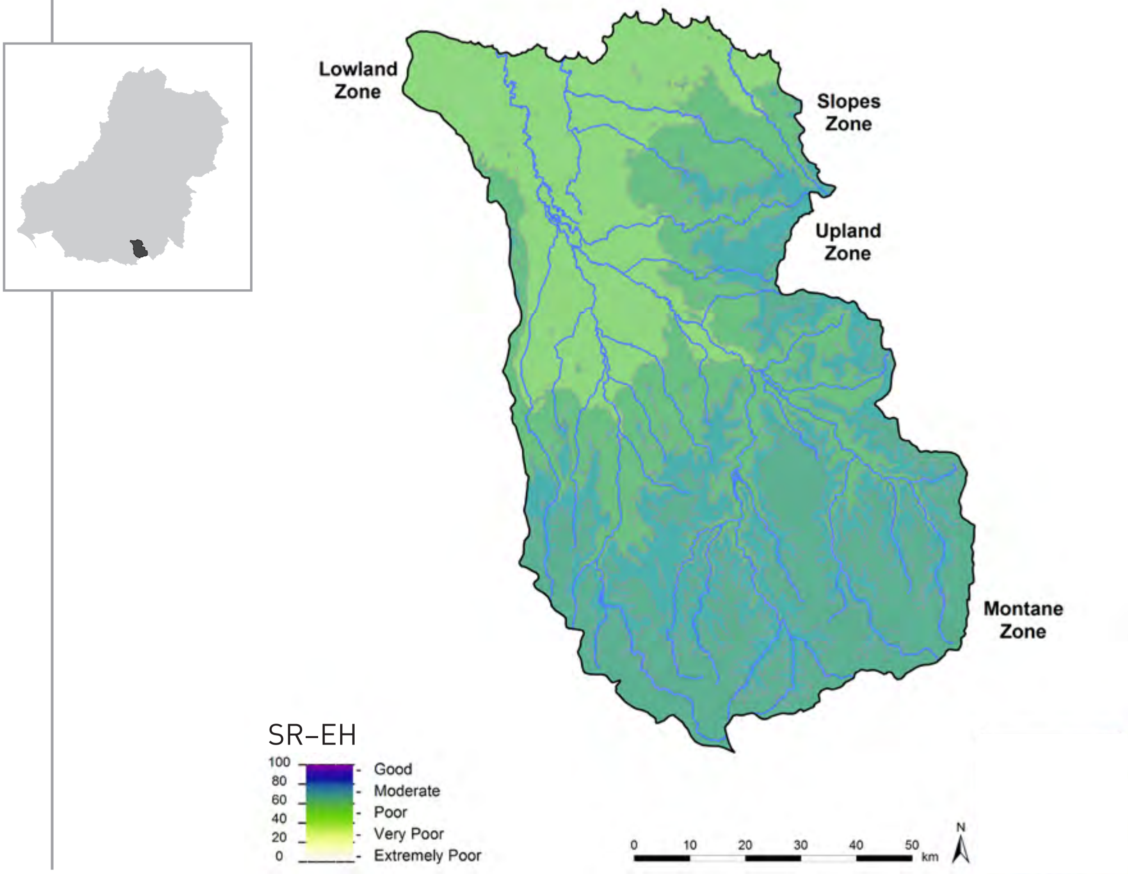



**Figure OVN 1: Ovens Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure OVN 1 shows the Ecosystem Health ratings for the Ovens Valley and Tables OVN 1 and OVN 2 also show the index values and ratings for each Theme. Ecosystem health shows a large difference from Reference Condition for the Ovens Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Poor, Moderate 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 Ovens Valley river system. Riverine Ecosystem Health was rated as Poor (Lowland zone: Poor; Slopes zone: Poor; Upland zone: Moderate; Montane zone: Poor).

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

*The Ovens Valley river ecosystem was in Poor health. River Ecosystem Health for the zones was as follows: Upland Moderate; Montane, Slopes and Lowland 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; and recruitment levels among the remaining native species were greatly reduced. 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, stability and nativeness in the Near Riparian and Lowland Floodplain domains, and a moderate increase in the degree of fragmentation in the Lowland Floodplain. The Physical Form of the river system was in Good condition with channel form, bank and bed dynamics in Good condition, and moderate levels of floodplain sediment deposition.The river system's Hydrology was in Good condition, with little change from Reference Condition in magnitudes of annual flow volumes low and zero flows, flow variability, seasonality and high flows.*

### *Ecosystem Health*

The Ovens Valley is ranked eighth highest amongst the 23 SRA valleys in terms of River Ecosystem Health (see Table 5.2). It is ranked in the upper 50% of valleys for all Themes except Vegetation in which it is ranked 16th. In terms of physical condition it is ranked third for Physical Form condition and equal 2nd (with the Kiewa, Avoca, Broken and Mitta Mitta valleys) for Hydrology. For Fish and Macroinvertebrate condition it is ranked ninth and seventh respectively.

The Ovens Valley, with some of its neighboring valleys, has experienced the most extreme of drought conditions that have affected much of the Murray–Darling Basin between 2001 and 2010. Unlike some nearby river systems (e.g. Goulburn, Mitta Mitta) the Ovens is not highly regulated (in-stream storage capacity 38 GL) and therefore the hydrological effects of drought – especially extreme low-flow and zero-flow events – are not ameliorated in downstream reaches by releases for consumptive requirements, exposing Lowland and Slopes zones to the same drought effects as the catchment streams and tributaries. In-stream sediment deposits in the floodplain reaches may have a significant effect on biota under drought flow conditions.

Without data collected under non-drought conditions it is difficult to assess to what degree observed shortfalls in condition are responses to the current climatic factors rather than more independent or objective reflections of Ecosystem Health. An important indication of underlying health can be gained by understanding the response of these systems (or their failure to respond) to future more benign climatic conditions.

### *Fish Theme*

The Fish Condition Index SR–FI = 40, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Poor; Upland zone: Very Poor; Montane zone: Very Poor). The Expectedness indicator = 48, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 61, indicating Moderate condition, and a moderate difference from Reference Condition. The Recruitment indicator = 49, indicating Poor condition, and a large difference from Reference Condition.

# OVENS VALLEY

Much of the native fish species richness has been lost, especially in the Lowland zone. Numbers of native fish were reduced substantially and alien species contributed over 72% of the biomass in samples. Native fish recruitment was generally Poor to Very Poor.

### *Macroinvertebrate Theme*

The Macroinvertebrate Condition Index SR–MI = 79, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Good; Upland zone: Good; Montane zone: Moderate). The simOE metric = 53, 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 site communities in Moderate or Good condition was high across both zones (91% overall), with 23 of the 35 rated sites in Good condition (18 of which were in the Upland and Slopes zones).

Family richness generally was high, but was reduced relative to Reference Condition.

### *Riverine Vegetation Theme*

The Riverine Vegetation Condition Index SR–VI = 48, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Very Poor; Upland zone: Good; Montane zone: Good). The Vegetation Abundance and Diversity indicator = 61, indicating Moderate condition and 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 = 56, indicating Poor condition and a large difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in both 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 accompanied by a large increase in fragmentation.

### *Physical Form Theme*

The Physical Form Condition Index SR–PI = 97, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good; Montane zone: Good). The Channel Form indicator = 91, the Bed Dynamics indicator = 81, the Bank Dynamics indicator = 98 and the Floodplain Form indicator = 84; all indicating Good condition and near Reference Condition.

Overall, the valley's riverine physical form was characterised by close to Reference Conditions, although there was some indication of elevated sediment loads and deposition in the Lowland zone.

### *Hydrology Theme*

The Hydrology Condition Index SR–HI = 99, indicating Good condition (Lowland zone: Good; Slopes zone: Good; Upland zone: Good; Montane zone: Good). The In-Channel Flow Regime indicator = 100, indicating Good condition and near Reference Condition for the flow regime within the channels.

Both mainstem river and headwater streams were characterised by little or no alteration from reference in Flow Variability, Flow Seasonality, Low and Zero Flow Events, High Flow Events and Flow Gross Volume.

**Table OVN 1: Ovens 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 | Moderate | Poor | Poor |

| THEME | | VALLEY | ZONE | | | |
|---|---|---|---|---|---|---|
| | | | MONTANE | UPLAND | SLOPES | LOWLAND |
| Fish | SCORE RATING | 40 (29–46) Poor | 35 (28–43) Very poor | 34 (15–44) Very poor | 52 (32–66) Poor | 29 (21–38) Very poor |
| Macro-invertebrates | SCORE RATING | 79 (72–85) Moderate | 73 (60–84) Moderate | 92 (86–95) Good | 86 (81–90) Good | 67 (46–82) Moderate |
| Vegetation | SCORE RATING | 48 Poor | 100 Good | 100 Good | 30 Very Poor | 27 Very Poor |

**Table OVN 2: Ovens 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 | 97 (93–100) Good | 100 (100–100) Good | 100 (94–100) Good | 98 (94–100) Good | 95 (84–100) Good |
| Hydrology | SCORE RATING | 99 Good | 100 Good | 100 Good | 99 Good | 100 Good |

# OVENS VALLEY

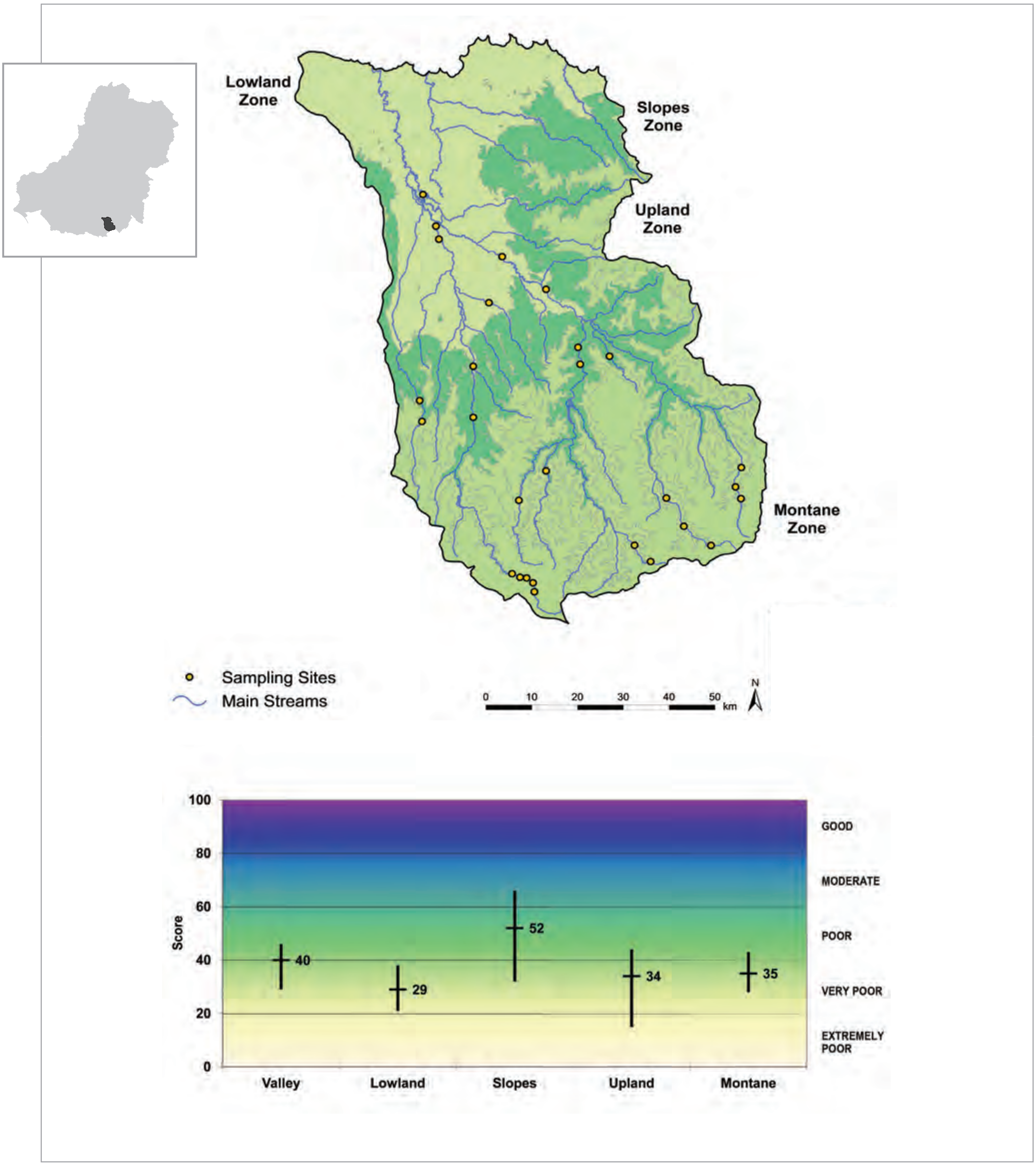



**Figure OVN 2: Ovens Valley map with sampling sites and zones coloured by SR Fish Index (SR–FI) scores.**

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

*The Fish community of the Ovens Valley river system was in Poor condition, with an aggregate Fish Index score (SR–FI) of 40. The condition of the Fish community in the zones was as follows: Montane zone: Very Poor; Upland zone: Very Poor; Slopes zone: Poor; and Lowland zone: Very Poor. The fish community was characterised by a Poor score for expected native fish species, a Moderate score for nativeness and a Poor score for native fish recruitment. The Montane and Upland zones in particular had few fish and the Upland zone lacked 75% of the predicted native species. The valley had lost much of its native species richness and alien species contributed over 72% of the biomass in samples. Native fish recruitment was Very Poor, Moderate, Poor and Very Poor in the Montane, Upland, Slopes, and Lowland zones respectively.*

Twenty-eight sites were surveyed across the Ovens Valley in February–March 2010, yielding 1,431 fish. Analyses showed a large difference from Reference Condition for the Ovens Valley, with:

- SRA Fish Index (SR–FI) = 40 (CL 29–46), indicating Poor condition of the fish community.
- The Expectedness indicator = 48 (CL 42–53), indicating Poor condition, and a large difference from Reference Condition. Only 55% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 61 (CL 54–72), indicating Moderate condition, and a moderate difference from Reference Condition.
- The Recruitment indicator = 49 (CL 28–55), indicating Poor condition, and a large difference from Reference Condition. Evidence of recruitment was observed for 9 of the 12 native species observed in the valley.

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

SR–FI for the Ovens Valley was the eighth highest of all 23 Basin valleys, and close to that for the Upper Murray and Castlereagh valleys. The Slopes zone community was in better condition (SR–FI = 52) than that of the Montane, Upland, and Lowland zones (SR–FI = 35, 34, and 29 respectively).

Expectedness was highly variable amongst zones, ranging from Good in the Montane zone to Very Poor in the Upland zone. The relatively high score for the Montane zone is due in part to the fact that only three species of native fish were expected under Reference Condition (a low figure equalled only in the Kiewa Upland zone) of which two were caught, and only two alien species (Brown and Rainbow trout) occurred in samples. In the Upland zone the same two alien species were captured, but only 2 of the 8 expected native species were sighted.

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In contrast, Nativeness was Extremely Poor in the Montane zone with 107 specimens of two native species totalling 1.7 kg. in biomass, and 185 alien fish (brown and rainbow trout) weighing nearly ten times as much. Numbers of alien fish were relatively low in all zones, though their individual biomass was greater than that of the native fish on average, and higher numbers of native species present in the Slopes and Lowland zones gave them each a Nativeness rating of moderate.

Table OVN 4 shows native species abundances in the Ovens Valley compared with Reference Condition. Mountain galaxias was expected but not caught in all four zones. Other expected species not represented in samples included freshwater catfish, Macquarie perch, and silver perch. Golden perch and southern pygmy perch were each represented by one individual. Two-spined blackfish, two galaxias taxa, and Australian smelt were the most numerous native species. Six alien species were caught in the Ovens Valley, numerically dominated by brown and rainbow trout. Common carp were caught only in the Slopes and Lowland zones and in relatively low numbers. However, at an average weight of nearly 2 kg, they contributed substantially to the total fish biomass in those zones (51% and 75% respectively).

Recruitment varied amongst zones. Only one native species, two-spined blackfish, was recorded as recruiting in the Montane zone. Both Murray cod and trout cod were reported as recruiting in some sites in the Ovens Valley. Five alien species showed evidence of recruitment, the exception being goldfish (caught only in the Lowlands zone).

In general, The Fish community of the Ovens had reduced numbers of expected native species. It had the sixth lowest number of fish caught per site (51) of all 23 Basin valleys, of which 33 belonged to native species and 18 were alien. Alien biomass averaged 4.7 kg/site whilst native biomass averaged 1.8 kg/site.

**Table OVN 3: Ovens 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) | 40 (29–46) | 35 (28–43) | 34 (15–44) | 52 (32–66) | 29 (21–38) |
| Indicator | Expectedness | 48 (42–53) | 89 (67–92) | 31 (21–40) | 56 (47–64) | 42 (34–52) |
| Metric | O/E | 0.54 (0.46–0.62) | 0.82 (0.51–1.00) | 0.57 (0.44–0.70) | 0.59 (0.45–0.70) | 0.39 (0.28–0.53) |
| Metric | O/P (Zone level) | 0.45 (0.45–0.45) | 0.67 (0.67–0.67) | 0.25 (0.25–0.25) | 0.50 (0.50–0.50) | 0.50 (0.50–0.50) |
| Indicator | Nativeness | 61 (54–72) | 16 (7–25) | 44 (29–60) | 74 (59–95) | 67 (56–83) |
| Metric | Proportion biomass native | 0.44 (0.30–0.58) | 0.10 (0.05–0.16) | 0.32 (0.12–0.58) | 0.61 (0.33–0.89) | 0.36 (0.14–0.63) |
| Metric | Proportion abundance native | 0.67 (0.54–0.78) | 0.35 (0.19–0.52) | 0.56 (0.40–0.74) | 0.71 (0.45–0.93) | 0.75 (0.62–0.88) |
| Metric | Proportion species native | 0.61 (0.53–0.70) | 0.33 (0.21–0.43) | 0.40 (0.33–0.50) | 0.70 (0.54–0.88) | 0.72 (0.59–0.83) |
| Indicator | Recruitment | 49 (28–55) | 28 (28–41) | 70 (28–75) | 53 (21–67) | 29 (18–40) |
| Metric | Proportion of sites with native recruits | 0.65 (0.41–0.68) | 0.50 (0.50–0.50) | 1.00 (0.50–1.00) | 0.62 (0.37–0.73) | 0.39 (0.26–0.48) |
| Metric | Proportion of native taxa with recruits | 0.74 (0.56–0.83) | 0.50 (0.50–1.00) | 1.00 (0.50–1.00) | 0.75 (0.50–0.86) | 0.55 (0.46–0.75) |
| Metric | Proportion of abundance as recruits | 0.32 (0.20–0.38) | 0.08 (0.03–0.17) | 0.14 (0.05–0.33) | 0.43 (0.16–0.50) | 0.38 (0.27–0.53) |

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# OVENS VALLEY

| 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 | 4 | 4 | 13 | 15 |
| | Number of native species | 12 | 2 | 2 | 8 | 11 |
| | Number of predicted species | 22 | 3 | 8 | 16 | 22 |
| | Number of alien species | 6 | 2 | 2 | 5 | 4 |
| | Mean number of fish per site | 51 | 42 | 49 | 58 | 56 |
| | Biomass/site all species (g) | 6494 | 2425 | 2911 | 7594 | 13045 |
| | Mean native biomass/fish (g) | 54 | 16 | 18 | 69 | 71 |
| | Mean alien biomass/fish (g) | 262 | 83 | 103 | 443 | 820 |

**Table OVN 4: Ovens 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 | 146 | | 0 | 0 | 146 |
| Bony herring | 0 | | | | 0 |
| Dwarf flathead gudgeon | 0 | | | | 0 |
| Flathead gudgeon | 2 | | | 0 | 2 |
| Freshwater catfish | 0 | | | 0 | 0 |
| Galaxias | 71 | 5 | 9 | 52 | 5 |
| Golden perch | 1 | | | 0 | 1 |
| Gudgeon | 53 | | | 1 | 52 |
| Macquarie perch | 0 | | 0 | 0 | 0 |
| Mountain galaxias | 0 | 0 | 0 | 0 | 0 |
| Murray cod | 50 | | 0 | 17 | 33 |
| Murray jollytail | 0 | | | 0 | 0 |
| Murray–Darling rainbowfish | 0 | | | | 0 |

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# OVENS VALLEY

| Fish species | Valley | Zone | | | |
|---|---|---|---|---|---|
| | | Montane | Upland | Slopes | Lowland |
| Obscure galaxias complex | 124 | | | 119 | 5 |
| River blackfish | 66 | | | 30 | 36 |
| Shortheaded lamprey | 0 | | | | 0 |
| Silver perch | 0 | | | 0 | 0 |
| Southern purple-spotted gudgeon | 0 | | | | 0 |
| Southern pygmy perch | 1 | | 0 | 1 | 0 |
| Trout cod | 5 | | 0 | 1 | 4 |
| Two-spined blackfish | 398 | 102 | 167 | 119 | 10 |
| Unspecked hardyhead | 11 | | | | 11 |

Continued/...

| Fish species | Valley | Zone | | | |
|---|---|---|---|---|---|
| | | Montane | Upland | Slopes | Lowland |
| Alien species | | | | | |
| Brown trout | 192 | 91 | 72 | 29 | |
| Common carp | 49 | | | 11 | 38 |
| Gambusia | 50 | | | 15 | 35 |
| Goldfish | 11 | | | | 11 |
| Rainbow trout | 199 | 94 | 94 | 11 | |
| Redfin perch | 2 | | | 1 | 1 |

# OVENS VALLEY

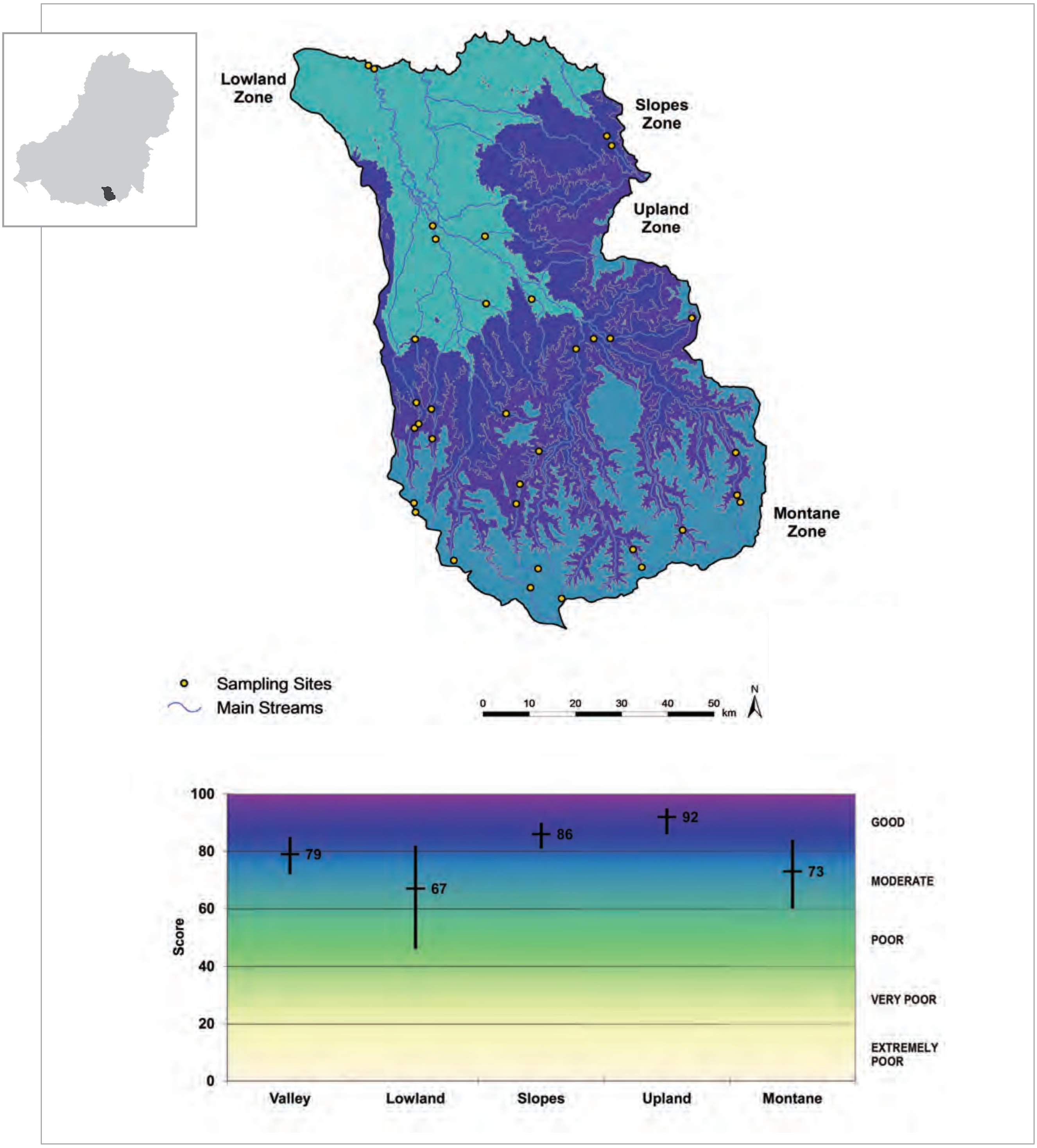



**Figure OVN 3: Ovens Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.**

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

*The Macroinvertebrate community of the Ovens Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 79. The condition of the Macroinvertebrate community in the zones was as follows: Montane Moderate; Upland Good; Slopes Good; Lowland Moderate. The proportion of sites in Moderate or Good condition was very high (91%); 23 of the 35 rated sites (66%) were in Good condition. Family richness generally was high, but was reduced relative to Reference Condition.*

Thirty-five sites were surveyed across the Ovens Valley in October–December 2009 yielding 8,384 macroinvertebrates in 77 families (82% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 79 (CL 72–85), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 53 (CL 50–55) indicating minor to moderate differences from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats.
- The proportion of site communities in Moderate or Good condition was high across both zones (91% overall), with 23 of the 35 rated sites (66%) in Good condition (18 of which were in the Upland and Slopes zones).
- The number of families found was lowest in the Lowland zone (38 families) and highest in the Slopes zone (59 families), with the Upland and Slopes zones having the highest average numbers of families per site (60 and 66, respectively).

Figure OVN 3 shows sampling sites, zones and SR–MI values, and Table OVN 5 shows index and metric values. The SR–MI score for the Ovens Valley indicated Moderate condition of macroinvertebrate communities, rating 7th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Montane and Lowland zones showed moderate differences from Reference Condition (SR–MI = 73 and 67, respectively), while those of the Upland and Slopes showed no or minor differences from Reference Condition (SR–MI = 92 and 86, respectively. A very wide confidence interval (36 points) for the Lowland zone SR–MI value indicates high spatial variability there, with most sites showing either a large or moderate difference from Reference Condition. Expectedness (simOE) was generally Moderate and varied by up to 37 points among sites.

# OVENS VALLEY

Table OVN 6 shows that most sites had Moderate SR–MI values, though most sites (66%) were rated in Good condition, especially in the Upland and Slopes zones (eight and 10 sites, respectively). The Lowland zone had two sites 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.

Family richness generally was reduced compared to Reference Condition. Diversity was high (average 28 families per site), with the Upland zone being most diverse at site scale (average 34 families per site). The valley contained 82% of the families found across the Basin (Table OVE 6), with the Lowland zone having the lowest representation of Basin-wide fauna. Most (77%) of the fauna of the valley was found in the Slopes zone.

**Table OVN 5: Ovens 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) | 79 (72–85) | 73 (60–84) | 92 (86–95) | 86 (81–90) | 67 (46–82) |
| Metric | SimOE | 53 (50–55) | 50 (44–56) | 60 (56–62) | 56 (53–58) | 47 (39–53) |

Table OVN 6: Ovens 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 | 7 | 9 | 12 | 7 |
| Number of sites with index values* | 35 | 7 | 9 | 12 | 7 |
| N sites by SR–MI condition band | | | | | |
| Good (80–100) | 23 | 2 | 8 | 10 | 3 |
| Moderate (60–80) | 9 | 4 | 1 | 2 | 2 |
| Poor (40–60) | 1 | 1 | | | |
| Very or Extremely Poor (0–40) | 2 | | | | 2 |
| Families | | | | | |
| Number of families sampled | 77 | 49 | 54 | 59 | 38 |
| No. families/site (min-max) | 53 (50–55) | 50 (44–56) | 60 (56–62) | 56 (53–58) | 47 (39–53) |
| Percent of families in Basin | 82 | 52 | 57 | 63 | 40 |
| Percent of families in valley | 100 | 64 | 70 | 77 | 49 |

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

# OVENS VALLEY

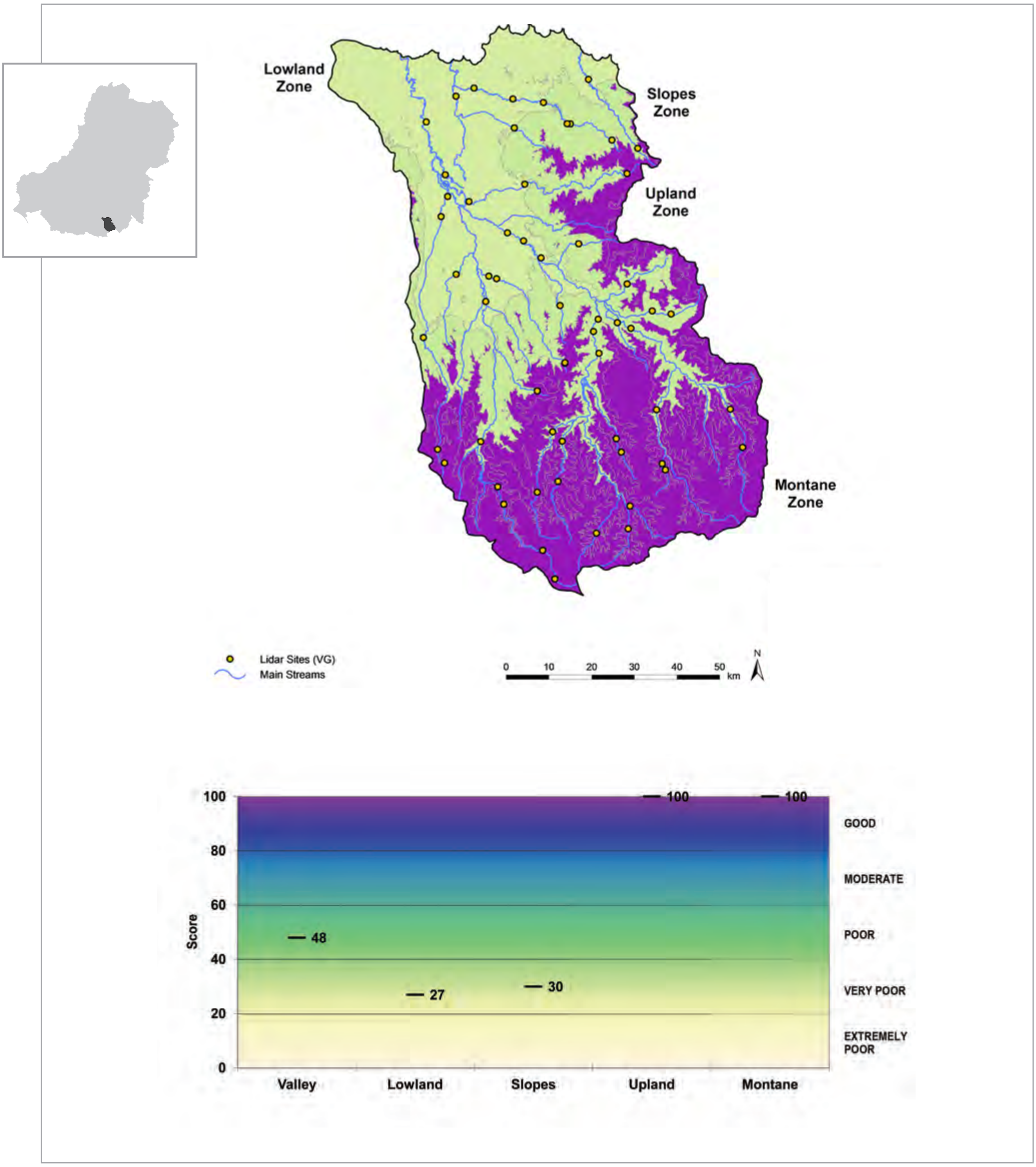



**Figure OVN 4: Ovens Valley map with LiDAR sites and zones coloured by SRA Vegetation Index scores.**

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Ovens Valley river system was in Poor condition, with an aggregate Vegetation Index score (SR–VI) of 48. Overall condition for the four zones in this valley was: Montane Good; Upland Good; Slopes Very Poor; Lowland Very Poor.*

*The Abundance and Diversity indicator score was 61 for the valley, indicating a Moderate rating overall. In the four zones it was: Montane Good; Upland Good; Slopes Poor; Lowland Poor.*

*The Quality and Integrity indicator score was 56 for the valley, indicating a Poor rating overall. In the four zones it was: Montane Good; Upland Good; Slopes Poor; Lowland Very Poor.*

The SRA Vegetation assessment for the Ovens Valley considers riverine vegetation in two spatial domains: Near Riparian, along 1,387 km of stream, and Lowland Floodplain, for 134 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. Most of the stream lengths are in the two lowest zones, and the length of stream assessed per zone is as follows: Montane 92 km; Upland 279 km; Slopes 519 km; and Lowland 497 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 61 sites set back 50 m from the top of the channel bank. LiDAR sites are distributed along the stream network, and amongst the zones as follows: Montane five sites; Upland 14 sites; Slopes 23 sites; and Lowland 19 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure OVN 4 shows values of the Vegetation Index (SR–VI) for the Ovens Valley and Table OVN 7 shows the index, indicator and sub-indicator values. Tables OVN 8 and OVN 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 Ovens Valley with:

- SRA Vegetation Index (SR–VI) = 48, indicating Poor condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 61, 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 = 56, 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 of major vegetation groups in the sampled area shows a moderate difference from reference and the degree of fragmentation shows a large difference from Reference Condition.

# OVENS VALLEY

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, being near reference in the Montane and Upland zones and showing a very 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 major vegetation groups as given in NVIS 3.0. Valley-wide abundance for the Near Riparian domain was near reference in the Montane and Upland zones, and showed a very large difference from reference in the Slopes and Lowland zones; and a moderate difference from reference in the Lowland Floodplain domain. MVG richness is maintained near reference in the Near Riparian domain and is moderately different from reference in the Lowland Floodplain domain. Vegetation in the Lowland Floodplain domain has 70% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Poor condition overall, and highly variable between zones: it is near Reference Condition in the Montane and Upland zones, shows a large difference from Reference Condition in the Slopes zone, and a very large difference from reference in the Montane 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 OVN 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 a moderate difference from reference 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 the Montane, Upland and Slopes zones. Just one MVG, Callitris Forests and Woodland, accounts for the change in richness in the Lowland zone and the Lowland Floodplain.

***Abundance***

- The Abundance of pre–1750 MVGs in the combined Near Riparian–Lowland Floodplain (NRLF) spatial domain is in Very Poor condition overall, and differs between zones and domains. Abundance in the Near Riparian domain is near reference in the Montane and Upland zones, and shows a very large difference from reference in the Slopes and Lowlands zones; and in the Lowland Floodplain domain, abundance is moderately different from reference.

***Stability***

- Floodplain areas in the Lowland Floodplain domain are in Moderate condition, with evidence of moderate 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 Very Poor condition overall, and differs between zones and domains. Nativeness in the Near Riparian domain is near reference in the Montane and Upland zones, and shows a very large difference from reference in the Slopes and Lowlands zones; nativeness in the Lowland Floodplain domain is moderately different 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 moderately different from reference in the Montane zone, and near reference in the Upland, Slopes and Lowland zones, however the overlapping confidence limits show there is very little difference between zones. Structure refers only to the heights 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 Poor condition. This is due to severe dissection, and is manifest as a large increase in number of patches and severe reduction in mean patch area relative to reference in Eucalypt Woodlands, which originally covered nearly all the Lowland Floodplain domain.

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

- Montane zone: The Near Riparian domain was mostly Eucalypt Open Forests (66% of the domain area) and Eucalypt Woodlands (23%) with five other MVGs present, of which only one covered more than 5% of the domain.

- Upland zone: The Near Riparian domain was mostly (78% of domain area) Eucalypt Open Forests with four other MVGs present, of which two covered 5% or more of the domain.

- Slopes zone: The Near Riparian domain is mostly Eucalypt Woodlands (47% of domain area) and Eucalypt Open Forests (39%) with three other MVGs present of which only one covered 5% or more of the domain.

- Lowland zone: The Near Riparian domain is dominated by Eucalypt Woodlands (95% of domain area) with four other MVGs also present.

- Lowland zone: The Lowland Floodplain domain is also dominated by Eucalypt Woodlands (96% of domain area) with only one other MVG present.

# OVENS VALLEY

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley has not been much reduced except in the Slopes and Lowland zones, principally affecting Eucalypt Woodlands, formerly the most extensive MVG.

- Montane zone: the Near Riparian domain is little changed, and Eucalypt Open Forests now cover 63% and Eucalypt Woodlands still covers 23% of the domain. About 4% of the domain is either cleared or non-native vegetation, and this affects the condition of the MVGs very little. Six of the MVGs present have the same area as under Reference Condition, and Eucalypt Open Forests are 94% of their reference area.
- Upland zone: in the Near Riparian domain, Eucalypt Open Forests are still the most extensive MVG although reduced to 66% of the domain area. About 17% of the domain is either cleared or non-native vegetation. The MVGs are variously affected: two retain 100% of their reference areas; while Eucalypt Woodlands (the most severely affected MVG) are now 42% of their reference area.
- Slopes zone: in the Near Riparian domain, Eucalypt Open Forest is now the most extensive MVG—although reduced to 21% of the domain area. Eucalypt Woodlands are reduced to 8%. About 61% of the domain is either cleared or non-native. All MVGs are affected. Eucalypt Woodlands now retain only 18% of their reference area.
- Lowland zone: in the Near Riparian domain, Eucalypt Open Woodlands are reduced to 32% of the area of the domain. About 66% is either cleared or non-native vegetation and most MVGs are affected. Eucalypt Woodlands are now 34% of their reference area. Casuarina Forests and Woodlands are reduced to an extremely low area (from an originally small area of 0.3% of the domain).
- The Lowland Floodplain is still mainly covered by Eucalypt Woodlands, although these are reduced to 66% of the domain. About 29% of the domain is either cleared or non-native vegetation. There are few MVGs present and all are affected: Casuarina Forests and Woodlands are reduced to an extremely low area.

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 May-June 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 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 is of variable quality. Between 1 and 35% of the Near Riparian domain in the Slopes and Lowland zones, and 3% of the Lowland Floodplain domain are not assigned to an MVG. The condition of either or both the Near Riparian and Lowland Floodplain domains, and hence of the four zones and of the valley itself, may have changed since the source mapping was compiled.

The riverine vegetation of the Ovens Valley is notable for the marked contrast in condition between the upper and lower parts of the valley (Montane and Upland zones versus Slopes and Lowland zones). This includes low MVG abundance and low nativeness in the Near Riparian domain in the Slopes and Lowland zones, and a contrast between the Near Riparian domain in the lower valley and the Lowland Floodplain domain. The latter has moderate scores for abundance, stability, and nativeness and is in better condition than in the Near Riparian domain.

The condition of riverine vegetation is quite variable, and ranges from near reference for the Montane and Upland zones to Very Poor for the Slopes and Lowland zones. The Montane zone has the highest score overall, with abundance, nativeness and richness all rated as near reference and structure rated as Moderate. The Slopes and Lowland zones have low scores for MVG abundance and nativeness but no loss of any MVG, and structure is near reference. The Lowland zone has a slightly lower score, due to lower MVG abundance and fragmentation in the Lowland Floodplain domain. As most of the valley stream length is in the Lowland and Slopes zones, these have greater influence on the overall condition score than the Montane and Upland zones.

In the Lowland zone, the condition of the two domains differs. The Near Riparian domain has low MVG abundance and low nativeness and loss of one MVG (Callitris Forests and Woodlands), all indicative of considerable clearing. By contrast while the Lowland Floodplain has also lost the Callitris Forests and Woodlands MVG, it has higher scores for MVG abundance and nativeness, and a Poor score for fragmentation. The two domains assess differing but overlapping parts of the riverine landscape: the Lowland Floodplain is floodplain land near the main river channel, whereas the Near Riparian domain is a continuous strip centred on all channels in the network, and covers a larger area.

# OVENS VALLEY

**Table OVN 7: Ovens 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) | 48 | 100 | 100 | 30 | 27 |
| Indicator | Abundance and diversity | 61 | 100 | 98 | 46 | 48 |
| Metric | LF stability | 0.70 | | | | 0.70 |
| Sub-ind. | NRLF richness | 88 | | | | 88 |
| Metric | NR richness | 0.93 | 1 | 1 | 1 | 0.80 |
| Metric | LF richness | 0.67 | | | | 0.67 |
| Sub-ind. | NRLF abundance | 38 | | | | 38 |
| Metric | NR abundance | 0.49 | 0.96 | 0.81 | 0.37 | 0.34 |
| Metric | LF abundance | 0.67 | | | | 0.67 |
| Indicator | Quality and integrity | 56 | 99 | 97 | 45 | 38 |
| Sub-ind. | NRLF nativeness | 38 | | | | 38 |
| Metric | NR nativeness | 0.49 | 0.96 | 0.81 | 0.37 | 0.34 |
| Metric | LF nativeness | 0.67 | | | | 0.67 |
| Sub-ind. | NR structure | 81 (77–84) | 79 (76–84) | 86 (82–89) | 80 (71–85) | 80 (74–86) |
| Sub-ind. | LF fragmentation | 40 | | | | 40 |

**Table OVN 8: The most abundant MVGs in the Near Riparian domain in the Ovens 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.

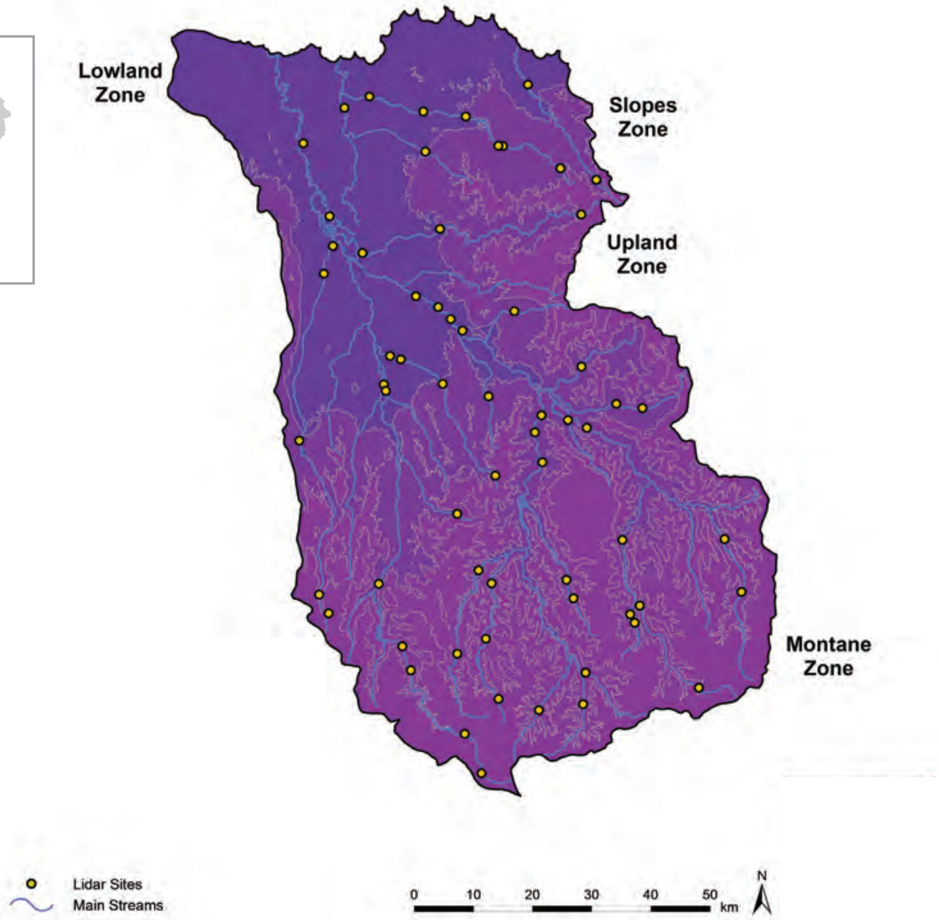
| Major Vegetation Groups | Zone | | | |
|---|---|---|---|---|
| | Montane | Upland | Slopes | Lowland |
| MVG | | | | |
| 2. Eucalypt Tall Open Forests | 10 | 14 | 9 | |
| 3. Eucalypt Open Forests | 66 | 78 | 39 | |
| 5. Eucalypt Woodlands | 23 | 7 | 47 | 95 |

**Table OVN 9: Most abundant MVGs in the Lowland Floodplain domain in the Ovens 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 | 96 | 4.71 | 0.14 |

# OVENS VALLEY



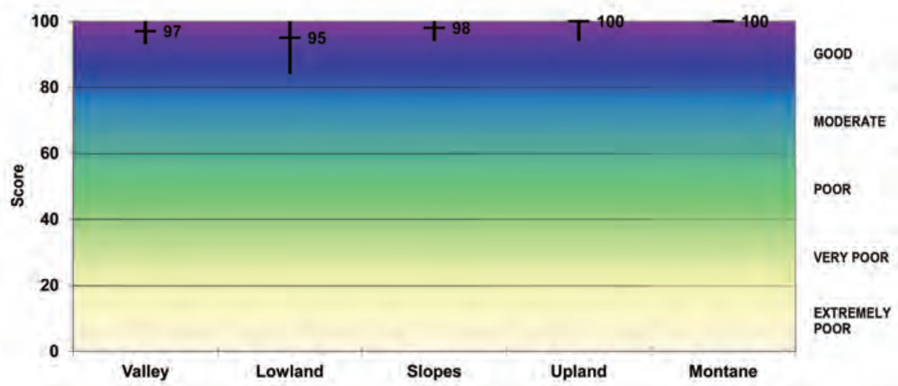




**Figure OVN 5: Ovens Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.**

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

*The Physical Form of the Ovens Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 97. The condition of Physical Form in the zones was: Montane, Upland, Slopes and Lowland Good. The valley's river Channel Form, Bank Dynamics, Bed Dynamics and Floodplain Dynamics were rated as Good. Overall, the valley's riverine physical form was characterised by close to Reference Conditions, although there was some indication of elevated sediment loads and deposition in the Lowland zone.*

The SRA Physical Form assessment considers physical form and processes along 1,387 km of stream across the valley. It is based on LiDAR data collected at 63 sites along river channels, as well as modelling of all 91 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 OVN 5 shows values of the Physical Form Index (SR–PI) for the Ovens Valley and Table OVN 10 shows the index, indicator, sub-indicator and metric values.

Analyses showed near Reference Condition for the Ovens Valley with:

- SRA Physical Form condition Index (SR–PI) = 97 (CL 93–100), indicating Good Physical Form condition
- the Channel Form indicator = 91 (CL 85–95), showing near Reference Condition
- the Bed Dynamics indicator = 81 (CL 79–84), showing near Reference Condition
- the Bank Dynamics indicator = 98 (CL 97–99), showing near Reference Condition
- the Floodplain indicator = 84 (CL 74–93), showing near Reference Condition.

***Montane zone***

There were five LiDAR survey sites and two SedNet river segments in the Montane zone of the Ovens 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 (a few sites having large increases). Channel Depth, Channel Width Variability and Bank Variability were modified from reference for less than half of the Montane zone. At these sites Channel Depth and Channel Width Variability were generally reduced and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width, Sinuosity, Meander Wavelength and Channel Sediment Deposition were largely unmodified from reference in the Montane zone.

# OVENS VALLEY

***Upland zone***

There were 14 LiDAR survey sites and 13 SedNet river segments in the Upland zone of the Ovens 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 10% of the zone for the post-European period. Channel Depth and Bank Variability were modified from reference for approximately half of the Upland zone. At these sites results show both increases and decreases in Channel Depth across the zone and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width Variability and Meander Wavelength were modified from reference for less than half of the Upland zone. At these sites Channel Width Variability was generally reduced and Meander Wavelength was generally increased (many sites having large increases). Channel Width, Sinuosity and Channel Sediment Deposition were largely unmodified from reference in the Upland zone.

***Slopes zone***

There were 23 LiDAR survey sites and 37 SedNet river segments in the Slopes zone of the Ovens 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 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 and Sinuosity were modified from reference for less than half of the Slopes zone. At these sites Channel Depth was generally increased (a few sites having large increases) and results show both increases and decreases in Channel Width Variability and Sinuosity across the zone. Meander Wavelength and Channel Sediment Deposition were largely unmodified from reference in the Slopes zone. These results are not entirely consistent with previous field observations. The tributaries and main channels of the Slopes zone have been substantially modified by gullying, alluvial gold mining, and channelisation (I. Rutherfurd, Pers. Comm.). Alluvial mining and dredging has had a major impact on the Ovens River and its floodplain in the Slopes zone, converting it from a tight meandering stream to a broad, straight braided stream (Beard, 1979). Up to half of the length of the Ovens and King rivers through this zone are now artificially rocked to control erosion (Cottingham *et.al*. 2001). These cannot therefore be described as streams in near Reference Condition.

***Lowland zone***

There were 21 LiDAR survey sites and 39 SedNet river segments in the Lowland zone of the Ovens Valley. Based on these samples, Channel Sediment Ratio and Floodplain Sediment Deposition were modified from reference 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.

Sinuosity and Meander Wavelength were modified from reference for approximately half of the Lowland zone. At these sites Sinuosity was generally increased (many sites having large increases) and results show both increases and decreases in Meander Wavelength across the zone. Channel Width Variability and Bank Variability were modified from reference for less than half of the Lowland zone. At these sites Channel Width Variability was generally reduced and Bank Variability was generally increased indicating enhanced Bank Dynamics. Channel Width, Channel Depth and Channel Sediment Deposition were largely unmodified from reference in the Lowland zone. These results are generally consistent with previous field observations (Rutherfurd pers. comm.). The lower Ovens River (and its anabranches) remains one of the least disturbed Lowland Floodplain stream systems in the Victorian portion of the Basin. This is not true of the more disturbed Black Dog Creek system (Rutherfurd pers. comm.).

***Channel Form***

There was little change from Reference Condition in Channel Form in the Montane, Upland, Slopes and Lowland zones. There was evidence of a degree of channel contraction and channel simplification across the Montane zone. There was widespread evidence of channel enlargement and channel simplification in the Upland zone. There was widespread evidence of channel enlargement in the Slopes zone. There was widespread evidence of channel straightening and channel simplification in the Lowland zone. In all zones, 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, Upland, Slopes and Lowland zones. Bank variability exceeded Reference Conditions at 40%-70% of sites in the Montane, Upland and Slopes zones. 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 Montane, Upland, Slopes and Lowland zones as a result of widespread elevated sediment load (90%-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 little change from reference in Floodplain Sedimentation in the Slopes zone as a result of sedimentation (for 90% of SedNet river segments). There was minor change from Reference Condition in Floodplain Sedimentation in the Lowland zone (90% of SedNet river segments).

**Table OVN 10: Ovens 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) | 97 (93–100) | 100 (100–100) | 100 (94–100) | 98 (94–100) | 95 (84–100) |
| Indicator | Channel Form (volume and flow events) | 91 (85–95) | 99 (98–100) | 87 (76–96) | 89 (78–96) | 93 (86–98) |
| Sub-ind. | Cross-section Form | 91 (85–95) | 96 (91–99) | 92 (84–98) | 86 (74–95) | 95 (92–98) |
| Metric | Channel Depth (mean) | 1.07 (1.01–1.14) | 0.94 (0.84–1.00) | 1.06 (0.95–1.18) | 1.14 (1.02–1.30) | 1.04 (0.99–1.11) |
| Metric | Channel Width (mean) | 1.08 (1.04–1.15) | 0.99 (0.96–1.00) | 1.06 (1.00–1.15) | 1.17 (1.06–1.31) | 1.02 (0.99–1.08) |
| Sub-ind. | Cross-section Form (variability) | 98 (97–99) | 94 (87–100) | 100 (100–100) | 99 (98–100) | 97 (93–99) |
| Metric | Channel Width (CV) | 0.99 (0.97–1.00) | 0.93 (0.86–1.00) | 1.01 (0.99–1.04) | 1.01 (0.98–1.03) | 0.96 (0.93–0.98) |
| Sub-ind. | Channel Planform | 88 (83–92) | 95 (88–99) | 84 (70–94) | 93 (85–98) | 83 (73–90) |
| Metric | Sinuosity | 1.03 (1.01–1.05) | 1.00 (1.00–1.00) | 1.00 (1.00–1.00) | 1.00 (0.99–1.03) | 1.07 (1.01–1.14) |

Continued/...

| Indexes Indicators Metrics | Description | Valley | Zone | | | |
|---|---|---|---|---|---|---|
| | | | Montane | Upland | Slopes | Lowland |
| Metric | Meander Wavelength | 1.03 (0.98–1.09) | 0.89 (0.67–1.00) | 1.11 (1.02–1.23) | 1.03 (0.96–1.12) | 1.00 (0.91–1.11) |
| Indicator | Bed Dynamics | 81 (79–84) | 93 (86–100) | 89 (81–98) | 82 (78–88) | 74 (70–79) |
| Metric | Channel Sediment Ratio | 26 (19–32) | 5 (1.93–7) | 14 (3–28) | 21 (12–30) | 41 (27–57) |
| Metric | Channel Sediment Depth | 0.0003 (0–0.0006) | 0 (0–0) | 0.0001 (0–0.0004) | 0.0003 (0–0.001) | 0.0005 (0–0.001) |
| Indicator | Bank Dynamics | 98 (97–99) | 100 (100–100) | 99 (98–100) | 96 (93–99) | 99 (98–100) |
| Metric | Bank Variability (longitudinal) | 1.11 (1.08–1.15) | 1.02 (1.00–1.06) | 1.09 (1.03–1.15) | 1.19 (1.09–1.30) | 1.06 (1.01–1.12) |
| Indicator | Floodplain | 84 (74–93) | 100 (99–100) | 81 (55–100) | 91 (74–100) | 74 (56–94) |
| Metric | Floodplain Sediment Deposition | 1.29 (0.73–2.00) | 0.42 (0.10–0.74) | 1.07 (0.28–1.97) | 0.78 (0.39–1.40) | 2.00 (0.76–4) |

# OVENS VALLEY

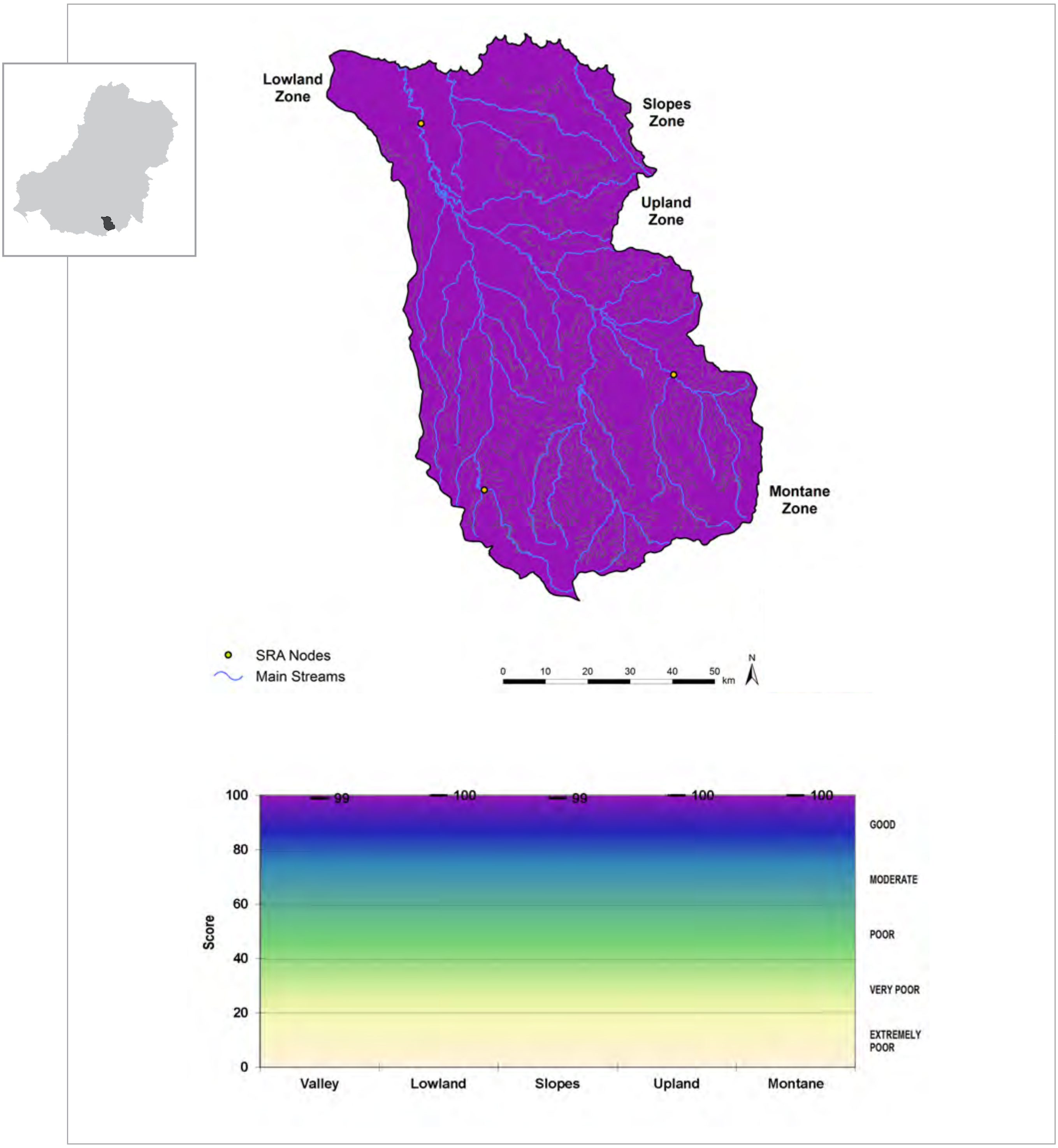



Figure OVN 6: Ovens Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Ovens valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 99. The Lowland, Slopes, Upland and Montane zones were in Good condition. The mainstem river system and headwater streams of the Ovens 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 two principal streams in the Ovens Valley are the Ovens and King rivers. The Ovens rises near Mount Buffalo, flows north-west to Wangaratta thence north to join the Murray at Lake Mulwala, impounded by Yarrawonga Weir. The King rises near the Goulburn catchment and flows north to join the Ovens at Wangaratta. Other tributaries of the Ovens include the Buckland River, joining the Ovens in its Slopes zone, and the Buffalo River and Reedy Creek, joining the Ovens near Wangaratta. Fifteen Mile Creek also joins downstream of Wangaratta. Between its junctions with the Buffalo and the King, the Ovens forms a number of anabranches across a wide floodplain, part-shared with the King. From this point to the Murray, the Ovens flows through a confined floodplain with anabranches and billabongs. There are two instream storages, Lake Buffalo (24 GL) on the Buffalo and Lake William Hovell (14 GL) on the King, but they have little influence on the respective rivers. In the past there was extensive mining of alluvial gold, particularly in the Buckland River and Reedy Creek.

In the Ovens Valley, hydrological condition is assessed using metrics of hydrological alteration available for 1,434 km of mainstem rivers and headwater streams. There are 214 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 Ovens Valley there is 1,220 km of headwater stream (61 km in the Montane zone; 379 km in the Upland zone; 431 km in the Slopes zone; 348 km in the Lowland zone). 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 Ovens Valley there is 545 km of these mid-size tributaries (45 km in the Upland zone; 236 km in the Slopes zone; 264 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,

# OVENS VALLEY

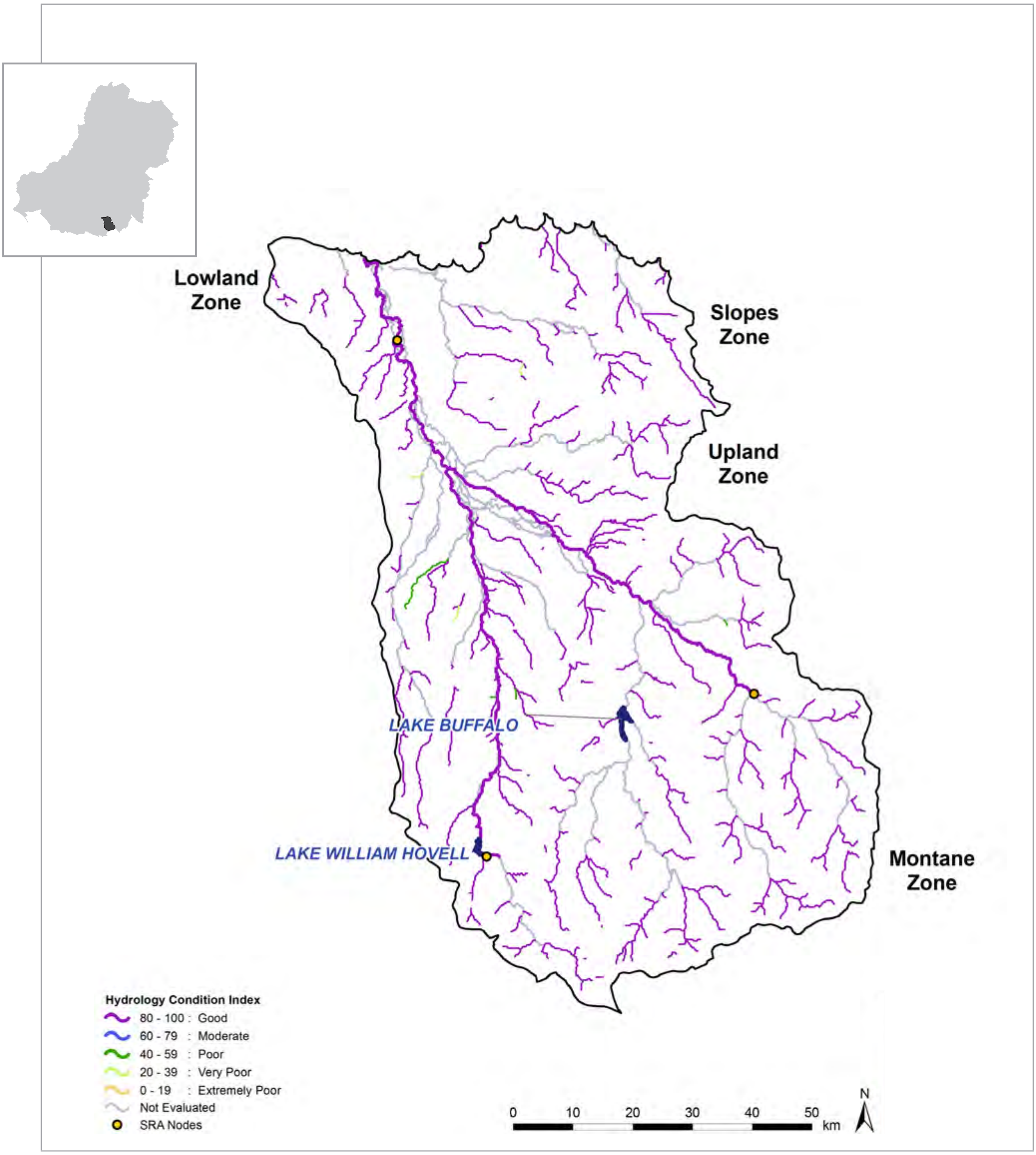



Figure OVN 7: Ovens Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

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

- The Hydrology Condition Index for the whole valley = 99, indicating Good hydrological condition.
- The Hydrology Condition Index for the Montane, Upland, Slopes and Lowland zones = 100, 100, 99 and 100, all 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) = 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.

***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.

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.

# OVENS VALLEY

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 throughout the mainstem river length (mostly associated with increased flows). 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 20% 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.

***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 near Reference Condition. Results for the Low Flow metric showed 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 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 10% of the headwater 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 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. 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 very significant alteration from Reference Condition in 1% of the headwater river length (mostly an increased amplitude) and a significant alteration from reference in 39% 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 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 a significant alteration from reference in 5% 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 Slopes zone and most in the Lowland zone.

### *Summary: mainstem rivers*

The mainstem river system of the Ovens Valley was 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.

### *Summary: headwater streams*

The headwater streams of the Ovens 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. Throughout some of the headwater streams the amplitude of seasonal flow variations was increased.

**Table OVN 11: Ovens 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 | 99 | 100 | 100 | 99 | 100 |

# OVENS VALLEY

**Table OVN 12: Ovens 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)** | **99 (32–100)** |
| Sub-index | In-Channel Flow Regime | 100 (100–100) | 99 (32–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 100 (100–100) | 100 (77–100) |
| Sub-ind. | Flow Gross Volume | 100 (100–100) | 99 (89–100) |
| Metric | Mean Annual Flow | 1.00 (0.99–1.00) | 1.04 (0.84–1.19) |
| Metric | Flow Duration | 1.00 (1.00–1.00) | 1.02 (0.87–1.22) |
| Sub-ind. | High Flow Events | 100 (100–100) | 98 (65–100) |
| Metric | High Flow | 1.00 (0.97–1.00) | 1.10 (0.76–1.70) |
| Metric | High Flow Spells | | |
| Sub-ind. | Low and Zero Flow Events | 98 (92–99) | 97 (60–99) |
| Metric | Zero Flows Proportion | 1.00 (0.99–1.01) | 0.99 (0.96–1.00) |
| Metric | Low Flow | 0.95 (0.70–1.00) | 1.00 (0.28–1.69) |
| Metric | Low Flow Spells | | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 100 (100–100) | 97 (20–100) |
| Sub-ind. | Flow Seasonality | 100 (98–100) | 93 (65–100) |
| Metric | Flow Seasonal Amplitude | 1.00 (1.00–1.00) | 1.17 (0.89–1.66) |
| Metric | Flow Seasonal Period | 0.99 (0.93–1.00) | 0.97 (0.84–1.00) |
| Sub-ind. | Flow Variability | 100 (99–100) | 93 (7–100) |
| Metric | Flow Variation | 1.00 (1.00–1.03) | 0.95 (0.57–1.00) |
| 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** | **100** | **100** | **100** | **100** | **99** |
| | 100 | 100 | 100 | 100 | 100 | 99 |
| | 100 | 100 | 100 | 100 | 100 | 100 |
| | 100 | 100 | 100 | 100 | 99 | 98 |
| | 1.00 | 1.00 | 1.00 | 1.02 | 1.02 | 1.06 |
| | 1.00 | 1.00 | 1.00 | 1.01 | 1.02 | 1.04 |
| | 100 | 100 | 100 | 100 | 99 | 97 |
| | 1.00 | 1.00 | 1.00 | 1.02 | 1.05 | 1.15 |
| | | | | | | |
| | 99 | 99 | 98 | 98 | 98 | 97 |
| | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 |
| | 1.00 | 0.97 | 0.93 | 1.04 | 1.03 | 1.07 |
| | | | | | | |
| | 100 | 100 | 100 | 100 | 100 | 98 |
| | 100 | 100 | 99 | 99 | 98 | 91 |
| | 1.00 | 1.00 | 1.00 | 1.03 | 1.07 | 1.23 |
| | 1.00 | 0.99 | 0.98 | 1.00 | 1.00 | 0.98 |
| | 100 | 100 | 100 | 100 | 100 | 96 |
| | 1.00 | 1.00 | 1.01 | 1.00 | 0.99 | 0.96 |
| | | | | | | |
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| | | | | | | |

# PAROO VALLEY

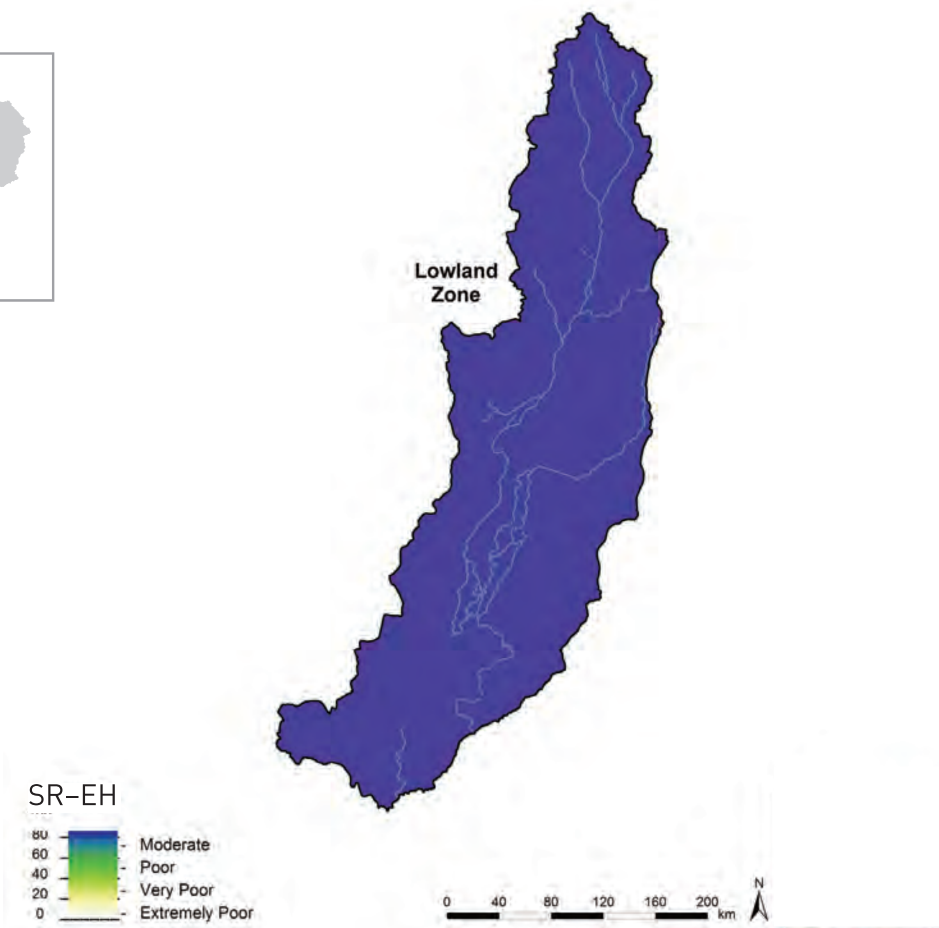


**Figure PAR 1: Paroo Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure PAR 1 shows the Ecosystem Health ratings for the Paroo Valley and Tables PAR 1 and PAR 2 also show the index values and ratings for each Theme. Ecosystem Health is largely equivalent to (near) Reference Condition for the Paroo Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Good, Good and Good condition respectively, while Physical Form and Hydrology were both in Good condition.

The condition ratings for the Fish, Macroinvertebrate and Riverine Vegetation were used to derive an Ecosystem Health Index, which formed the primary basis on which ISRAG rated the River Ecosystem Health of the Paroo Valley river system. River Ecosystem Health was rated as Good for the valley (comprising one Lowland zone).

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

*The Paroo Valley river ecosystem (contained within a single Lowland zone) was in Good health. The Fish community was in Good condition, though some expected species were absent; species counts, abundance and biomass were dominated by native species and recruitment levels among the native species were high. The Macroinvertebrate community was in Good condition, with the frequency and occurrence of expected macroinvertebrate families at near reference levels. Riverine vegetation was in Good condition overall, with diversity, stability, abundance and richness in the Near Riparian and Lowland Floodplain areas, and fragmentation in the Lowland Floodplain all in near Reference Condition. The Physical Form of the river system was in Good condition with channel form, bank and bed dynamics in Good condition, and low levels of floodplain sediment deposition.The river system's Hydrology was in Good condition, with no substantial change from Reference Condition in magnitudes of annual flow volumes, flow variability, seasonality, high flows and low and zero flows.*

### *Ecosystem Health*

The Ecosystem Health of the Paroo Valley river system was assessed as good and all ecosystem components were assessed as being in Good condition. The Paroo Valley was ranked first amongst the 23 SRA valleys in terms of Ecosystem Health. It was also ranked first or equal first for all other Themes except Macroinvertebrate Condition for which it ranked equal third with the Warrego Valley. At the extreme north-western corner of the Murray–Darling Basin, the Paroo did not experience the persistent extreme drought conditions that prevailed in other parts of the Basin, particularly after 2005 (though the valley has a low and variable rainfall naturally). To the degree that it is a 'yardstick' for ecological health it will be informative to assess the health of other valleys relative to the Paroo as climatic conditions improve more generally.

### *Fish Theme*

The Fish Condition Index SR–FI = 83, indicating Good condition (Lowland zone: Good). The Expectedness indicator = 58, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 88, indicating Good condition, and near Reference Condition. The Recruitment indicator = 93, indicating Good condition, and near Reference Condition.

The valley had less than half of its expected native species richness but native fish outnumbered aliens by greater than 9:1. Numbers and distributions of expected native species were reduced compared to Reference Condition but the native species caught were recruiting in the majority of sites in which they occurred.

### *Macroinvertebrate Theme*

The Macroinvertebrate Condition Index SR–MI = 86, indicating Good condition (Lowland zone: Good). The simOE metric = 56 (CL 54–57) indicating a minor difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of site communities in Good condition was very high (82% overall), and the remaining six of the 33 rated sites (18%) were rated in Moderate condition.

Family richness generally was low, but was high relative to Reference Condition.

# PAROO VALLEY

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 100, indicating Good condition (Lowland zone: Good). The Vegetation Abundance and Diversity indicator = 100, indicating Good condition and a minimal or no 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 = 99, indicating Good condition and a minimal or no 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 was little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled floodplain area were at near reference levels.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 99, indicating Good condition (Lowland zone: Good). The Channel Form indicator = 84, the Bed Dynamics indicator = 92, the Bank Dynamics indicator = 97 and the Floodplain Form indicator = 97; all indicating Good condition and near Reference Condition.

Overall, the valley's riverine physical form was characterised by close to Reference Conditions for all indicators, although there was some indication of channel enlargement, elevated sediment loads.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 100, indicating Good condition (Lowland zone: Good). The In-Channel Flow Regime sub-index = 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.

The mainstem river and headwater streams were generally characterised by little or no alteration from Reference Condition 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.

**Table PAR 1: Paroo 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 | LOWLAND |
|---|---|---|---|
| | | Good | Good |

| THEME | | VALLEY | ZONE |
|---|---|---|---|
| | | | LOWLAND |
| Fish | SCORE<br>RATING | 83 (70–88)<br>Good | 83 (70–88)<br>Good |
| Macro-invertebrates | SCORE<br>RATING | 86 (83–89)<br>Good | 86 (83–89)<br>Good |
| Vegetation | SCORE<br>RATING | 100<br>Good | 100<br>Good |

**Table PAR 2: Paroo 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 |
|---|---|---|---|
| | | | LOWLAND |
| Physical Form | SCORE<br>RATING | 99 (96–100)<br>Good | 99 (96–100)<br>Good |
| Hydrology | SCORE<br>RATING | 100<br>Good | 100<br>Good |

# PAROO VALLEY

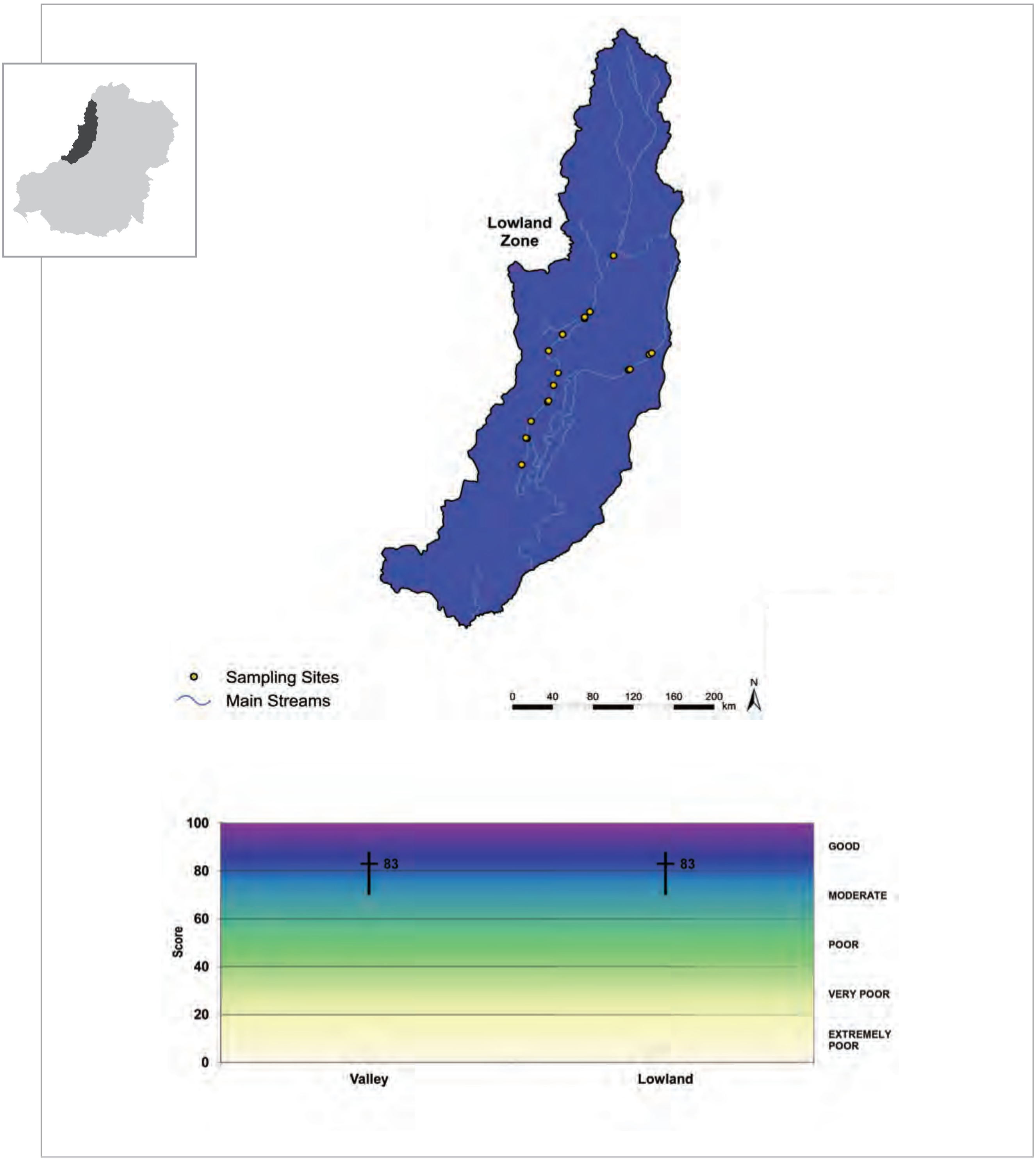


Figure PAR 2: Paroo Valley map with sampling sites and zones coloured by SR Fish Index (SR–FI) scores.

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

*The Fish community of the Paroo Valley river system was in Good condition, with an aggregate Fish Index score (SR–FI) of 83. The fish community was characterised by a Poor score for expected native fish species, a Good score for nativeness and a Good score for native fish recruitment. The valley had less than half of its expected native species richness but native fish outnumbered aliens by greater than 9:1.*

Eighteen sites were surveyed across the Paroo Valley in March–April 2009, yielding 1,262 fish. Analyses showed a minor difference from Reference Condition for the Paroo Valley, with:

- SRA Fish Index (SR–FI) = 83 (CL 70–88), indicating Good condition of the fish community.
- The Expectedness indicator = 58 (CL 51–64), indicating Poor condition, and a large difference from Reference Condition. Only 46% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 88 (CL 80–94), indicating Good condition, and a minor difference from Reference Condition.
- The Recruitment indicator = 93 (CL 71–94), indicating Good condition, and a minor difference from Reference Condition. Evidence of recruitment was observed for all 6 native species observed in the valley.

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

SR–FI for the Paroo Valley was the highest for all valleys, and considerably higher than the next best fish community in the Condamine Valley.

Expectedness was rated as Poor, reflecting the fact that seven of the fish species predicted to be present under Reference Condition were not caught at any of the 18 sampling sites and two of the species that were caught were present at less than half the sites.

Nativeness was rated as Good. Only three alien species were caught and these contributed less than 10% of the number of fish caught and 44% of the total fish biomass.

Table PAR 4 shows native species abundances in the Paroo Valley compared with Reference Condition. Bony herring was the most numerous species caught followed by golden perch. Freshwater catfish, Murray cod and silver perch were expected under Reference Condition but did not appear in samples. Gudgeon were expected to be wide spread but only one specimen was caught. Three alien species were caught. Common carp was the most numerous, with 81 individuals, but these were mostly small with a mean weight of 123 g.

# PAROO VALLEY

The Paroo Valley ranked first amongst all 23 Basin valleys for Recruitment. All native fish species caught showed evidence of recruitment at some sites. Bony herring was caught at 17 of the 18 sites sampled and recruits were observed at all 17 sites. Golden perch, also caught at 17 sites, had recruits at 14 of them and spangled perch had recruits in 11 of the 16 sites in which the species was captured. Of the three alien species, only goldfish showed no evidence of recruitment.

In general, the fish community of the Paroo had reduced numbers and distributions of expected native species but all those observed, were recruiting in the majority of sites in which they occurred. The balance between native and alien species, as reflected by the Nativeness indicator, was Good.

**Table PAR 3: Paroo 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 |
|---|---|---|---|
| | | | Lowland |
| Index | Fish Condition (SR–FI) | 83 (70–88) | 83 (70–88) |
| Indicator | Expectedness | 58 (51–64) | 58 (51–64) |
| Metric | O/E | 0.67 (0.57–0.76) | 0.67 (0.57–0.76) |
| Metric | O/P (Zone level) | 0.46 (0.46–0.46) | 0.46 (0.46–0.46) |
| Indicator | Nativeness | 88 (80–94) | 88 (80–94) |
| Metric | Proportion biomass native | 0.61 (0.48–0.74) | 0.61 (0.48–0.74) |
| Metric | Proportion abundance native | 0.92 (0.88–0.95) | 0.92 (0.88–0.95) |
| Metric | Proportion species native | 0.76 (0.70–0.83) | 0.76 (0.70–0.83) |

Continued/...

| Indexes Indicators Metrics | Description | Valley | Zone |
|---|---|---|---|
| | | | Lowland |
| Indicator | Recruitment | 93 (71–94) | 93 (71–94) |
| Metric | Proportion of sites with native recruits | 0.79 (0.66–0.84) | 0.79 (0.66–0.84) |
| Metric | Proportion of native taxa with recruits | 1.00 (1.00–1.00) | 1.00 (1.00–1.00) |
| Metric | Proportion of abundance as recruits | 0.78 (0.55–0.73) | 0.78 (0.55–0.73) |
| Variables | | | |
| | Number of sites sampled | 18 | 18 |
| | Total number of species | 9 | 9 |
| | Number of native species | 6 | 6 |
| | Number of predicted species | 13 | 13 |
| | Number of alien species | 3 | 3 |
| | Mean number of fish per site | 70 | 70 |
| | Biomass/site all species (g) | 1448 | 1448 |
| | Mean native biomass/fish (g) | 13 | 13 |
| | Mean alien biomass/fish (g) | 94 | 94 |

# PAROO VALLEY

**Table PAR 4: Paroo 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 |
|---|---|---|
| | | Lowland |
| Sites sampled | 18 | 18 |
| Native species | | |
| Australian smelt | 0 | 0 |
| Bony herring | 915 | 915 |
| Desert rainbowfish | 0 | 0 |
| Freshwater catfish | 0 | 0 |
| Golden perch | 112 | 112 |
| Gudgeon | 1 | 1 |
| Hyrtl's tandan | 23 | 23 |
| Murray cod | 0 | 0 |
| Murray–Darling rainbowfish | 40 | 40 |
| Olive perchlet | 0 | 0 |
| Silver perch | 0 | 0 |
| Southern purple-spotted gudgeon | 0 | 0 |
| Spangled perch | 49 | 49 |

Continued/...

| Fish species | Valley | Zone |
|---|---|---|
| | | Lowland |
| Alien species | | |
| Common carp | 81 | 81 |
| Gambusia | 5 | 5 |
| Goldfish | 36 | 36 |

# PAROO VALLEY

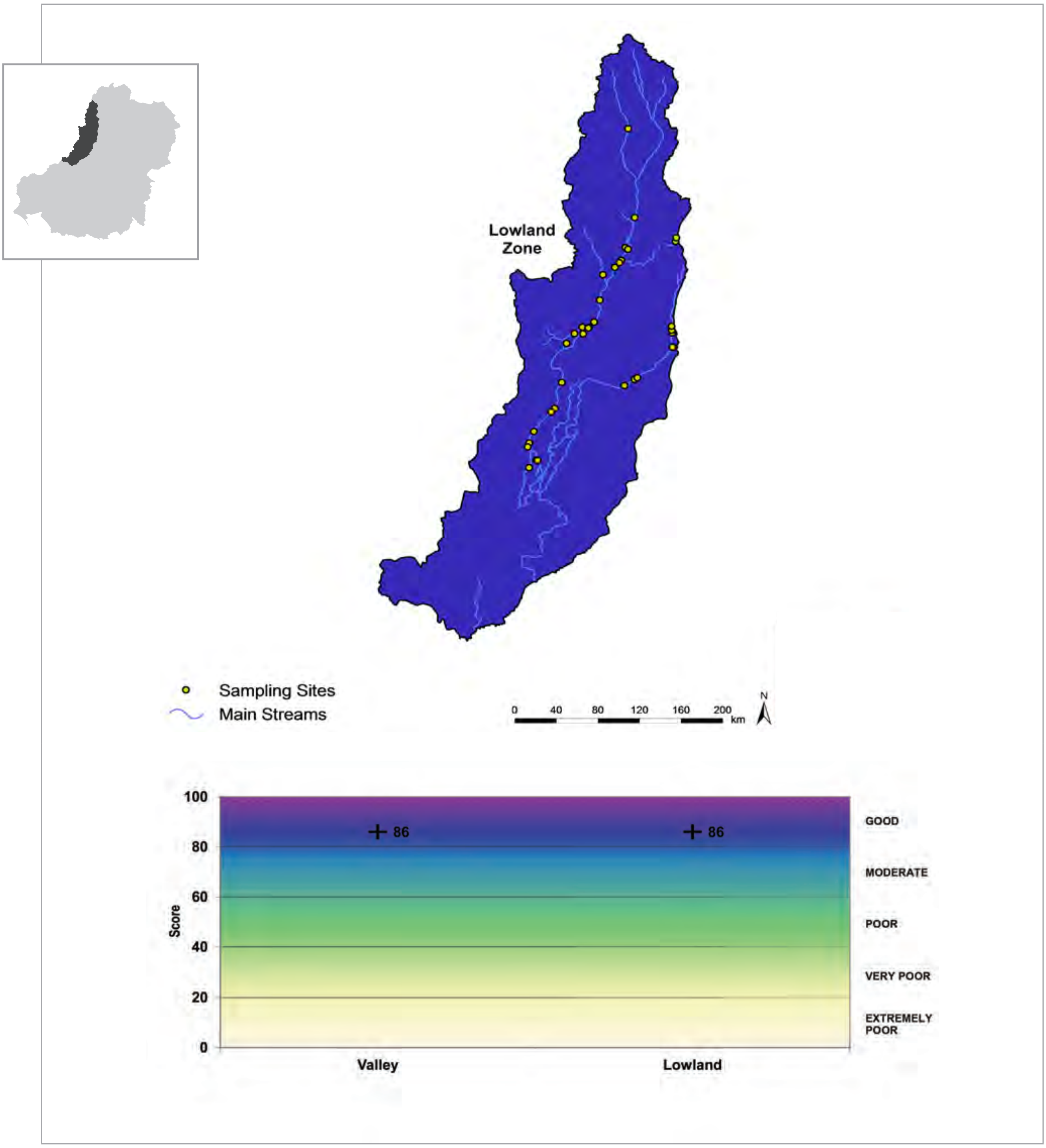


Figure PAR 3: Paroo Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Paroo Valley river system was in Good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 86.*

*The proportion of sites in Good condition was very high (82%); the remaining six of 35 rated sites (18%) were in Moderate condition. Family richness generally was low, but was high relative to Reference Condition.*

Thirty-five sites were surveyed across the Paroo Valley in April–July 2010 yielding 6,068 macroinvertebrates in 38 families (40% of Basin families). Analyses showed a minor difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 86 (CL 83–89), indicating Good condition of benthic macroinvertebrate communities.
- The simOE metric = 56 (CL 54–57) 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 site communities in Good condition was very high across both zones (82% overall), and the remaining six of the 33 rated sites (18%) were rated in Moderate condition.
- 38 families were found in the valley and an average of 18 families per site.

Figure PAR 3 shows sampling sites, zones and SR–MI values, and Table PAR 5 shows index and metric values. The SR–MI score for the Paroo Valley indicated Good condition of macroinvertebrate communities, rating 3rd highest out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of the valley showed no or minor differences from Reference Condition (SR–MI = 86). A small confidence interval (6 points) for the SR–MI value indicates low spatial variability in condition. Expectedness (simOE) was moderate to high and varied by only 19 points among sites.

Table PAR 6 shows that most sites had high SR–MI values; six sites were rated in Moderate condition, with four of these falling at the upper end of the moderate range. No site had a low simOE score (<40 points). Most sites had the expected diversities of macroinvertebrates, occasionally accompanied with slight reductions in frequency of occurrence of the families present.

Family richness generally was high compared to Reference Condition. Diversity was low (average 18 families per site). This river system has naturally low macroinvertebrate diversity at family level. The valley contained 40% of the families found across the Basin (Table PAR 6).

# PAROO VALLEY

**Table PAR 5: Paroo 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 |
|---|---|---|---|
| | | | Lowland |
| Index | Macroinvertebrate Condition (SR–MI) | 86 (83–89) | 86 (83–89) |
| Metric | SimOE | 56 (54–57) | 56 (54–57) |

Table PAR 6: Paroo Valley distribution of sample sites and values of derived variables.

| Number of sites and families sampled | Valley | Zone |
|---|---|---|
| | | Lowland |
| Sites | | |
| Number of sites sampled | 35 | 35 |
| Number of sites with index values* | 33 | 33 |
| N sites by SR–MI condition band | | |
| Good (80–100) | 27 | 27 |
| Moderate (60–80) | 6 | 6 |
| Poor (40–60) | | |
| Very or Extremely Poor (0 – 40) | | |
| Families | | |
| Number of families sampled | 38 | 38 |
| No. families/site (min–max) | 18 (11–25) | 18 (11–25) |
| Percent of families in Basin | 40 | 40 |
| Percent of families in valley | 100 | 100 |

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

# PAROO VALLEY

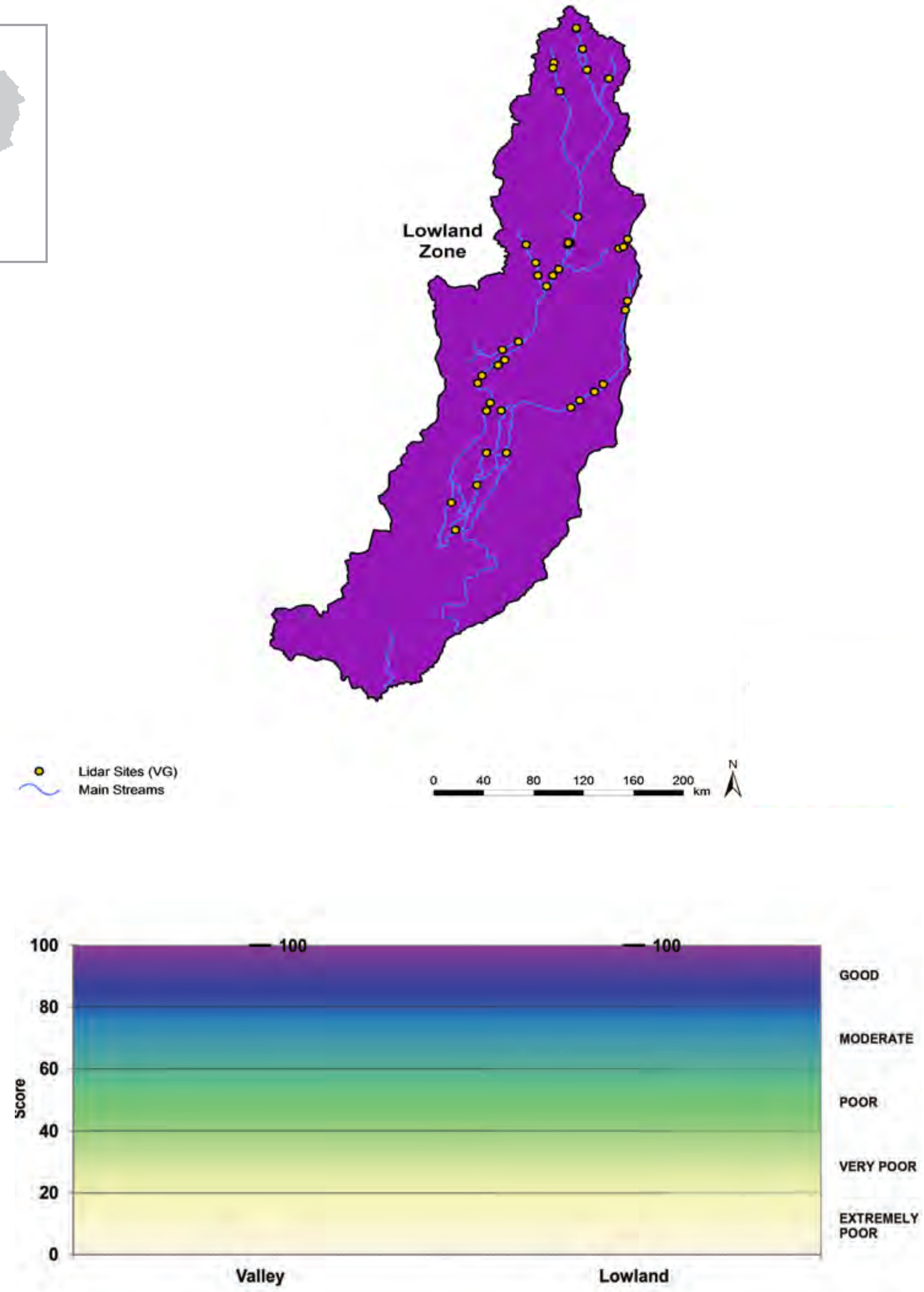


Figure PAR 4: Paroo Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Paroo Valley river system was in Good condition, with an aggregate Vegetation Index score (SR–VI) of 100. Overall condition for the only zone in this valley, Lowland was Good.*

*The Abundance and Diversity indicator score was 100 for the valley, indicating a Good rating overall.*

*The Quality and Integrity indicator score was 99 for the valley, also indicating a Good rating overall.*

The SRA Vegetation assessment for the Paroo Valley considers riverine vegetation in two spatial domains: Near Riparian, along 1,935 km of stream, and Lowland Floodplain, for 7,573 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. 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 41 sites set back 50 m from the top of the bank. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure PAR 4 shows values of the Vegetation Index (SR–VI) for the Paroo Valley and Table PAR 7 shows the index, indicator and sub-indicator values. Tables PAR 8 and PAR 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 Paroo Valley with:

- SRA Vegetation Index (SR–VI) = 100, indicating Good condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 100, indicating a 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 = 99, 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 little affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

The Abundance and Diversity of valley vegetation is in Good condition overall, being near Reference Condition. 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 is near Reference Condition for both the Near Riparian and Lowland Floodplain domains. MVG richness in both the Near Riparian and Lowland Floodplain domains is near Reference Condition. Vegetation in the Lowland Floodplain domain has 99% stability.

In addition, the Quality and Integrity of valley vegetation is in Good condition overall. 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 PAR 8 as well as other native but non-specific MVGs. Valley-wide Nativeness is near Reference Condition in both the Near Riparian and Lowland Floodplain domains. The degree of MVG fragmentation in the Lowland Floodplain 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 in the Lowland zone 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 Good condition overall and the metrics show no difference between the domains, with abundance being near Reference Condition in both the Near Riparian and Lowland Floodplain domains.

***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 no difference between the domains, with abundance being near Reference Condition in both.

***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. 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 near Reference Condition, with the number of patches and mean patch area being near Reference Condition for all MVGs present.

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

- Lowland zone: The Near Riparian domain was mostly (53% of the domain area) Eucalypt Woodlands with nine other MVGs, four of which covered at least 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was mostly Eucalypt Woodlands (30% of the domain area) and Tussock Grasslands (25%), with eight other MVGs four of which covered 5% or more of the domain.

Under current conditions, according to the GIS layer "NVIS_IntVeg_vz", the riverine vegetation in the valley is little reduced, and there is no detectable effect on individual MVGs, which are all equivalent in condition to Reference Condition.

- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG. Less than 1% of the domain is cleared or non-native vegetation, and the current area of each MVG is the same as Reference Condition.
- Lowland zone: The Lowland Floodplain domain is still mostly Eucalypt Woodlands and Tussock Grasslands and the extent of these two MVGs is almost unchanged from Reference Condition. Less than 1% of the domain is cleared or non-native vegetation, and the current area of each MVG is the same as Reference Condition.

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 2009–2010. This means that the Structure sub-indicator and three mapping metrics (abundance, richness and nativeness) are off-set slightly in time and space, and for this reason are not readily integrated into a single assessment. 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, which is not current and 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 of the Paroo Valley is notable for its Good condition and lack of change and loss, and for the condition of the Near Riparian and Lowland Floodplain domains being similar.

Riverine vegetation in the Paroo Valley is in Good condition, with near Reference Condition scores for nativeness, MVG abundance and richness, stability and fragmentation. There is very little difference between the Near Riparian and Lowland Floodplain domains, as all metrics and sub-indicators are near reference except for Structure in the Near Riparian domain. These two domains assess overlapping parts of the riverine landscape: the Lowland Floodplain is land that floods associated with the main channels and flood-out areas in the riverine corridor, whereas the Near Riparian domain is centred on all channels in the network, and about one tenth the area.

# PAROO VALLEY

**Table PAR 7: Paroo 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 |
|---|---|---|---|
| | | | Lowland |
| **Index** | **Vegetation Condition (SR-VI)** | **100** | **100** |
| Indicator | Abundance and diversity | 100 | 100 |
| Metric | LF stability | 0.99 | 0.99 |
| **Sub-ind.** | **NRLF richness** | **100** | **100** |
| Metric | NR richness | 1 | 1 |
| Metric | LF richness | 1 | 1 |
| **Sub-ind.** | **NRLF abundance** | **100** | **100** |
| Metric | NR abundance | 1 | 1 |
| Metric | LF abundance | 0.99 | 0.99 |
| Indicator | Quality and integrity | 99 | 99 |
| **Sub-ind.** | **NRLF nativeness** | 100 | 100 |
| Metric | NR nativeness | 1 | 1 |
| Metric | LF nativeness | 0.99 | 0.99 |
| **Sub-ind.** | **NR structure** | **79 (73–85)** | **79 (73–85)** |
| **Sub-ind.** | **LF fragmentation** | **98** | **98** |

**Table PAR 8: The most abundant MVGs in the Near Riparian domain in the Paroo 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 |
|---|---|
| | Lowland |
| **MVG** | |
| 5. Eucalypt Woodlands | 53 |
| 6. Acacia Forests and Woodlands | 17 |
| 8. Casuarina Forests and Woodlands | 8 |
| 13. Acacia Open Woodlands | 76 |
| 19. Tussock Grasslands | 8 |

**Table PAR 9: Most abundant MVGs in the Lowland Floodplain domain of the Paroo Valley.**

Showing percentage of domain area under Reference Condition in the Paroo 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 | 30 | 1.03 | 0.97 |
| 6. Acacia Forests and Woodlands | 17 | 1.04 | 0.93 |
| 8. Casuarina Forests and Woodlands | 8 | 1 | 1 |
| 11. Eucalypt Open Woodlands | 6 | 1.05 | 0.95 |
| 13. Acacia Open Woodlands | 10 | 1.01 | 0.98 |
| 19. Tussock Grasslands | 25 | 1 | 1 |

# PAROO VALLEY

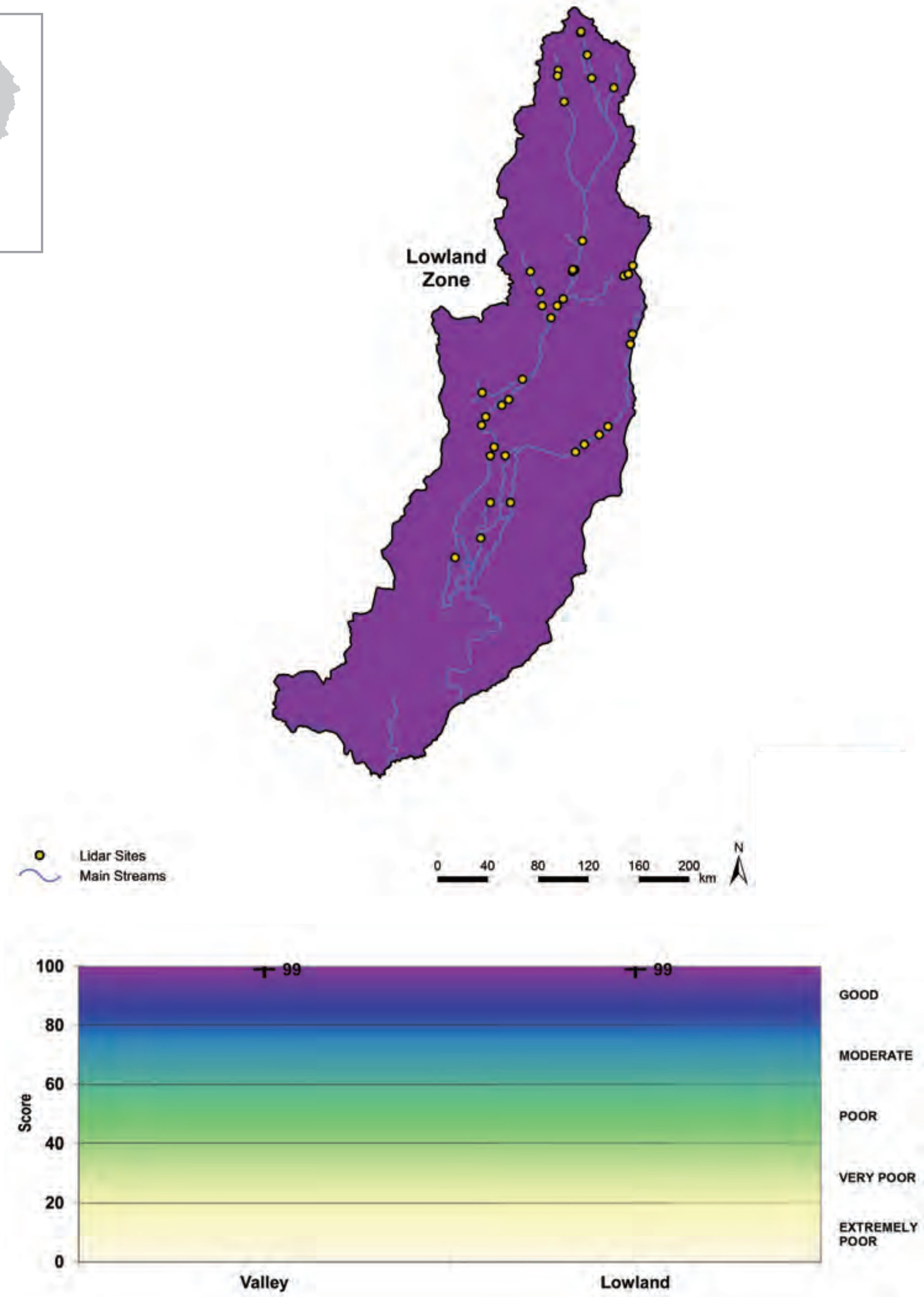


**Figure PAR 5: Paroo Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.**

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

*The Physical Form of the Paroo Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 99. The valley's river Channel Form, Bank Dynamics, Bed Dynamics and Floodplain Dynamics were rated as Good.*

*Overall, the valley's riverine physical form was characterised by close to Reference Conditions for all indicators, although there was some indication of channel enlargement and elevated sediment loads.*

The SRA Physical Form assessment considers physical form and processes along 1,935 km of stream across the valley. It is based on LiDAR data collected at 40 sites along river channels, as well as modelling of all 393 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 PAR 5 shows values of the Physical Form Index (SR–PI) for the Paroo Valley and Table PAR 10 shows the index, indicator, sub-indicator and metric values.

Analyses showed near Reference Condition for the Paroo Valley with:

- SRA Physical Form Condition Index (SR–PI) = 99 (CL 96–100), indicating Good Physical Form condition
- the Channel Form indicator = 84 (CL 77–90), showing near Reference Condition
- the Bed Dynamics indicator = 92 (CL 90–94), showing near Reference Condition
- the Bank Dynamics indicator = 97 (CL 94–99), showing near Reference Condition
- the Floodplain indicator = 97 (CL 94–100), showing near Reference Condition.

***Lowland zone***

There were 40 LiDAR survey sites and 393 SedNet river segments in the Lowland zone of the Paroo Valley—noting that the valley was comprised of only this one, single Lowland zone. 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. 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). Sinuosity and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites Sinuosity was generally reduced and there was a moderate increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Channel Width Variability, Meander Wavelength and Bank Variability were modified from Reference Condition for less than half of the Lowland zone. At these sites Channel Width Variability and Bank Variability were generally reduced and results show both increases and decreases in Meander Wavelength across the zone. Channel Width was largely unmodified from reference in the Lowland zone.

***Channel Form***

There was little 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 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 Lowland zone. There was little overall change from Reference Condition in Bed Dynamics in the Lowland zone as a result of sedimentation (noted for 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.

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 Lowland zone as a result of widespread sedimentation (100% of SedNet river segments).

**Table PAR 10: Paroo 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 |
|---|---|---|---|
| | | | Lowland |
| Index | Physical Form Condition (SR–PI) | 99 (96–100) | 99 (96–100) |
| Indicator | Channel Form (volume and flow events) | 84 (77–90) | 84 (77–90) |
| Sub-ind. | Cross-section Form | 75 (68–81) | 75 (68–81) |
| Metric | Channel Depth (mean) | 1.31 (1.17–1.46) | 1.31 (1.17–1.46) |
| Metric | Channel Width (mean) | 1.08 (0.99–1.18) | 1.08 (0.99–1.18) |
| Sub-ind. | Cross-section Form (variability) | 93 (88–97) | 93 (88–97) |
| Metric | Channel Width (CV) | 0.98 (0.93–1.03) | 0.98 (0.93–1.03) |
| Sub-ind. | Channel Planform | 90 (84–95) | 90 (84–95) |
| Metric | Sinuosity | 0.97 (0.96–0.98) | 0.97 (0.96–0.98) |
| Metric | Meander Wavelength | 1.01 (0.98–1.05) | 1.01 (0.98–1.05) |
| Indicator | Bed Dynamics | 92 (90–94) | 92 (90–94) |
| Metric | Channel Sediment Ratio | 12 (8–17) | 12 (8–17) |
| Metric | Channel Sediment Depth | 0.0005 (0.0003–0.0006) | 0.0005 (0.0003–0.0006) |
| Indicator | Bank Dynamics | 97 (94–99) | 97 (94–99) |
| Metric | Bank Variability (longitudinal) | 0.99 (0.95–1.03) | 0.99 (0.95–1.03) |
| Indicator | Floodplain | 97 (94–100) | 97 (94–100) |
| Metric | Floodplain Sediment Deposition | 0.40 (0.17–0.76) | 0.40 (0.17–0.76) |

# PAROO VALLEY

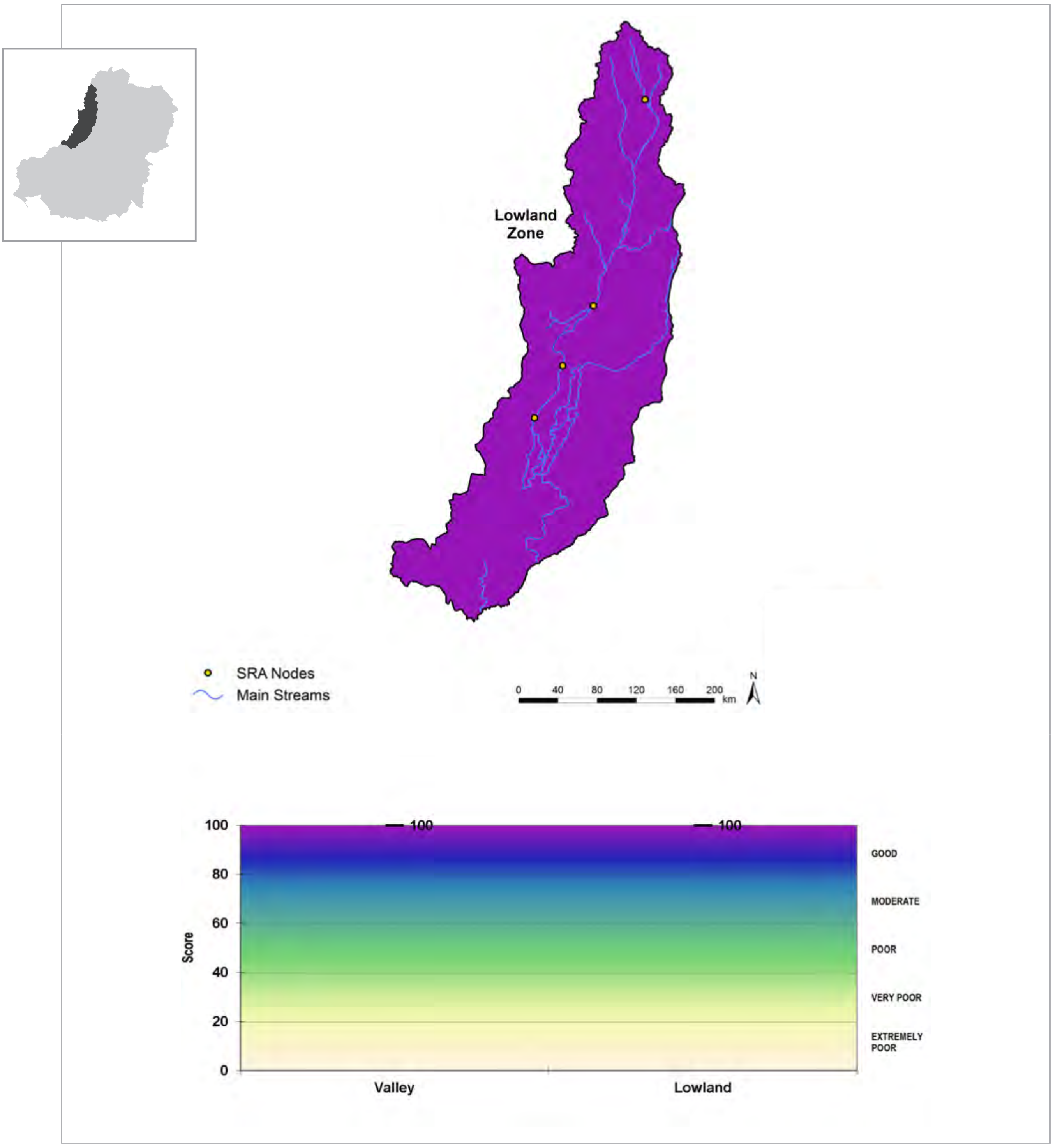


**Figure PAR 6: Paroo Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.**
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Paroo Valley river system was in Good condition, with an aggregate Hydrology Index score of 100. The mainstem riversystem and headwater streams of the Paroo Valley were rated in Good condition, with all hydrological indicators assessed as being equivalent to Reference Condition.*

The Paroo is the most north-westerly valley in the Murray–Darling Basin. It is an episodic stream, and at the Wanaaring gauge (Site 1), the furthest point downstream where gauging is possible, there is no flow for about 37% of the time. Beyond this point the river dissipates into a large deflation area, the Paroo Overflow, which contains significant wetlands. Water rarely proceeds from this area to the Darling. There is little diversion from the Paroo (about 4 GL/y) and no instream storages. Most of the valley has access to the Great Artesian Groundwater Basin.

In the Paroo Valley, hydrological condition is assessed using metrics of hydrological alteration available for 8,179 km of mainstem rivers and headwater streams. There are 728 km of mainstem river extending across the Lowland zone. In the mainstem river, streamflow data for current and reference flow conditions were provided by daily water resource modelling. In the Paroo Valley there is 7,451 km of headwater stream all of which is in the Lowland zone. 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 Paroo Valley there is 5,262 km of these mid-size tributaries, which is 0.6 times the stream length for which metrics are available. All of these midsize tributaries are in the Lowland zone.

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

- The Hydrology Condition Index for the whole valley = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for the Lowland zone = 100 indicating Good hydrological condition.

# PAROO VALLEY

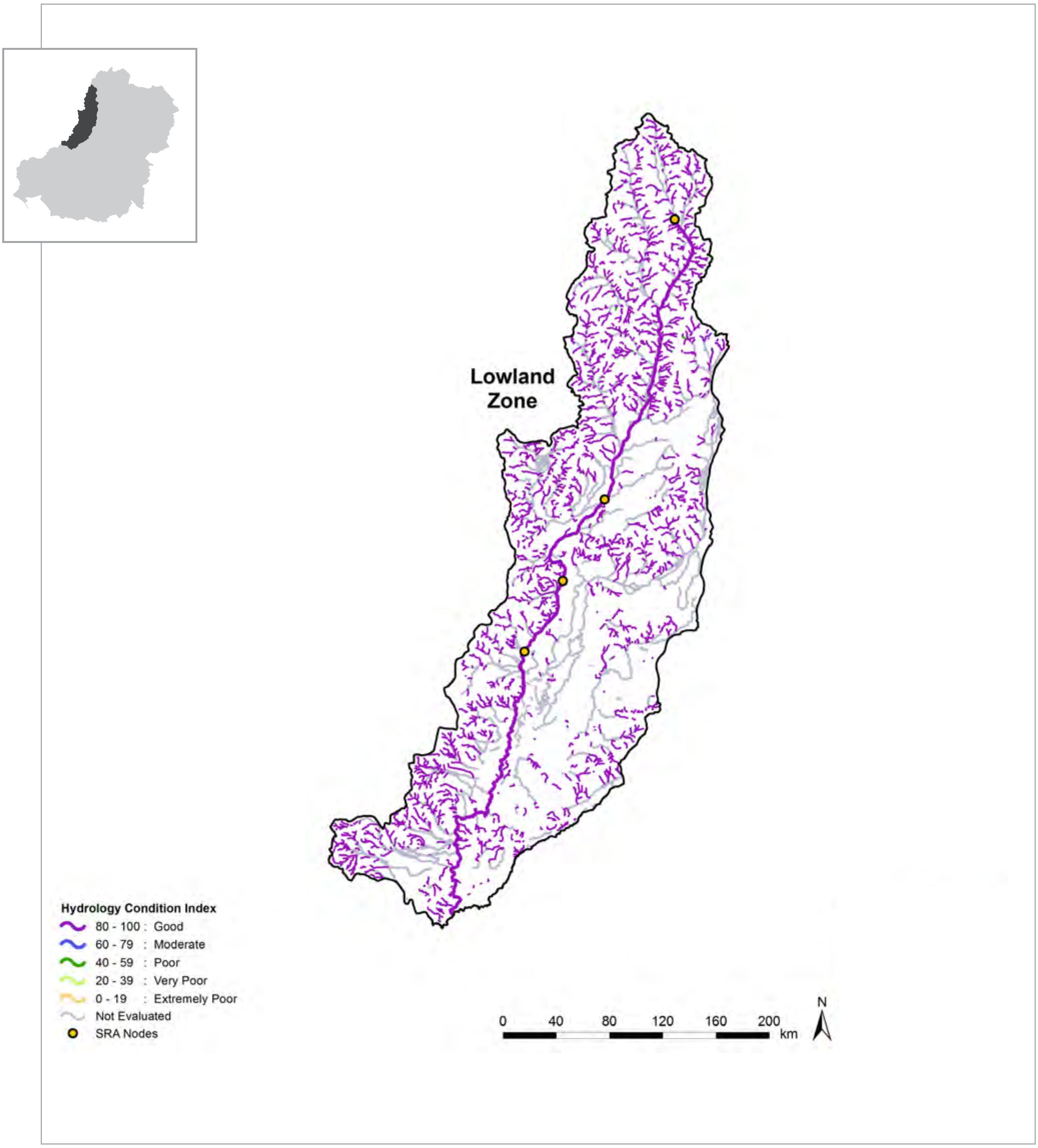


Figure PAR 7: Paroo Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

- The Hydrology Condition Index for headwater streams (valley-wide) = 100, indicating Good hydrological condition.
- 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 Condition.

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 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).

# PAROO 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 22% 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 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 near Reference Condition. Results for the Low Flow metric showed only small variations from reference 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 (associated with both increased and reduced flows).

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 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 only small variations from reference throughout the headwater river length (mostly associated with an increased amplitude). Results for the Seasonal Period metric showed only small variations from reference throughout the headwater river length.

### *Flow Variability*

The Flow Variability 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 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 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 increased 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 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 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 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 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).

# PAROO VALLEY

***Summary: mainstem rivers***

The mainstem river system of the Paroo 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.

***Summary: headwater streams***

The headwater streams of the Paroo 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. Throughout some of the headwater streams the amplitude of seasonal flow variations was increased.

**Table PAR 11: Paroo 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 |

# PAROO VALLEY

**Table PAR 12: Paroo 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).

| | | Valley | |
|---|---|---|---|
| | | Mainstem rivers | Headwater streams |
| **Index** | **Hydrological Condition (Mainstem: SR-HI*m*, Headwater: SR-HI*h*)** | **100 (100–100)** | **100 (49–100)** |
| Sub-index | In-Channel Flow Regime | 100 (100–100) | 100 (49–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 100 (100–100) | 100 (50–100) |
| Sub-ind. | Flow Gross Volume | 100 (100–100) | 100 (98–100) |
| Metric. | Mean Annual Flow | 1.00 (1.00–1.00) | 1.00 (0.93–1.08) |
| Metric | Flow Duration | 1.00 (1.00–1.00) | 0.98 (0.90–1.05) |
| Sub-ind. | High Flow Events | 99 (99–99) | 97 (9–100) |
| Metric | High Flow | 1.00 (1.00–1.00) | 0.91 (0.10–1.23) |
| Metric | High Flow Spells | 1.00 (1.00–1.00) | |
| Sub-ind. | Low and Zero Flow Events | 98 (97–98) | 99 (87–99) |
| Metric | Zero Flows Proportion | 0.98 (0.95–1.00) | 1.00 (0.96–1.00) |
| Metric | Low Flow | 1.00 (1.00–1.00) | 0.99 (0.60–1.09) |
| Metric | Low Flow Spells | 0.96 (0.91–1.00) | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 100 (100–100) | 100 (74–100) |
| Sub-ind. | Flow Seasonality | 100 (100–100) | 100 (85–100) |
| Metric. | Flow Seasonal Amplitude | 1.00 (1.00–1.00) | 0.99 (0.89–1.34) |
| Metric | Flow Seasonal Period | 0.99 (0.99–1.00) | 0.99 (0.90–1.00) |
| Sub-ind. | Flow Variability | 100 (100–100) | 98 (59–100) |
| Metric | Flow Variation | 1.00 (1.00–1.00) | 0.98 (0.76–1.00) |
| 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 | | | |
| | | | 1.00 | | | |
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# WARREGO VALLEY

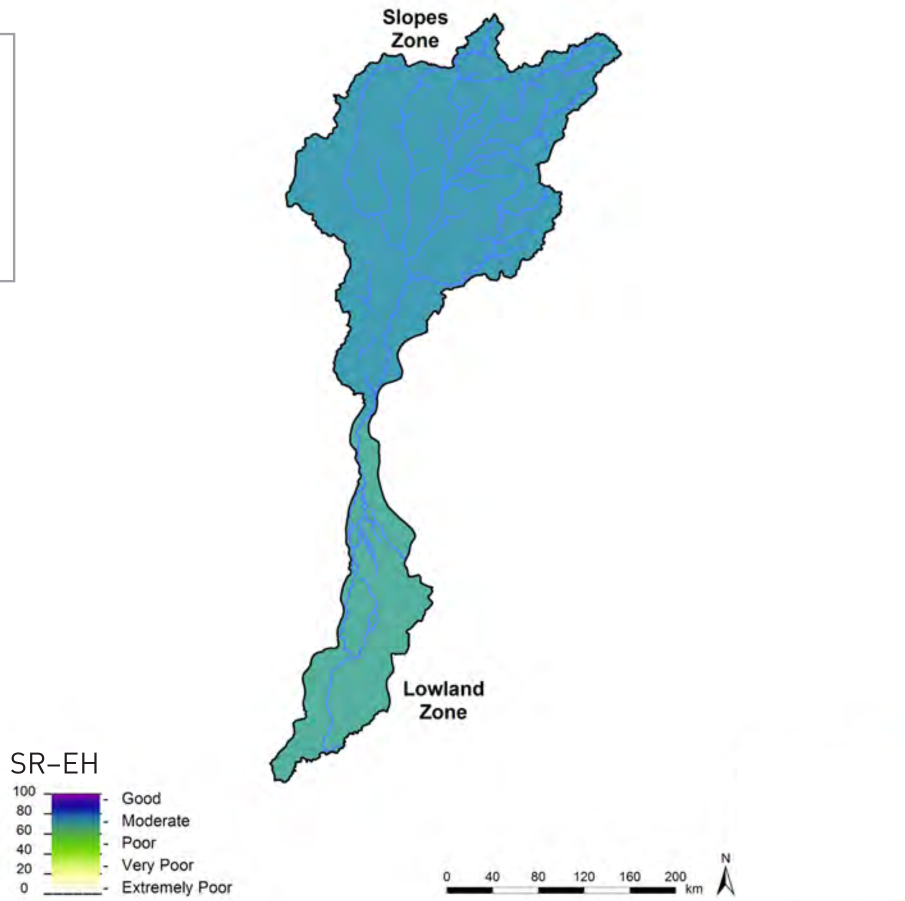



**Figure WAR 1: Warrego Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

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

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

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

*The Warrego Valley river ecosystem was in Moderate Health. River Ecosystem Health for the zones was as follows: Slopes and Lowland Moderate. The Fish community was in Poor condition with some expected species absent. Species count and abundance were dominated by native species but biomass was dominated by aliens; levels of recruitment among the remaining native species were low. The Macroinvertebrate community was in Good condition, with substantial declines in the frequency and occurrence of expected macroinvertebrate families. Riverine Vegetation was in Good condition overall, with all indicators except structure at close to reference values in near riparian and lowland floodplain domains. 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 low to moderate levels of floodplain sediment deposition. The river system's Hydrology was in Good condition, with magnitudes of annual flow volumes, low and zero flows, variability, seasonality and high flows all close to reference values.*

### *Ecosystem Health*

The Warrego Valley was ranked second highest amongst the 23 SRA valleys in respect to River Ecosystem Health and is the only valley rated in Moderate Health (see Table 5.2). All Theme condition indices ranked the Warrego in the top quartile of valleys.

In terms of Physical Form the valley was ranked equal sixth (with the Broken), mainly as a result of sedimentation in the Lowland zone and changes to channel morphology.

The valley was also ranked sixth in terms of Fish condition. Its score of 'Poor' was mainly the result of the absence of some native species and a low level of native fish recruitment. Recruitment might have been expected to be improving given that fish sampling was in a year following above-average rainfall, but details of the hydrological response and an understanding of the lags involved in the biological response are not available to assess this. Data collected following the recent breaking of the drought are required.

The high ranking in respect to Hydrology and Vegetation (equal first in both cases) indicate a valley relatively free of the effects of intensive land and water management.

### *Fish Theme*

The Fish condition Index SR–FI = 50, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Poor). The Expectedness indicator = 67, indicating Moderate condition, and a moderate difference from Reference Condition. The Nativeness indicator = 89, indicating Good, near Reference Condition. The Recruitment indicator = 33, indicating Very Poor condition, and a very large difference from Reference Condition.

Native species richness was reduced by over a third but native species still contributed over 58% of fish biomass. Native fish recruitment was Very Poor in both zones.

# WARREGO VALLEY

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 86, indicating Good condition (Lowland zone: Good; Slopes zone: Good). The simOE metric = 55, indicating a minor difference from Reference Condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of site communities in Good condition was high across both zones (74% overall); nine of the 32 rated sites (26%) were in Good condition (seven of which were in the Lowland zone), and none rated as in Poor condition.

Family richness generally was low, but was high relative to Reference Condition.

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 100, indicating Good condition (Lowland zone: Good; Slopes zone: Good). The Vegetation Abundance and Diversity indicator = 100, indicating Good condition and 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 = 98, indicating Good condition and near 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 only slightly affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled floodplain are at near reference levels.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 89, indicating Good condition (Lowland zone: Good; Slopes zone: Good). The Channel Form indicator = 84, the Bank Dynamics indicator = 96 and the Floodplain Form indicator = 81; all indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 72, 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 associated with limited sedimentation within the Lowland zone river channel and floodplain. There was also evidence of channel contraction.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 100, indicating Good condition (Lowland zone: Good; Slopes zone: Good). The In-Channel Flow Regime sub-index = 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.

Mainstem river and headwater streams were 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 and Flow Gross Volume.

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

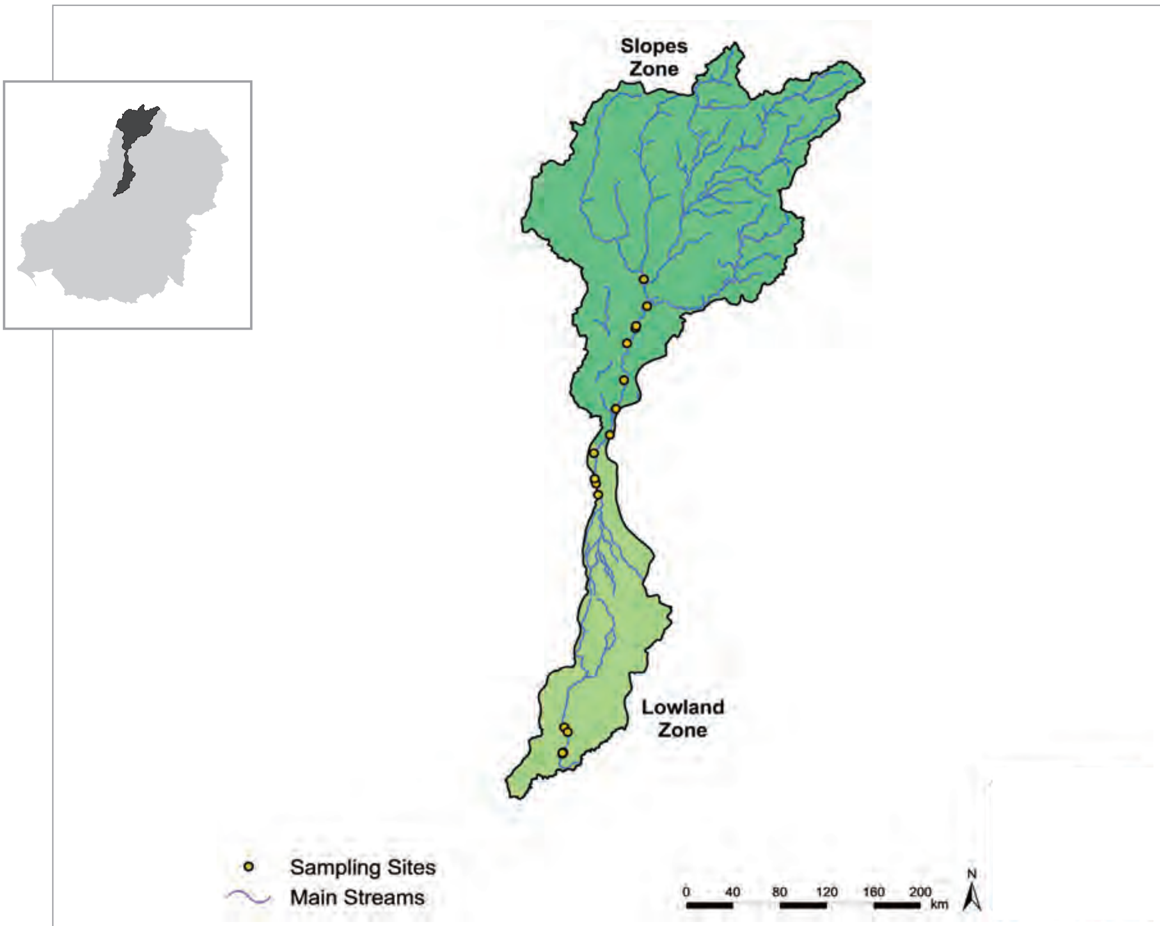
| Ecosystem Health | HEALTH RATING | VALLEY | SLOPES | LOWLAND |
|---|---|---|---|---|
| | | Moderate | Moderate | Moderate |

| THEME | | VALLEY | ZONE | |
|---|---|---|---|---|
| | | | SLOPES | LOWLAND |
| Fish | SCORE RATING | 50 (45–55) Poor | 53 (48–60) Poor | 38 (28–46) Very poor |
| Macro-invertebrates | SCORE RATING | 86 (83–89) Good | 87 (83–90) Good | 83 (80–86) Good |
| Vegetation | SCORE RATING | 100 Good | 100 Good | 100 Good |

**Table WAR 2: Warrego 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 (85–93) Good | 91 (88–94) Good | 84 (64–95) Good |
| Hydrology | SCORE RATING | 100 Good | 100 Good | 100 Good |

# WARREGO VALLEY



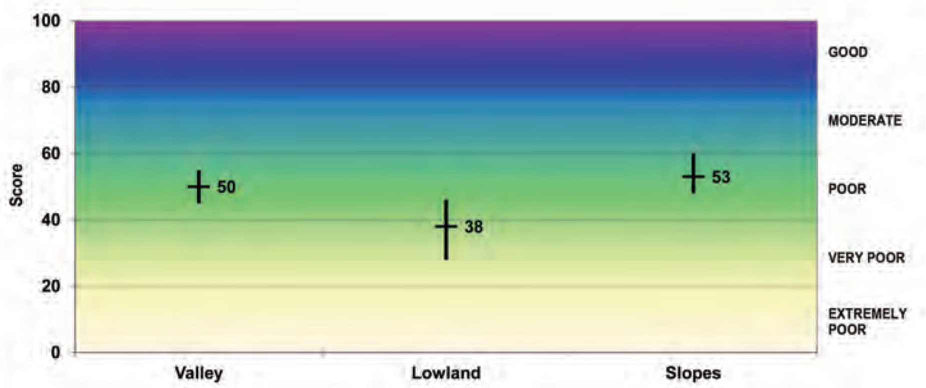




**Figure WAR 2: Warrego Valley map with sampling sites and zones coloured by SR Fish Index (SR–FI) scores.**

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

*The Fish community of the Warrego Valley river system was in Poor condition, with an aggregate Fish Index score (SR–FI) of 50. The condition of the fish community in the zones was as follows: Slopes Poor; Lowland Very Poor. The fish community was characterised by a Moderate score for expected native fish species, a Good score for nativeness and a Very Poor score for native fish recruitment (in both the Slopes and Lowland zones). The valley had lost native species richness but native species still contributed over 58% of the biomass in samples.*

Eighteen sites were surveyed across the Warrego Valley in March–April 2009, yielding 4,063 fish. Analyses showed a large difference from Reference Condition for the Warrego Valley, with:

- SRA Fish Index (SR–FI) = 50 (CL 45–55), indicating Poor condition of the fish community.
- The Expectedness indicator = 67 (CL 63–71), indicating Moderate condition, and a moderate difference from Reference Condition. Only 64% of fish species expected under Reference Condition were recorded.
- The Nativeness indicator = 89 (CL 87–92), indicating Good condition, and a minor difference from Reference Condition.
- The Recruitment indicator = 33 (CL 26–39), indicating Very Poor condition, and a very large difference from Reference Condition. Evidence of recruitment was observed for six of the nine native species observed in the valley.

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

SR–FI for the Warrego Valley was sixth highest for all valleys, and close to that for the Gwydir and Darling valleys. The Slopes zone community was in better condition (SR–FI = 53) than that in the Lowland zone (SR–FI = 38), reflecting better scores for Expectedness and Nativeness.

Expectedness was rated as Poor for the Lowland zone and Moderate for the Slopes zone. In both zones, more than half the species expected to be present under Reference Condition were caught during sampling; in the Slopes zone 69% of expected native species were caught. Whereas in the Lowland only 57% of expected native species were caught.

The Slopes zone scored the second highest for Nativeness of all zones, with Nativeness rated as Good. The narrow confidence limits (Table WAR 3) indicate the uniformity of this indicator across the eight sites in the zone. Only two alien species were caught, as against nine native species. Native fish were numerically dominant (93% of all fish caught belonged to native species) and contributed 67% of the total fish biomass.

# WARREGO VALLEY

Table WAR 4 shows native species abundances in the Warrego Valley compared with Reference Condition. Bony herring dominated the samples. With an average of nearly 200 fish per site, they were caught at all 18 sampling sites. Australian smelt and golden perch were also wide-spread: 149 fish from 12 sites and 109 individuals from 15 sites respectively. Freshwater catfish, Hyrtl's tandan, Murray–Darling rainbowfish, and spangled perch were all expected and were captured in both zones. Olive perchlet, silver perch, southern purple-spotted gudgeon, and unspecked hardyhead were also expected in both zones but not caught at any site. Three alien species were present in the valley, with common carp being the most numerous. Though small (averaging 141 g each), they contributed 96% of the total alien fish biomass and 40% of the biomass of all species in the valley.

Recruitment was rated as Very Poor throughout the valley. Freshwater catfish, Hyrtl's tandan and Murray cod showed no evidence of recruitment. Bony herring were recorded as recruiting at all 18 sites throughout the valley. Spangled perch were noted as recruiting at all three sites in which they were captured but golden perch—though caught at 15 sites— was recorded as recruiting at only two sites, both in the Lowland zone. All alien species showed evidence of recruitment—in the case of common carp, at all 17 sites in which it was caught.

In general, the fish community of the Warrego had reduced numbers of expected native species but native fish outnumbered (by more than 14:1) and outweighed the alien species (by more than 1.4:1). Bony herring were numerous, widespread, and recruiting strongly.

**Table WAR 3: Warrego 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) | 50 (45–55) | 53 (48–60) | 38 (28–46) |
| Indicator | Expectedness | 67 (63–71) | 72 (68–76) | 50 (43–57) |
| Metric | O/E | 0.51 (0.46–0.57) | 0.54 (0.49–0.60) | 0.40 (0.29–0.51) |
| Metric | O/P (Zone level) | 0.67 (0.67–0.67) | 0.69 (0.69–0.69) | 0.57 (0.57–0.57) |
| Indicator | Nativeness | 89 (87–92) | 93 (91–95) | 75 (66–84) |
| Metric | Proportion biomass native | 0.64 (0.59–0.69) | 0.68 (0.64–0.72) | 0.49 (0.35–0.64) |
| Metric | Proportion abundance native | 0.92 (0.89–0.95) | 0.92 (0.88–0.96) | 0.92 (0.87–0.95) |
| Metric | Proportion species native | 0.76 (0.73–0.79) | 0.81 (0.78–0.83) | 0.59 (0.49–0.68) |
| Indicator | Recruitment | 33 (26–39) | 32 (24–40) | 34 (21–45) |
| Metric | Proportion of sites with native recruits | 0.41 (0.34–0.46) | 0.42 (0.34–0.47) | 0.36 (0.25–0.46) |
| Metric | Proportion of native taxa with recruits | 0.60 (0.55–0.72) | 0.56 (0.50–0.71) | 0.75 (0.57–0.86) |
| Metric | Proportion of abundance as recruits | 0.51 (0.45–0.61) | 0.49 (0.44–0.63) | 0.55 (0.45–0.68) |
| Variables | | | | |
| | Number of sites sampled | 18 | 8 | 10 |
| | Total number of species | 12 | 11 | 11 |
| | Number of native species | 9 | 9 | 8 |
| | Number of predicted species | 14 | 13 | 14 |
| | Number of alien species | 3 | 2 | 3 |
| | Mean number of fish per site | 226 | 212 | 237 |
| | Biomass/site all species (g) | 4857 | 7043 | 3109 |
| | Mean native biomass/fish (g) | 13 | 24 | 6 |
| | Mean alien biomass/fish (g) | 136 | 178 | 108 |

**Table WAR 4: Warrego 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 | 149 | 91 | 58 |
| Bony herring | 3488 | 1393 | 2095 |
| Desert rainbowfish | 0 | | 0 |
| Freshwater catfish | 8 | 4 | 4 |
| Golden perch | 109 | 74 | 35 |
| Gudgeon | 12 | 10 | 2 |
| Hyrtl's tandan | 5 | 2 | 3 |
| Murray cod | 2 | 2 | 0 |
| Murray–Darling rainbowfish | 9 | 7 | 2 |
| Olive perchlet | 0 | 0 | 0 |
| Silver perch | 0 | 0 | 0 |
| Southern purple-spotted gudgeon | 0 | 0 | 0 |
| Spangled perch | 14 | 5 | 9 |

Continued/...

| Fish species | Valley | Zone | |
|---|---|---|---|
| | | Slopes | Lowland |
| Unspecked hardyhead | 0 | 0 | 0 |
| Alien species | | | |
| Common carp | 247 | 104 | 143 |
| Gambusia | 5 | | 5 |
| Goldfish | 15 | 1 | 14 |

# WARREGO VALLEY

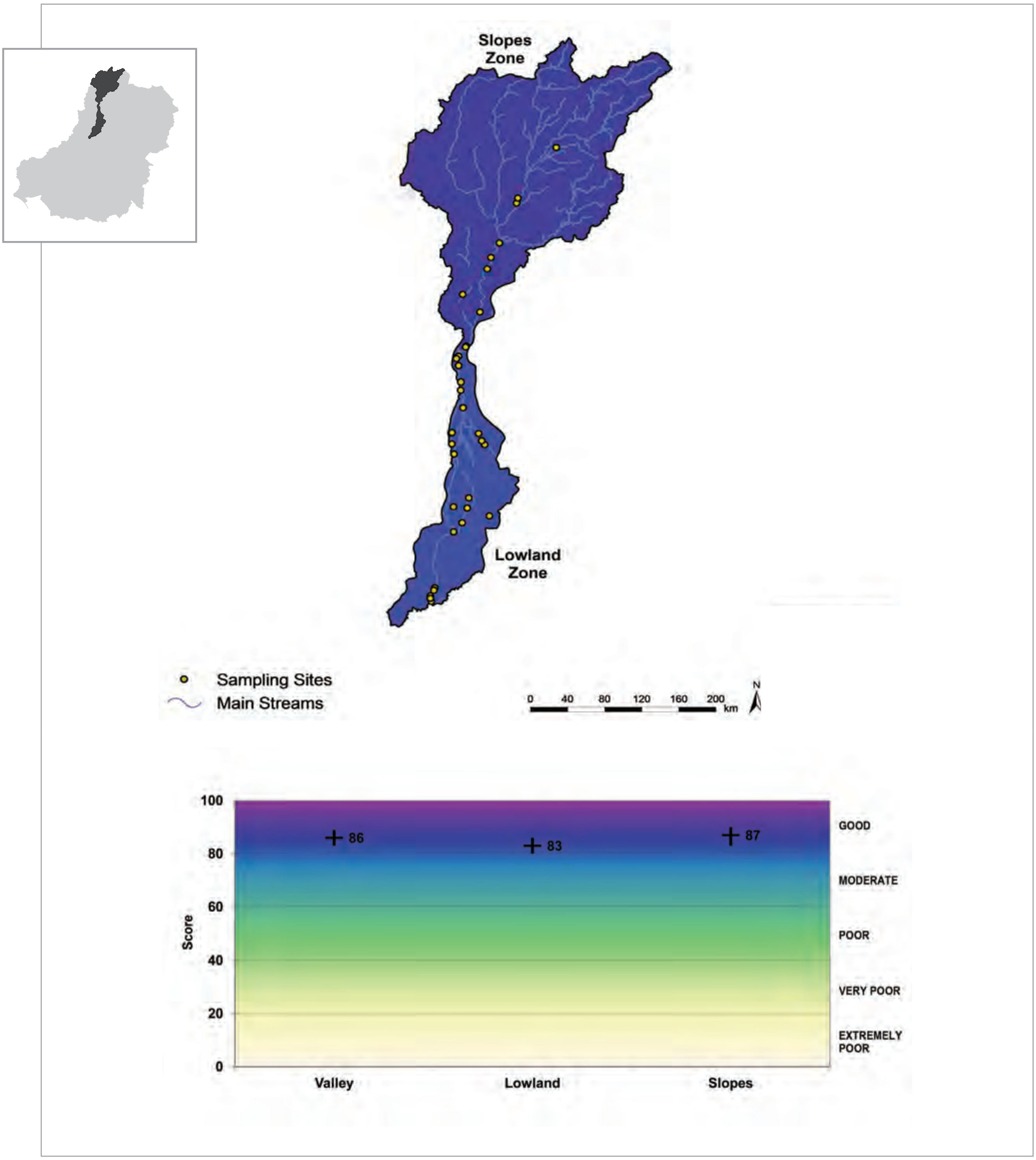



Figure WAR 3: Warrego Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR-MI) scores.

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

*The Macroinvertebrate community of the Warrego Valley river system was in Good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 86. The condition of the Macroinvertebrate community in the zones was as follows: Slopes Good; Lowland Good. The proportion of sites in Good condition was high (71%); 10 of the 35 rated sites (29%) were in Moderate condition. Family richness generally was low, but was high relative to Reference Condition.*

Thirty-five sites were surveyed across the Warrego Valley in April–July 2010 yielding 6,733 macroinvertebrates in 42 families (45% of Basin families). Analyses showed a minor difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 86 (CL 83–89), indicating Good condition of benthic macroinvertebrate communities.
- The simOE metric = 55 (CL 53–57) 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 site communities in Good condition was high across both zones (71% overall); ten of the 35 rated sites (29%) were in Moderate condition (eight of which were in the Lowland zone), and none rated as in Poor condition.
- The number of families found was lowest in the Slopes zone (31 families) and highest in the Lowland zone (41 families), though the two zones had similar average number of families per site (20 and 19, respectively).

Figure WAR 3 shows sampling sites, zones and SR–MI values, and Table WAR 5 shows index and metric values. The SR–MI score for the Warrego Valley indicated Good condition of macroinvertebrate communities, rating 4th highest out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both zones showed no or minor differences from Reference Condition (SR–MI = 87 and 83), with the Slopes zone being in better condition. Small confidence intervals (six – seven points) for the zone SR–MI values indicates low spatial variability in condition. Expectedness (simOE) was moderate to high, varying by only 19 points among sites.

Table WAR 6 shows that most sites in both zones had high SR–MI values. No site had a low simOE score (<40 points). Most sites had the expected diversities of macroinvertebrates, occasionally accompanied with slight reductions in frequency of occurrence of the families present.

# WARREGO VALLEY

Family richness generally was high compared to Reference Condition. Diversity was low (average 19 families per site), with the zones being equally diverse at site scale (average of 19 – 20 families per site). As in the Paroo, this river system has naturally low macroinvertebrate diversity at family level. The valley contained 45% of the families found across the Basin (Table WAR 6), with the Slopes zone having the lowest representation of Basin-wide fauna. Most (98%) of the fauna of the valley was found in the Lowland zone.

**Table WAR 5: Warrego 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) | 86 (83–89) | 87 (83–90) | 83 (80–86) |
| Metric | SimOE | 55 (53–57) | 56 (53–58) | 54 (52–56) |

Table WAR 6: Warrego 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 | 8 | 27 |
| Number of sites with index values* | 35 | 8 | 27 |
| N sites by SR–MI condition band | | | |
| Good (80–100) | 25 | 6 | 19 |
| Moderate (60–80) | 10 | 2 | 8 |
| Poor (40–60) | | | |
| Very or Extremely Poor (0 – 40) | | | |
| Families | | | |
| Number of families sampled | 42 | 31 | 41 |
| No. families/site (min–max) | 19 (12–29) | 20 (15–23) | 19 (12–29) |
| Percent of families in Basin | 45 | 33 | 44 |
| Percent of families in valley | 100 | 74 | 98 |

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

# WARREGO VALLEY

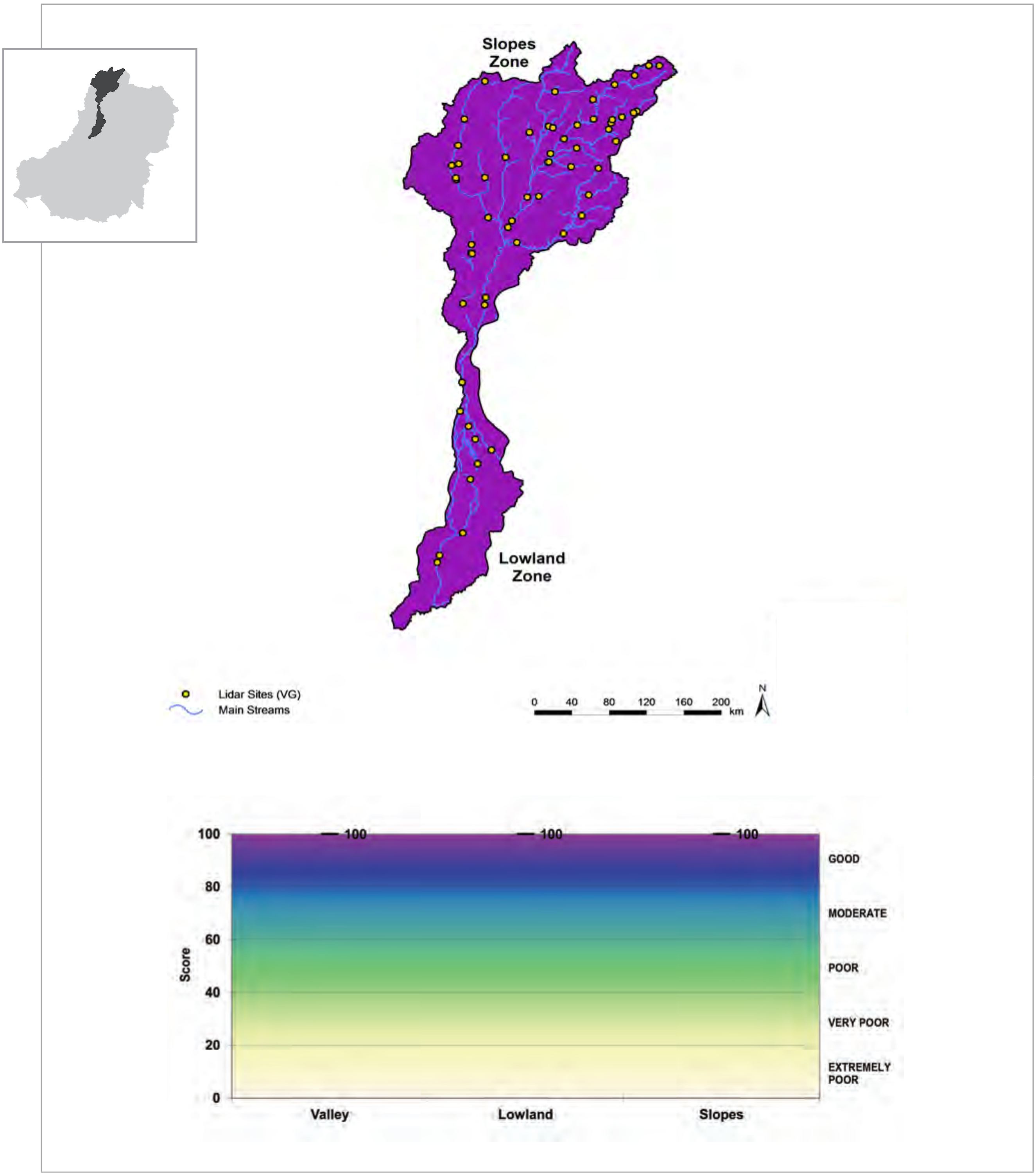



Figure WAR 4: Warrego Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Warrego Valley river system was in Good condition, with an aggregate Vegetation Index score (SR–VI) of 100. Overall condition for both of the two zones in this valley (Slopes, Lowland) was Good.*

*The Abundance and Diversity indicator score was 100 for the valley, indicating a Good rating overall. It was rated as Good in both zones.*

*The Quality and Integrity indicator score was 98 for the valley, indicating a Good rating overall. It was rated as Good in both zones.*

The SRA Vegetation assessment for the Warrego Valley considers riverine vegetation in two spatial domains: Near Riparian, along 3,912 km of stream, and Lowland Floodplain, for 3,798 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. Most (78%) of the stream length in the valley is in the Slopes zone, and stream length per zone is as follows: Slopes 3,061 km; Lowland 851 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 59 sites set back 50 m from the top of the channel bank. LiDAR sites are distributed amongst the two zones along the stream network, as follows: Slopes 49 sites; Lowland 10 sites. The assessment of the Lowland Floodplain domain is also based on national mapping of Major Vegetation Groups.

Figure WAR 4 shows values of the Vegetation Index (SR–VI) for the Warrego Valley and Table WAR 7 shows the index, indicator and sub-indicator values. Tables WAR 8 and WAR 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 Warrego Valley with:

- SRA Vegetation Index (SR–VI) = 100, indicating Good condition for riverine vegetation.
- The Vegetation Abundance and Diversity indicator = 100, indicating a 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 = 98, 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 only slightly affected by clearing. The abundance and degree of fragmentation of major vegetation groups in the sampled area is near Reference Condition.

# WARREGO VALLEY

The Abundance and Diversity of valley riverine vegetation is in Good condition overall, being near Reference Condition in both the Slopes and the 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 is near Reference Condition in both the Near Riparian and Lowland Floodplain domains. MVG richness is near reference, in both the Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain has 99% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Good condition overall, and is near Reference Condition 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 WAR 8 as well as other native but non-specific MVGs. Valley-wide Nativeness is near Reference Condition in the Slopes and Lowland zones. The degree of MVG fragmentation is also near 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 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, with no substantive difference between zones and domains, which are all near Reference Condition.

***Stability***

- Floodplain areas in the Lowland Floodplain domain are in Good condition, with little evidence of turnover or change.

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 all domains and zones are similar, being near 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, and the zones differ. Structure is near Reference Condition in the Slopes zone and moderately different from reference in the Lowland zone, which is also highly variable. 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 near Reference Condition: for all MVGs present, the number of patches and mean patch area have near reference values.

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

- Slopes zone: The Near Riparian domain was mostly (65% of the domain area) Eucalypt Woodlands, with eight other MVGs present, of which two were more than 5% of the area.
- Lowland zone: The Near Riparian domain was mostly Eucalypt Woodlands (42% of domain area) and Eucalypt Open Woodlands (33%), with five other MVGs present, two of which occupied at least 5% of the area.
- Lowland zone: The Lowland Floodplain domain was a mix of Eucalypt Woodlands (27% of domain area), Eucalypt Open Woodlands (22%) and Tussock Grasslands (26%) with nine other MVGs present, two of which covered as much as 5% of the domain.

By contrast, under current conditions, the extent of the MVG vegetation in the valley has been little altered, and individual MVGs are largely unaffected.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are still the most extensive MVG (55% of the domain) although reduced in area. About 11% is either cleared or non-native vegetation. Most of the MVGs are slightly reduced in area but near their reference area.
- Lowland zone: the Near Riparian domain is very little changed. Less than 1% of the domain area is either cleared or non-native vegetation, and all MVGs are near their reference area.
- Lowland zone: Lowland Floodplain domain is very little changed. Less than 1% of the domain is either cleared or non-native vegetation and all MVGs are near their reference area.

# WARREGO 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 may range from 1997 to 2004 depending on source, whereas the LiDAR was flown in August 2010. This means that the mapping metrics such as abundance, richness and nativeness, are off-set slightly in time and space from the LiDAR-derived Structure sub-indicator. 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 used to assess the Warrego Valley are based on vegetation mapping which is not current and of variable quality. 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 Warrego Valley is notable for the consistently Good condition of its riverine vegetation, which is near Reference Condition for the valley overall, for both zones and both indicators.

The condition of riverine vegetation is near Reference Condition for the valley, and in both the Slopes and Lowland zones, with Abundance, Richness and Nativeness metrics all near reference in both zones. Structure is in Moderate condition in the Lowland zone, and quite variable, as indicated by the wide confidence limits, indicating patchy clearing in the Near Riparian domain.

In the Lowland zone, the Near Riparian domain and the Lowland Floodplain domain are in similar condition with nearly all metrics scoring highly, except for Structure in the Near Riparian domain. These two domains assess differing although slightly overlapping parts of the riverine landscape in the Lowland zone. The Lowland Floodplain domain includes flood-out areas and the floodplain and riverine corridor associated with the main river channels, whereas the Near Riparian domain is centred on all channels in the network, and is smaller in area.

**Table WAR 7: Warrego 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)** | **100** | **100** | **100** |
| Indicator | Abundance and diversity | 100 | 100 | 100 |
| Metric | LF stability | 0.99 | | 0.99 |
| Sub-ind. | NRLF richness | 100 | | 100 |
| Metric | NR richness | 1 | 1 | 1 |
| Metric | LF richness | 1 | | 1 |
| Sub-ind. | NRLF abundance | 100 | | 100 |
| Metric | NR abundance | 0.90 | 0.87 | 1 |
| Metric | LF abundance | 0.99 | | 0.99 |
| Indicator | Quality and integrity | 98 | 99 | 94 |
| Sub-ind. | NRLF nativeness | 100 | | 100 |
| Metric | NR nativeness | 0.91 | 0.89 | 1 |
| Metric | LF nativeness | 0.99 | | 0.99 |
| Sub-ind. | NR structure | 79 (73–85) | 84 (77–89) | 64 (47–78) |
| Sub-ind. | LF fragmentation | 98 | | 98 |

# WARREGO VALLEY

**Table WAR 8: The most abundant MVGs in the Near Riparian domain in the Warrego 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 | | |
| 5. Eucalypt Woodlands | 65 | 42 |
| 6. Acacia Forests and Woodlands | 7 | 10 |
| 8. Casuarina Forests and Woodlands | | 5 |
| 11. Eucalypt Open Woodlands | 20 | 33 |

**Table WAR 9: Most abundant MVGs in the Lowland Floodplain domain of the Warrego 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 | 27 | 1.03 | 0.97 |
| 6. Acacia Forests and Woodlands | 11 | 1.03 | 0.93 |
| 11. Eucalypt Open Woodlands | 22 | 1.09 | 0.91 |
| 16. Acacia Shrublands | 9 | 1.01 | 0.97 |
| 19. Tussock Grasslands | 26 | 0.98 | 1.02 |

# WARREGO VALLEY

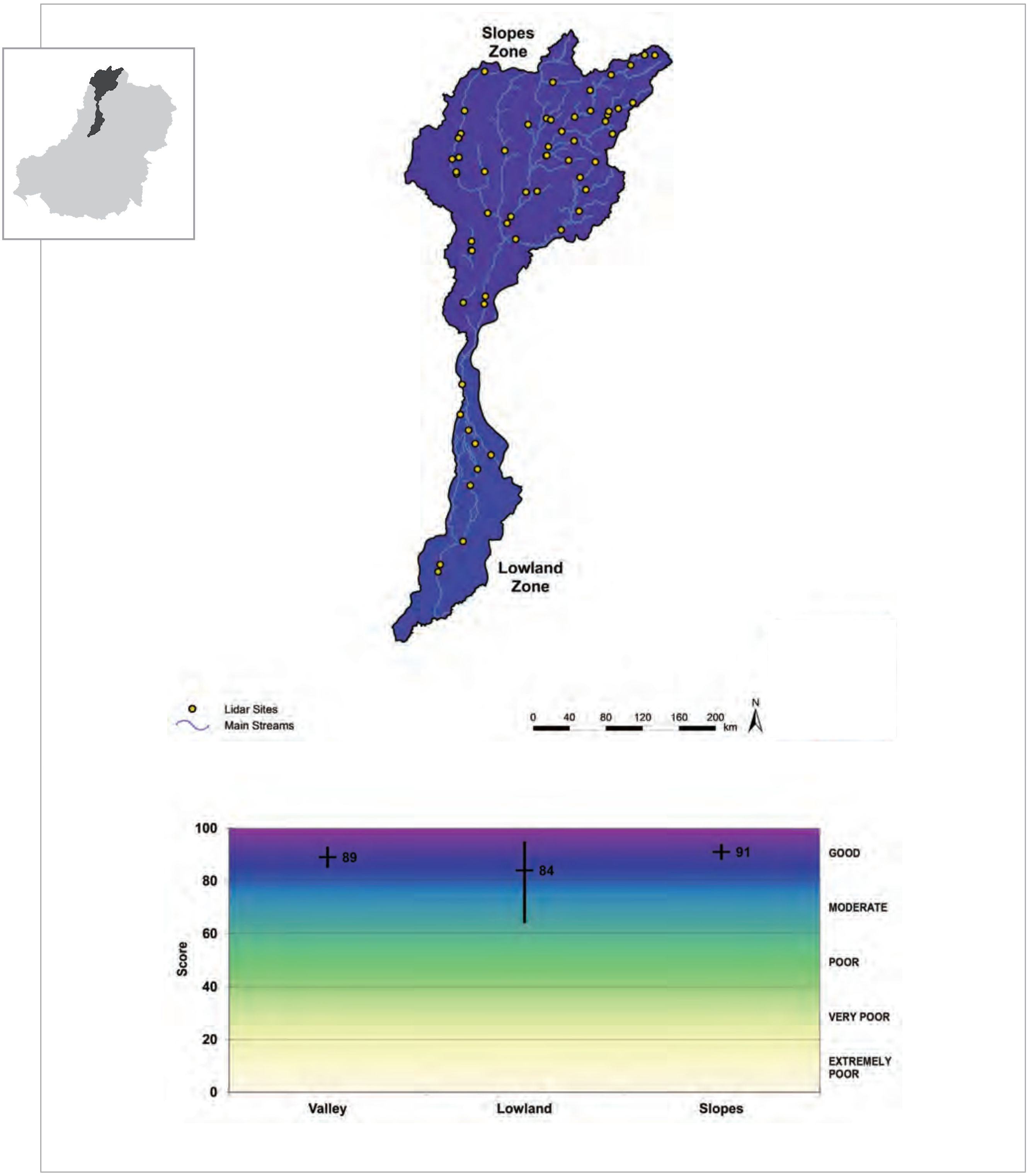



Figure WAR 5: Warrego Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

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

*The Physical Form of the Warrego Valley river system was 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, Bank Dynamics and Floodplain Dynamics were rated as Good. Bed Dynamics was rated as Moderate. Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement associated with limited sedimentation within the Lowland zone river channel and floodplain. There was also evidence of channel contraction.*

The SRA Physical Form assessment considers physical form and processes along 3,912 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 357 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 WAR 5 shows values of the Physical Form Index (SR–PI) for the Warrego Valley and Table WAR 10 shows the index, indicator, sub-indicator and metric values.

Analyses showed near Reference Condition for the Warrego Valley with:

- SRA Physical Form Condition Index (SR–PI) = 89 (CL 85–93), indicating Good Physical Form condition
- the Channel Form indicator = 84 (CL 79–90), showing near Reference Condition
- the Bed Dynamics indicator = 72 (CL 70–73), showing a moderate difference from Reference Condition
- the Bank Dynamics indicator = 96 (CL 92–98), showing near Reference Condition
- the Floodplain indicator = 81 (CL 76–85), showing near Reference Condition.

***Slopes zone***

There were 51 LiDAR survey sites and 281 SedNet river segments in the Slopes zone of the Warrego 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, Channel Depth and Sinuosity were modified from reference for approximately half of the Slopes zone. At these sites Channel Width and Sinuosity were generally reduced and results show both increases and decreases in Channel Depth across the zone. Channel Width Variability, Meander Wavelength and Bank Variability were modified from Reference Condition for less than half of the Slopes zone. At these sites Channel Width Variability, Meander Wavelength and Bank Variability were all generally reduced, Meander Wavelength (with a large reduction in Meander Wavelength at over half of these sites). Channel Sediment Deposition was largely unmodified from reference in the Slopes zone.

# WARREGO VALLEY

### *Lowland zone*

There were 10 LiDAR survey sites and 76 SedNet river segments in the Lowland zone of the Warrego 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 was modified from reference in more than half of the Lowland zone. At these sites Channel Width was generally reduced (with a large reduction at over half of these sites). Bank Variability and Channel Sediment Deposition were modified from reference for approximately half of the Lowland zone. At these sites Bank Variability was generally increased indicating enhanced Bank Dynamics and there was a large increase in Channel Sediment Deposition across 10% of the zone for the post-European period. Channel Depth, Channel Width Variability and Meander Wavelength were modified from reference for less than half of the Lowland zone. At these sites results show both increases and decreases in Channel Depth across the zone and both Channel Width Variability and Meander Wavelength were generally reduced (with a large reduction in Meander Wavelength at over half of these sites). Sinuosity was largely unmodified from reference in the Lowland zone.

### *Channel Form*

There was little change from Reference Condition in Channel Form in the Slopes 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 minor change from Reference Condition in Channel Form in the Lowland zone. The more serious impact was channel contraction. Channel contraction was indicated at 50% 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 Slopes and Lowland zones. Bank variability exceeded Reference Conditions at 40% of sites in the Lowland zone. Elevated Bank Variability may indicate accelerated erosion of stream banks but local knowledge should be used to interpret this result.

There was minor change from Reference Condition in Bed Dynamics in the Slopes zone mostly as a result of widespread elevated sediment load (for 100% of the SedNet river segments). There was little change from reference in Bed Dynamics in the Lowland zone as a result of sedimentation (noted for 50% 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 little change from Reference Condition in Floodplain Sedimentation in the Slopes and Lowland zones as a result of sedimentation (100% of SedNet river segments).

Table WAR 10: Warrego 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) | 89 (85–93) | 91 (88–94) | 84 (64–95) |
| Indicator | Channel Form (volume and flow events) | 84 (79–90) | 88 (82–94) | 69 (56–84) |
| Sub-ind. | Cross-section Form | 78 (72–84) | 84 (79–89) | 56 (39–74) |
| Metric | Channel Depth (mean) | 1.05 (0.96–1.16) | 1.04 (0.96–1.13) | 1.09 (0.86–1.43) |
| Metric | Channel Width (mean) | 0.96 (0.88–1.09) | 0.96 (0.90–1.02) | 1.00 (0.68–1.51) |
| Sub-ind. | Cross-section Form (variability) | 90 (85–96) | 90 (84–97) | 90 (77–100) |
| Metric | Channel Width (CV) | 0.93 (0.90–0.96) | 0.94 (0.90–0.97) | 0.92 (0.83–1.00) |
| Sub-ind. | Channel Planform | 95 (94–97) | 95 (93–97) | 98 (96–99) |
| Metric | Sinuosity | 0.99 (0.98–1.00) | 0.99 (0.98–1.01) | 0.99 (0.97–1.00) |
| Metric | Meander Wavelength | 0.97 (0.94–0.99) | 0.97 (0.93–1.00) | 0.98 (0.95–1.00) |
| Indicator | Bed Dynamics | 72 (70–73) | 69 (68–70) | 83 (78–87) |
| Metric | Channel Sediment Ratio | 42 (40–45) | 50 (47–53) | 13 (10–18) |
| Metric | Channel Sediment Depth | 0.0004 (0.0003–0.0006) | 0.0004 (0.0003–0.0006) | 0.0006 (0.0002–0.001) |
| Indicator | Bank Dynamics | 96 (92–98) | 94 (90–98) | 100 (99–100) |
| Metric | Bank Variability (longitudinal) | 0.98 (0.96–1.01) | 0.97 (0.95–1.01) | 1.02 (0.99–1.05) |
| Indicator | Floodplain | 81 (76–85) | 80 (76–86) | 81 (66–91) |
| Metric | Floodplain Sediment Deposition | 1.34 (1.10–1.63) | 1.31 (1.05–1.56) | 1.45 (0.79–3.00) |

# WARREGO VALLEY

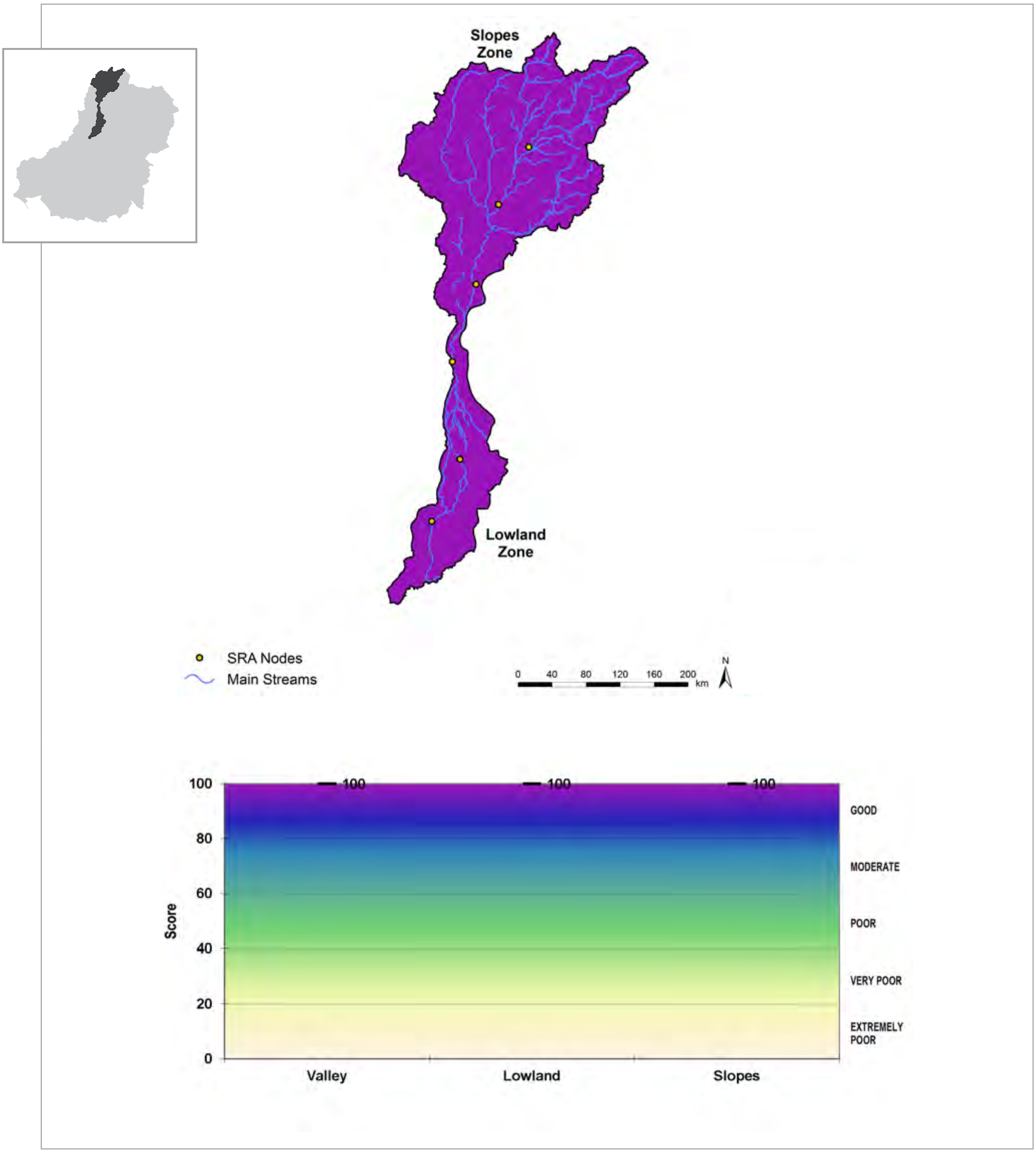



Figure WAR 6: Warrego Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Warrego Valley river system was in Good condition, with an aggregate Hydrology Index (SR–HI) score of 100. The Lowland and Slopes zones were in Good condition. The mainstem river system of the Warrego Valley was rated in Good condition. Throughout some of the mainstem river system the duration and frequency of high flow spells were reduced relative to Reference Condition. The headwater streams of the Warrego Valley were rated in Good condition.*

The Warrego River rises in the Chesterton Ranges in the northern part of the Basin. The headwater streams converge around Augathella and Charleville and flow southward as the Warrego, to meet the Darling downstream of Bourke. Downstream of Cunnamulla the river breaks into distributaries, some of feeding the Yantabulla swamp in the Cuttaburra Basin, and it may deliver flood flows to the Paroo system. Water reaches the Darling from the Warrego only during flood conditions. At the southern most gauging station, Site 1 at Ford's Bridge (some 87 km from the Darling confluence), there is zero flow for about half the time. There are no instream storages other than weirs used for stock and domestic supply. At Cunnamulla, the Allan Tannock Weir may divert water for local cotton irrigation.

In the Warrego Valley, hydrological condition is assessed using metrics of hydrological alteration available for 5,266 km of mainstem rivers and headwater streams. There are 681 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 Warrego Valley there is 4,585 km of headwater stream (4,146 km in the Slopes zone; 438 km in the Lowland zone). 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 Warrego Valley there is 6,560 km of these mid-size tributaries (4,076 km in the Slopes zone; 2,484 km in the Lowland zone) which is 1.2 times the stream length for which metrics are available.

In contrast to the other Themes, the Hydrology Theme uses metrics calculated from model runs, 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.

# WARREGO VALLEY

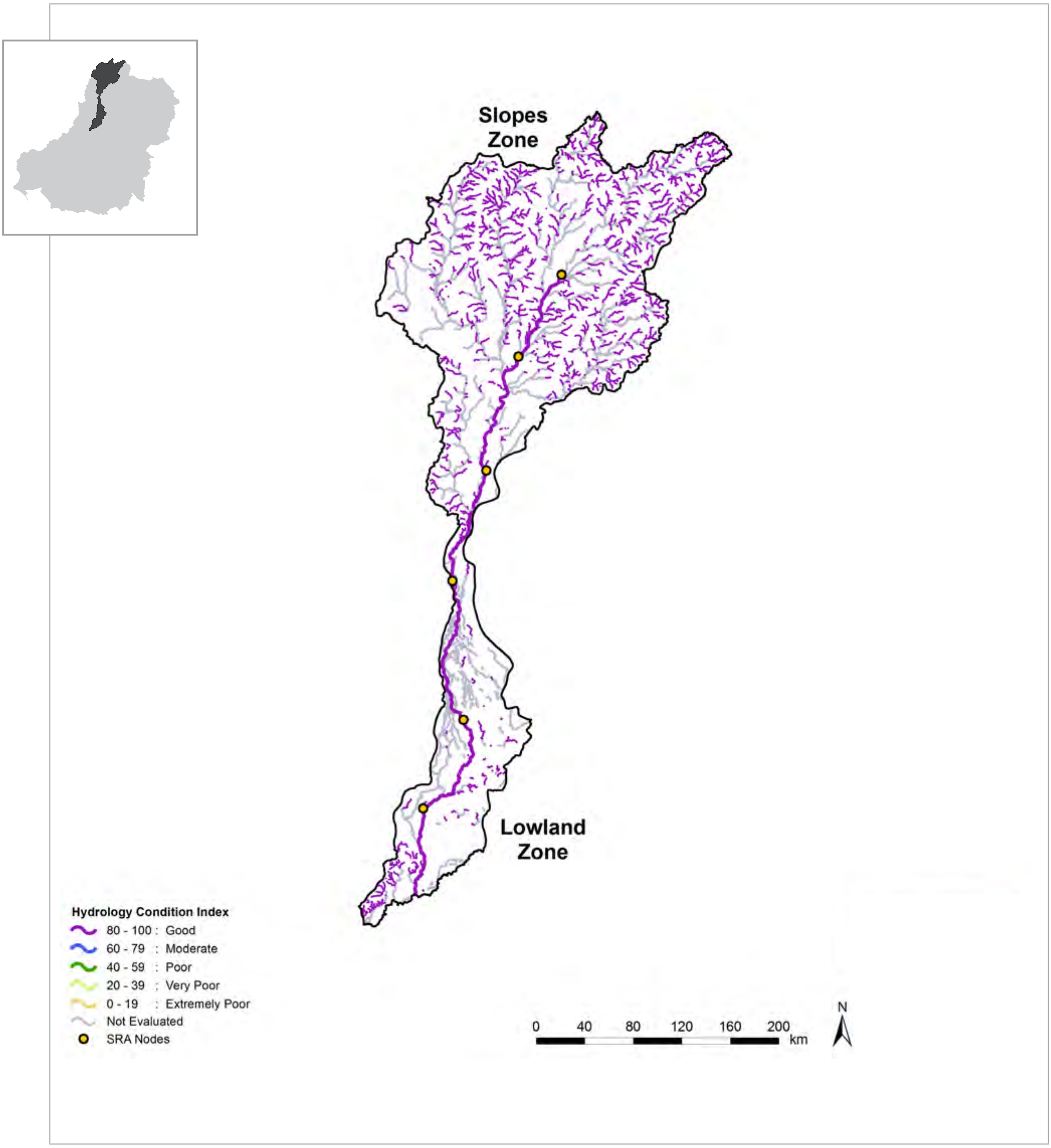



Figure WAR 7: Warrego Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

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

- The Hydrology Condition Index for the whole valley = 100, indicating Good hydrological condition.
- The Hydrology Condition Index for the Slopes and Lowland zones = 100 and 100 indicating Good and Good 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) = 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*

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 reduced 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 Condition.

In the mainstem rivers, the High Flow Events sub-indicator showed near Reference Condition. Results for the High Flow metric showed 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. Results for the High Flow Spells metric showed 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 most 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 17% 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.

### *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 only small variations from reference throughout the mainstem river length (mostly associated with increased flows). Results for the Zero Flows Proportion metric showed 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. Results for the Low Flow Spells metric showed 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 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 13% 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 near Reference Condition. Results for the Seasonal Amplitude metric showed only small variations from reference throughout the mainstem river length (mostly associated with reduced 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 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 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 (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 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 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 only small variations from reference throughout the mainstem river length (mostly associated with reduced flows). Results for the Low Over Bank Flow Spells metric showed a significant alteration from reference in 16% 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.

### *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 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 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 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.

### *Summary: mainstem rivers*

The mainstem river system of the Warrego 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. Throughout some of the mainstem river system the duration and frequency of high flow spells were reduced.

### *Summary: headwater streams*

The headwater streams of the Warrego 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.

**Table WAR 11: Warrego 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 |

# WARREGO VALLEY

**Table WAR 12: Warrego 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 (2–100)** |
| Sub-index | In-Channel Flow Regime | 100 (100–100) | 100 (2–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 100 (99–100) | 100 (16–100) |
| Sub-ind. | Flow Gross Volume | 99 (96–100) | 100 (61–100) |
| Metric | Mean Annual Flow | 0.96 (0.88–1.00) | 1.01 (0.53–1.15) |
| Metric | Flow Duration | 0.98 (0.96–1.00) | 0.98 (0.70–1.08) |
| Sub-ind. | High Flow Events | 96 (91–99) | 97 (9–100) |
| Metric | High Flow | 0.91 (0.77–1.00) | 0.90 (0.10–1.36) |
| Metric | High Flow Spells | 0.87 (0.75–1.00) | |
| Sub-ind. | Low and Zero Flow Events | 96 (87–98) | 97 (39–99) |
| Metric | Zero Flows Proportion | 0.88 (0.68–1.00) | 1.00 (0.96–1.00) |
| Metric | Low Flow | 1.00 (1.00–1.00) | 0.90 (0.13–1.22) |
| Metric | Low Flow Spells | 0.91 (0.68–1.00) | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 100 (100–100) | 100 (20–100) |
| Sub-ind. | Flow Seasonality | 99 (97–100) | 99 (78–100) |
| Metric | Flow Seasonal Amplitude | 0.98 (0.91–1.00) | 1.02 (0.89–1.46) |
| Metric | Flow Seasonal Period | 0.98 (0.93–1.00) | 0.98 (0.77–1.00) |
| Sub-ind. | Flow Variability | 97 (87–100) | 96 (0–100) |
| Metric | Flow Variation | 1.04 (1.00–1.12) | 0.96 (0.34–1.00) |
| Sub-index | Over Bank Flow Regime | 100 (100–100) | |
| Indicator | Over Bank Floods Low | 97 (91–99) | |
| Metric | OB Flow Duration (ARI 1) | 0.96 (0.85–1.00) | |
| Metric | OB Flow Spells (ARI 1) | 0.96 (0.76–1.08) | |
| Indicator | Over Bank Floods High | 97 (88–98) | |
| Metric | OB Flow Duration (ARI 8) | 0.97 (0.91–1.00) | |
| Metric | OB Flow Spells (ARI 8) | 0.94 (0.72–1.00) | |

| | Zone | | | | | |
|---|---|---|---|---|---|---|
| | Mainstem rivers | | | Headwater streams | | |
| | Upland | Slopes | Lowland | Montane | Upland | Slopes |
| | | 100 | 100 | | | 100 |
| | | 100 | 100 | | | 100 |
| | | 100 | 100 | | | 100 |
| | | 100 | 98 | | | 100 |
| | | 0.99 | 0.94 | | | 1.01 |
| | | 0.99 | 0.98 | | | 0.98 |
| | | 97 | 96 | | | 97 |
| | | 0.91 | 0.90 | | | 0.90 |
| | | 0.91 | 0.84 | | | |
| | | 97 | 95 | | | 97 |
| | | 0.92 | 0.85 | | | 1.00 |
| | | 1.00 | 1.00 | | | 0.90 |
| | | 0.96 | 0.88 | | | |
| | | 100 | 100 | | | 100 |
| | | 99 | 98 | | | 98 |
| | | 1.00 | 0.96 | | | 1.02 |
| | | 0.99 | 0.97 | | | 0.98 |
| | | 100 | 95 | | | 96 |
| | | 1.01 | 1.06 | | | 0.96 |
| | | 100 | 100 | | | |
| | | 98 | 96 | | | |
| | | 1.00 | 0.93 | | | |
| | | 1.00 | 0.94 | | | |
| | | 98 | 96 | | | |
| | | | 0.97 | | | |
| | | | 0.94 | | | |

# WIMMERA VALLEY

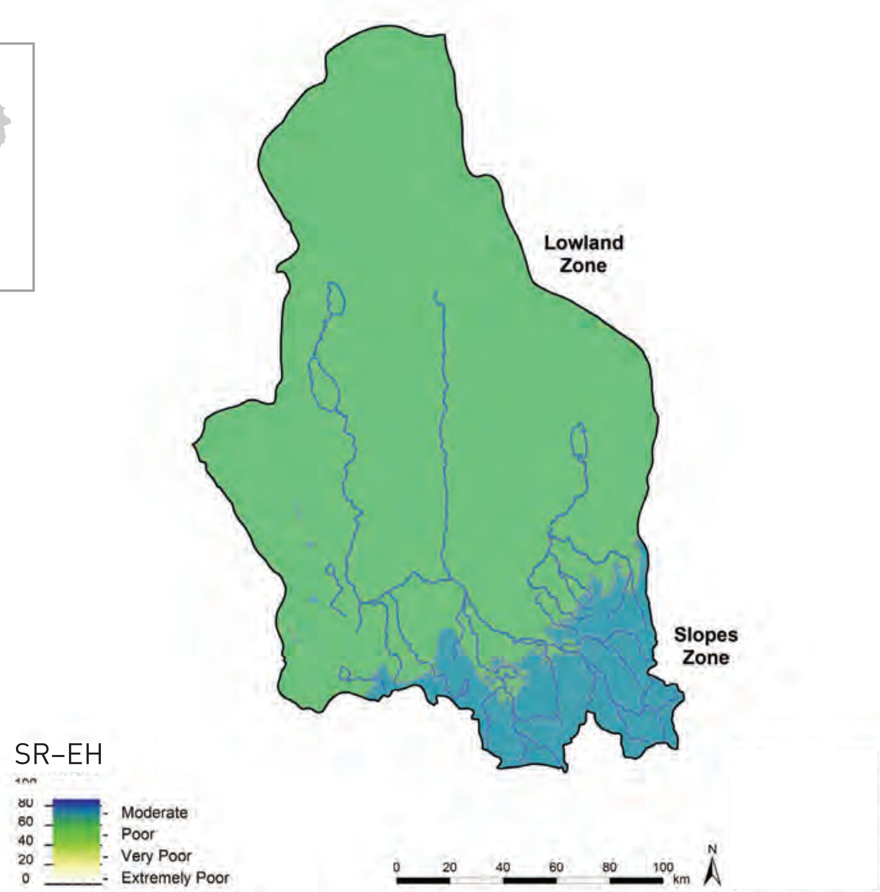



**Figure WIM 1: Wimmera Valley map with zones coloured by SRA River Ecosystem Health (SR–EH) rating.**

Figure WIM 1 shows the Ecosystem Health ratings for the Wimmera Valley and Tables WIM 1 and WIM 2 also shows the index values and ratings for each Theme. Ecosystem health shows a large difference from Reference Condition for the Wimmera Valley as a whole. The river system's Fish, benthic Macroinvertebrate and Riverine Vegetation communities were in Poor, Moderate and Poor condition 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 Ecosystem Health of the Wimmera Valley river system. River Ecosystem Health was rated Poor (Lowland zone: Poor; Slopes zone: Poor).

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

*The Wimmera Valley river ecosystem was in Poor Health. River Ecosystem Health for the zones was as follows: Slopes and Lowland Poor. The Fish community was in Poor condition. Several expected species were absent. The species count, abundance and biomass were dominated by aliens; and a low proportion of sites showed recruitment of the remaining native species. 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 high levels of 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 Poor condition. There were moderate levels of floodplain sediment deposition. The river system's Hydrology was in Moderate condition, with minor changes relative to Reference Condition in mainstem reaches for flow variability, flow seasonality, low and zero flow events and high flow events.*

***Ecosystem Health***

The Wimmera River is highly regulated and water is diverted for irrigation and stock and domestic supply. Inter-valley transfers are drawn from the Glenelg River. Under current conditions the Wimmera Valley's terminal lakes and wetlands receive less than half of the volume that would have flowed there under undeveloped condition.

The Wimmera Valley ranked 12th amongst the 23 SRA valleys in terms of River Ecosystem Health, midway among the 15 valleys rated as being in Poor Health (see Table 5.2). It had similar rankings for Hydrology, Physical Form, and Macroinvertebrates, being 13th, 11th, and 14th respectively. In terms of vegetation it ranked equal 18th (with the Avoca and Kiewa valleys) and was ranked seventh in terms of Fish condition. The relatively low score for vegetation probably reflects the effect of land clearing for agriculture, although fragmentation of the Near Riparian and Lowland Floodplain vegetation groups has also had a significant effect.

Macroinvertebrate data indicated that a number of expected families were absent. It is possible that this loss of diversity reflects a reduction in heterogeneity in the riverine environment. No significant (and consistent) trends have been observed in data for macroinvertebrates and fish at the valley scale except for a decline in the fish Nativeness Index between 2006 and 2009 samples. This reflects the situation in the Lowlands zone in which the few (mostly small-bodied) native fish are outnumbered (and outweighed) by common carp and redfin perch.

The aquatic ecosystems in the lower reaches of the Wimmera River are episodic in nature were effectively in a dry phase during the SRA. Recent high flows may provide the opportunity to observe their influence on the health of the Wimmera ecosystem during a wet 'boom' phase.

***Fish Theme***

The Fish Condition Index SR–FI = 44, indicating Poor condition (Lowland zone: Very Poor; Slopes zone: Moderate). The Expectedness indicator = 52, indicating Poor condition, and a large difference from Reference Condition. The Nativeness indicator = 29, indicating Very Poor condition, and a very large difference from Reference Condition. The Recruitment indicator = 64, indicating Moderate condition, and a moderate difference from Reference Condition.

# WIMMERA VALLEY

Native species richness was reduced relative to Reference Condition, three native species had been translocated to the valley, and alien species contributed over 89% of fish biomass. Native fish recruitment was Moderate to Poor across both zones.

***Macroinvertebrate Theme***

The Macroinvertebrate Condition Index SR–MI = 69, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Moderate). The simOE metric = 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 site communities in Moderate condition was high across both zones (41% overall), and 10 of the 30 rated sites were in Good condition (seven of which were in the Lowland zone).

Family richness generally was low, and was reduced relative to Reference Condition.

***Riverine Vegetation Theme***

The Riverine Vegetation Condition Index SR–VI = 40, indicating Poor condition (Lowland zone: Poor; Slopes zone: Very Poor). 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 in the Near Riparian and Lowland Floodplain domains. The Vegetation Quality and Integrity indicator = 44, indicating Poor condition and a large difference from Reference Condition for the structure, nativeness and fragmentation of communities and vegetation groups in the Near Riparian and Lowland Floodplain domains.

***Physical Form Theme***

The Physical Form Condition Index SR–PI = 84, indicating Good condition (Lowland zone: Good; Slopes zone: Moderate). The Channel Form indicator = 85 and the Bank Dynamics indicator = 98, indicating Good condition and near Reference Condition. The Bed Dynamics indicator = 46, indicating Poor condition and showing a large difference from Reference Condition. The Floodplain Form indicator = 68, indicating Moderate condition and a moderate 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 river channel and floodplain. There was also evidence of channel enlargement and simplification.

***Hydrology Theme***

The Hydrology Condition Index SR–HI = 74, indicating Moderate condition (Lowland zone: Moderate; Slopes zone: Poor). The In-Channel Flow Regime sub-index = 65, indicating Moderate condition and a moderate difference from Reference Condition for the flow regime within the channels.

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

The Lowland Floodplain domain is moderately affected by clearing. The abundance of major vegetation groups in the sampled floodplain area is moderately different from Reference Condition while the degree of fragmentation shows a large difference from Reference Condition.

**Table WIM 1: Wimmera 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 | Poor |

| THEME | | VALLEY | ZONE | |
|---|---|---|---|---|
| | | | SLOPES | LOWLAND |
| Fish | SCORE RATING | 44 (25–52) Poor | 68 (40–82) Moderate | 33 (12–45) Very poor |
| Macro-invertebrates | SCORE RATING | 69 (62–75) Moderate | 70 (64–77) Moderate | 69 (59–77) Moderate |
| Vegetation | SCORE RATING | 40 Poor | 21 Very poor | 49 Poor |

**Table WIM 2: Wimmera 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 | 84 (74–89) Good | 66 (46–83) Moderate | 91 (82–98) Good |
| Hydrology | SCORE RATING | 74 Moderate | 47 Poor | 66 Moderate |

# WIMMERA VALLEY

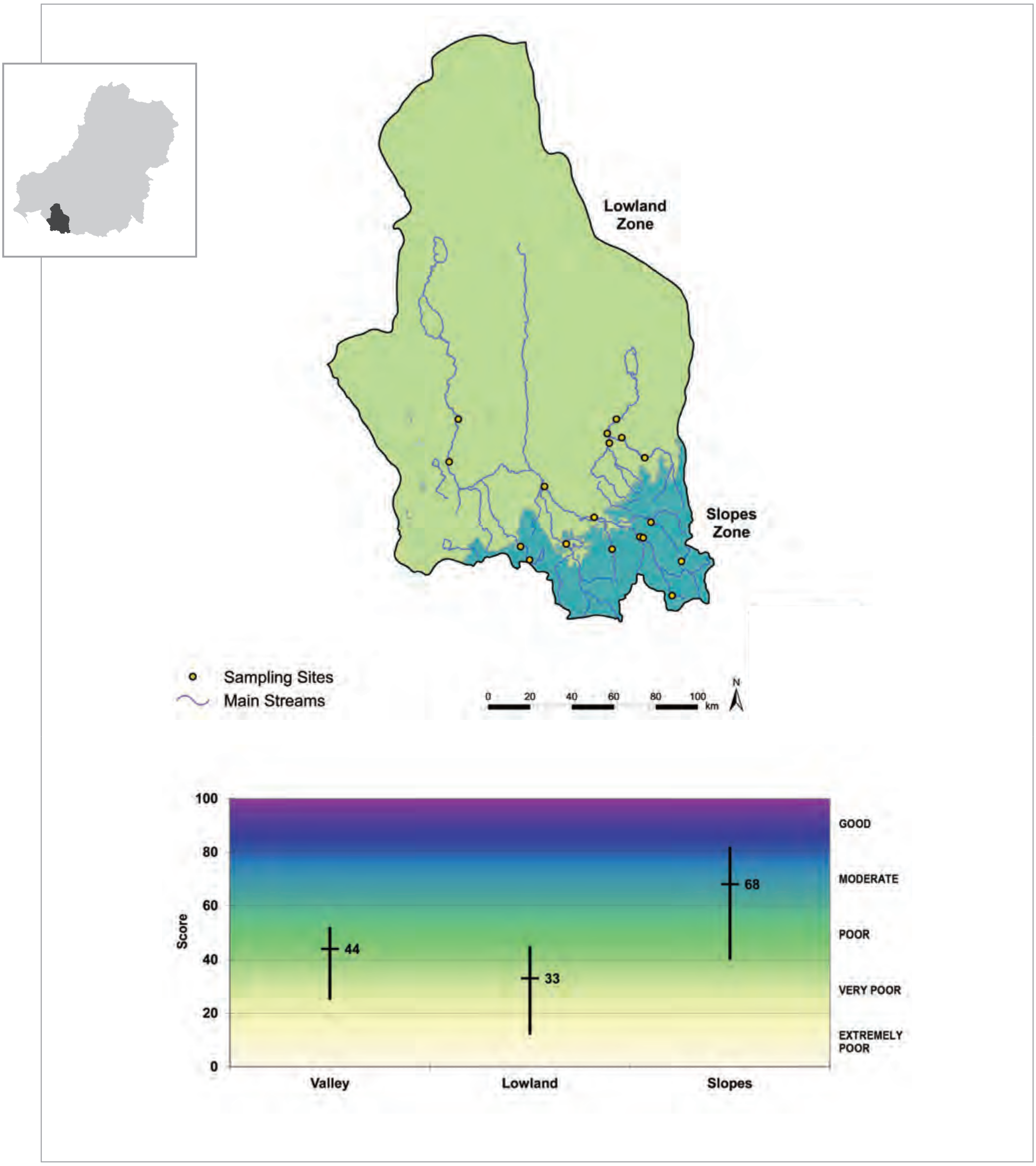



Figure WIM 2: Wimmera Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

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

*The Fish community of the of the Wimmera Valley river system was in Poor condition, with an aggregate Fish Index score (SR–FI) of 44. The condition of the fish community in the zones was as follows: Lowland Very 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 Moderate score for native fish recruitment. The Lowland zone in particular had few fish and lacked almost 43% of the predicted native species. The valley had lost native species richness and alien species contributed over 89% of the biomass in samples. Native fish recruitment was Poor in the Slopes zone and Moderate in the Lowland zone.*

Eighteen sites were surveyed across the Wimmera Valley in November 2009, yielding 536 fish. Analyses showed a large difference from Reference Condition for the Wimmera Valley, with:

- SRA Fish Index (SR–FI) = 44 (CL 25–52), indicating Poor condition of the fish community.
- The Expectedness indicator = 52 (CL 44–62), indicating Poor condition, and a large difference from Reference Condition. All fish species expected under Reference Condition were recorded somewhere in the valley, though the average proportion of expected native species caught at a sampling site was only 35%.
- The Nativeness indicator = 29 (CL 24–36), indicating Very Poor condition, and a very large difference from Reference Condition.
- The Recruitment indicator = 64 (CL 25–80), indicating Moderate condition, and a moderate difference from Reference Condition. Evidence of recruitment was observed for 6 of the 9 native species observed in the valley.

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

SR–FI for the Wimmera Valley was seventh highest of all 23 Basin valleys, and close to that for the Lower Murray and Ovens valleys. The Lowland zone community was in much worse condition (SR–FI = 33) than that in the Slopes zone (SR–FI = 68).

Expectedness varied between zones being rated as Moderate in the Slopes zone and Poor in the Lowland zone. In the Slopes zone, five of the seven native species expected to be present under Reference Condition were caught during sampling.

Nativeness was rated as Good in the Slopes zone reflecting the fact that almost all expected native species were present with only four alien species, native individuals outnumbered aliens by a factor of 7:1, and provided 72% of the total fish biomass. In the Lowland zone native fish were outnumbered by aliens by almost 6:1 and contributed just over 2% of fish biomass.

# WIMMERA VALLEY

The Wimmera Valley had the third lowest fish biomass per site amongst all Basin valleys. It had the lowest native fish biomass at 257 g/site with native species contributing just over 11% of the total fish biomass.

Table WIM 4 shows native species abundances in the Wimmera Valley compared with Reference Condition. Only two species, both alien, exceeded 100 individuals in total for the 18 sampling sites in the valley. Three native species, common jollytail, freshwater catfish, and golden perch, were found in small numbers but were not expected to occur in the valley under Reference Condition. None of these species showed evidence of recruitment. Flathead gudgeon, southern pygmy perch, and Australian smelt were the most numerous native species, averaging 4.3, 2.6, and 2.2 fish per site respectively. Common carp was the most numerous alien species—found almost entirely in the Lowland zone—though they were mostly small specimens averaging 194g/fish. Redfin perch were also numerous, mainly in the Lowland zone, and small (119 individuals at 11.8g/fish).

Recruitment was rated as Moderate for the Wimmera Valley. All of the five expected native species showed evidence of recruitment in one or more sites. Of the six alien species caught, brown trout and goldfish showed no evidence of recruitment. Common carp and redfin perch appeared to be recruiting at most or all of the sites in which they were caught.

In general, the fish community of the Wimmera contained almost all of the expected native species plus three other native species not expected under Reference Condition. However the biomass of native fish was the lowest of all 23 Basin valleys.

**Table WIM 3: Wimmera 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) | 44 (25–52) | 68 (40–82) | 33 (12–45) |
| Indicator | Expectedness | 52 (44–62) | 70 (57–81) | 43 (36–57) |
| Metric | O/E | 0.35 (0.20–0.52) | 0.49 (0.31–0.66) | 0.29 (0.10–0.51) |
| Metric | O/P (Zone level) | 0.62 (0.62–0.62) | 0.71 (0.71–0.71) | 0.57 (0.57–0.57) |
| Indicator | Nativeness | 29 (24–36) | 86 (69–99) | 2 (0–9) |
| Metric | Proportion biomass native | 0.27 (0.17–0.35) | 0.73 (0.45–0.95) | 0.05 (0.00–0.11) |
| Metric | Proportion abundance native | 0.34 (0.23–0.44) | 0.78 (0.53–0.97) | 0.12 (0.02–0.26) |
| Metric | Proportion species native | 0.38 (0.27–0.51) | 0.75 (0.50–0.95) | 0.21 (0.07–0.34) |
| Indicator | Recruitment | 64 (25–80) | 52 (16–67) | 71 (18–96) |
| Metric | Proportion of sites with native recruits | 0.56 (0.28–0.71) | 0.52 (0.24–0.67) | 0.58 (0.25–0.83) |
| Metric | Proportion of native taxa with recruits | 1.00 (0.65–1.00) | 1.00 (0.50–1.00) | 1.00 (0.67–1.00) |
| Metric | Proportion of abundance as recruits | 0.68 (0.50–0.77) | 0.50 (0.28–0.60) | 0.76 (0.52–1.00) |
| Variables | | | | |
| | Number of sites sampled | 18 | 8 | 10 |
| | Total number of species | 14 | 11 | 9 |
| | Number of native species | 9* | 7** | 5*** |
| | Number of predicted species | 7 | 7 | 7 |
| | Number of alien species | 5 | 4 | 4 |
| | Mean number of fish per site | 30 | 22 | 36 |
| | Biomass/site all species (g) | 2289 | 662 | 3591 |
| | Mean native biomass/fish (g) | 22 | 25 | 15 |
| | Mean alien biomass/fish (g) | 112 | 66 | 115 |

* Includes three native species not expected under Reference Condition.
** Includes two native species not expected under Reference Condition.
***Includes one native species not expected under Reference Condition..

**Table WIM 4: Wimmera 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 | |
|---|---|---|---|
| | | Slopes | Lowland |
| Sites sampled | 18 | 8 | 10 |
| Native species | | | |
| Australian smelt | 39 | 11 | 28 |
| Carp gudgeon complex | 0 | 0 | 0 |
| Common jollytail | [1] | [1] | |
| Flathead gudgeon | 78 | 60 | 18 |
| Freshwater catfish | [1] | | [1] |
| Golden perch | [2] | [2] | |
| Gudgeon | 5 | 0 | 5 |
| Obscure galaxias complex | 19 | 19 | 0 |
| River blackfish | 17 | 17 | 0 |
| Southern pygmy perch | 46 | 45 | 1 |

Continued/...

| Fish species | Valley | Zone | |
|---|---|---|---|
| | | Slopes | Lowland |
| Alien species | | | |
| Brown trout | 4 | 4 | |
| Common carp | 157 | 2 | 155 |
| Gambusia | 26 | 1 | 25 |
| Goldfish | 22 | | 22 |
| Redfin perch | 119 | 15 | 104 |

# WIMMERA VALLEY

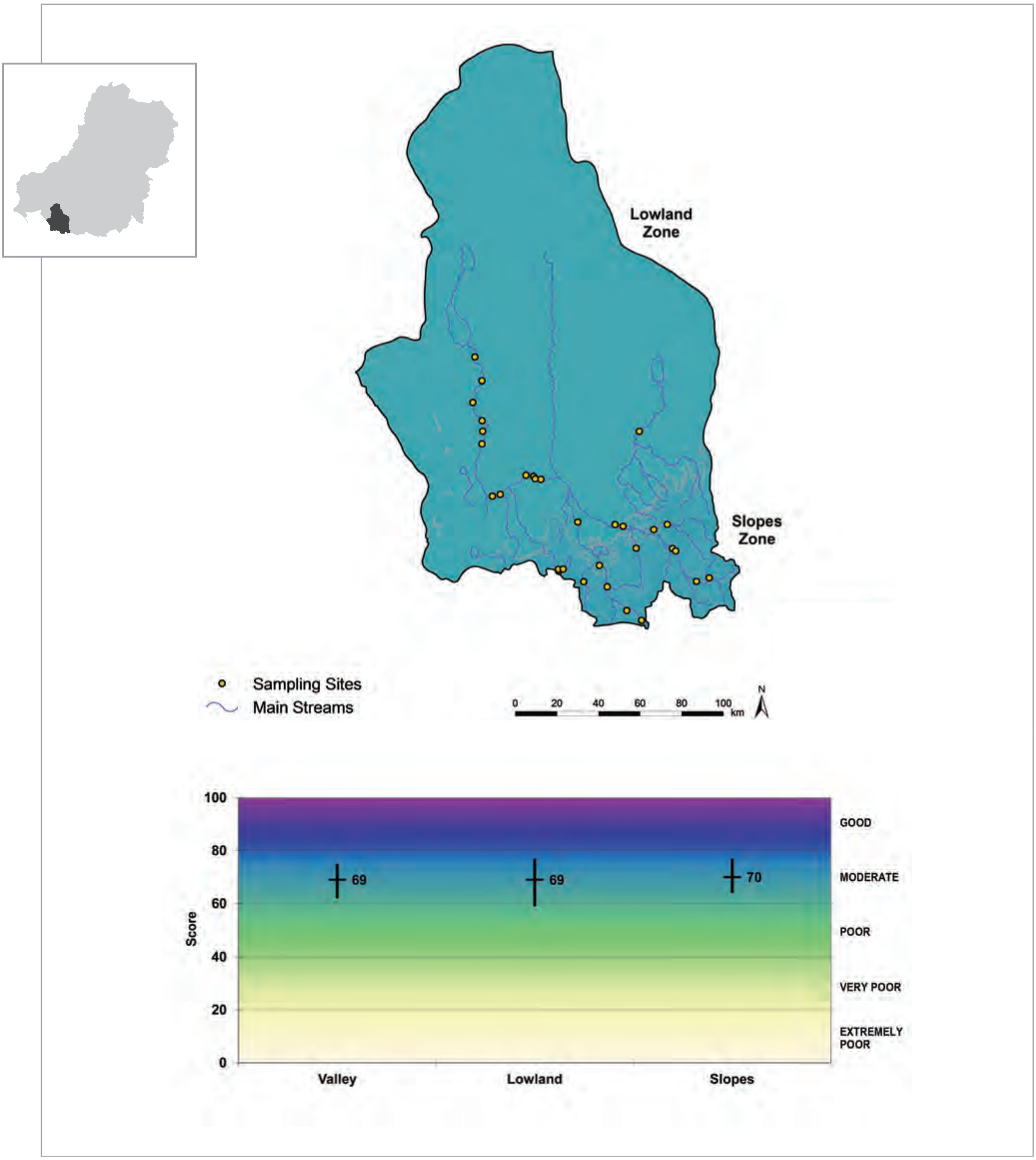



Figure WIM 3: Wimmera Valley map with sampling sites and zones coloured by SRA Macroinvertebrate Index (SR–MI) scores.

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

*The Macroinvertebrate community of the Wimmera Valley river system was in Moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 69. The condition of the macroinvertebrate community in the zones was as follows: Slopes Moderate; Lowland Moderate. The proportion of sites in Moderate or Good condition was high (77%); 10 of the 30 rated sites (33%) were in Good condition. Family richness generally was low, and was reduced relative to Reference Condition.*

Thirty-one sites were surveyed across the Wimmera Valley in October–December 2008 yielding 8,566 macroinvertebrates in 52 families (55% of Basin families). Analyses showed a moderate difference from Reference Condition, with:

- SRA Macroinvertebrate Index (SR–MI) = 69 (CL 62–75), indicating Moderate condition of benthic macroinvertebrate communities.
- The simOE metric = 48 (CL 45–50) 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 site communities in Moderate condition was high across both zones (45% overall), and 10 of the 30 rated sites (33%) were in Good condition (seven of which were in the Lowland zone).
- The number of families found was lowest in the Lowland zone (39 families) and highest in the Slopes zone (46 families), which also had the highest average number of families per site (18).

Figure WIM 3 shows sampling sites, zones and SR–MI values, and Table WIM 5 shows index and metric values. The SR–MI score for the Wimmera Valley indicated Moderate condition of macroinvertebrate communities, rating 14th out of all 23 valleys in the Basin during the 2008–2010 reporting period.

The communities of both the Slopes and Lowland zones showed moderate differences from Reference Condition (SR–MI = 70 and 69, respectively). A wider confidence interval (18 points) for the Slopes zone SR–MI value indicates slightly more spatial variability than in the Lowland zone, though most sites showed moderate difference from Reference Condition. Expectedness (simOE) was moderate and varied by up to 30 points among sites.

Table WIM 6 shows that most sites in both zones had moderate SR–MI values, though 10 sites were rated in Good condition. The Lowland zone had three sites 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.

# WIMMERA VALLEY

Family richness generally was reduced compared to Reference Condition. Diversity was low (average 17 families per site), with the Slopes zone being slightly more diverse at site scale (average 18 families per site). The valley contained 55% of the families found across the Basin (Table WIM 6), with the Slopes zone having the lowest representation of Basin-wide fauna. Most (75–88%) of the fauna of the valley was found in either zone.

**Table WIM 5: Wimmera 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) | 69 (62–75) | 70 (64–77) | 69 (59–77) |
| Metric | SimOE | 48 (45–50) | 48 (45–51) | 47 (44–51) |

Table WIM 6: Wimmera 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 | 31 | 13 | 18 |
| Number of sites with index values* | 30 | 12 | 18 |
| N sites by SR–MI condition band | | | |
| Good (80–100) | 10 | 3 | 7 |
| Moderate (60–80) | 14 | 6 | 8 |
| Poor (40–60) | 4 | 3 | 1 |
| Very or Extremely Poor (0–40) | 2 | | 2 |
| Families | | | |
| Number of families sampled | 52 | 46 | 39 |
| No. families/site (min–max) | 17 (4–26) | 18 (12–26) | 16 (4–24) |
| Percent of families in Basin | 55 | 49 | 41 |
| Percent of families in valley | 100 | 88 | 75 |

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

# WIMMERA VALLEY

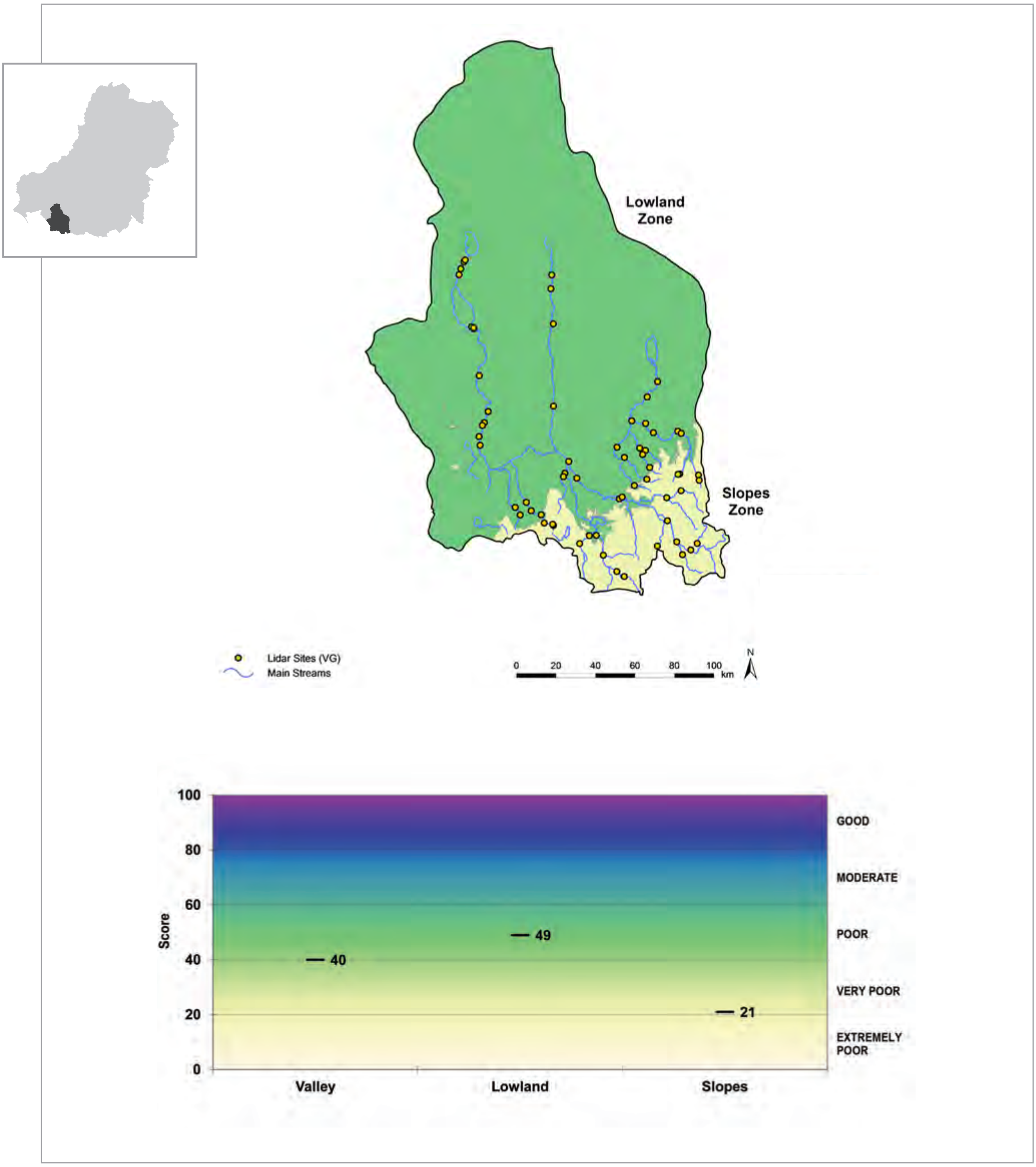



Figure WIM 4: Wimmera Valley map with LiDAR sites and zones coloured by SRA Vegetation Index (SR–VI) scores.

Graph shows mean SR–VI scores as horizontal bars.

*The Riverine Vegetation of the Wimmera 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 Very Poor; Lowland Poor.*

*The Abundance and Diversity indicator score was 60 for the valley, indicating a Moderate rating overall. In the two zones it was: Slopes Very Poor; Lowland Moderate.*

*The Quality and Integrity indicator score was 44 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 Wimmera Valley considers riverine vegetation in two spatial domains: Near Riparian, along 1,396 km of stream, and Lowland Floodplain, for 65 km$^2$ of flooding land which is part of the floodplain in the Lowland zone. Most (69%) of the stream length in the valley is in the Lowland zone, and the length of stream assessed per zone is as follows: Slopes 437 km; Lowland 959 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 64 sites set back 50 m from the top of the channel bank. LiDAR sites are distributed amongst the two zones along the stream network, as follows: Slopes 19 sites; Lowland 45 sites. The assessment of the Lowland Floodplain domain is also based on national vegetation mapping of Major Vegetation Groups.

Figure WIM 4 shows values of the Vegetation Index (SR–VI) for the Wimmera Valley and Table WIM 7 shows the index, indicator and sub-indicator values. Tables WIM 8 and WIM 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 Wimmera Valley with:

- SRA Vegetation Index (SR–VI) = 40, 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 = 44, 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 of major vegetation groups in the sampled area is moderately different from reference and the degree of fragmentation shows a large difference from Reference Condition.

# WIMMERA VALLEY

The Abundance and Diversity of valley riverine vegetation is in Moderate condition overall, with a very large difference from reference 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 large difference from reference in the Near Riparian domain and a moderate difference in the Lowland Floodplain domain. MVG richness is maintained near reference in the both the Near Riparian and Lowland Floodplain domains. Vegetation in the Lowland Floodplain domain has 76% stability.

In addition, the Quality and Integrity of valley riverine vegetation is in Poor condition overall, and shows a very large difference from reference in the Slopes zones and a 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 WIM 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 from reference 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–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, with 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.

***Stability***

- Floodplain areas in the Lowland Floodplain domain are in Moderate condition, with evidence of moderate 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, with differences between zones and domains. Nativeness in the Near Riparian domain shows a very large difference from reference in the Slopes zone, and a large difference in the Lowland zone; and a moderate difference from Reference Condition 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 little differences between zones as indicated by their overlapping confidence limits. Structure is near Reference Condition in the Slopes zone and moderately different from reference in the Lowland zone. Structure refers only to the 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 Poor condition. Eucalypt Woodlands, which dominated the Lowland Floodplain domain under Reference Condition, now has a higher number of patches and a smaller mean patch area than reference, indicating dissection and clearing.

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

- Slopes zone: The Near Riparian domain was mostly (86% of the domain area) Eucalypt Woodlands with six other MVGs present, of which one was more than 5% of the domain.
- Lowland zone: The Near Riparian domain was mostly (86% of domain area) Eucalypt Woodlands with five other MVGs present, of which none was more than 5% of the domain.
- Lowland zone: The Lowland Floodplain domain was mostly (93% of domain) Eucalypt Woodlands, with four other MVGs, none 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 Near Riparian domain, and Eucalypt Woodlands are particularly affected.

- Slopes zone: In the Near Riparian domain, Eucalypt Woodlands are now reduced to 19% of the domain area. About 68% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands, formerly the most extensive MVG, is one of the most affected, being reduced to 23% of its reference area. In contrast, four MVGs still have areas close to reference.
- Lowland zone: In the Near Riparian domain, Eucalypt Woodlands are now reduced to 38% of the domain area. About 50% of the domain is either cleared or non-native vegetation. Eucalypt Woodlands, formerly the most extensive MVG, is one of the most affected, being reduced to 44% of its reference area. In contrast, four MVGs have areas close to reference.
- Lowland zone: In the Lowland Floodplain domain, Eucalypt Woodlands is reduced to 72% of the domain area. About 24% of the domain is either cleared or non-native vegetation. The most proportionally affected is Mallee Woodlands and Shrublands, reduced to 33% of its reference area, while Eucalypt Woodlands has the most reduced absolute area. In contrast, three MVGs have areas the same as Reference Condition.

# WIMMERA 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 January–February 2010. This means that the mapping metrics such as abundance, richness and nativeness, are off-set slightly in time and space from the LiDAR-derived Structure sub-indicator. 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 used to assess the Wimmera Valley are based on vegetation mapping which is not current and can be of variable quality. About 6% of the Near Riparian domain in the Slopes zone is not assigned to an MVG. 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 Wimmera Valley is notable for being in low condition throughout (Poor to Very Poor), for the low abundance of MVGs and low nativeness in the Near Riparian domain of the Slopes zone, and for the somewhat better condition of the Lowland Floodplain domain.

The condition of riverine vegetation varies slightly between zones from Very Poor in the Slopes zone, largely due to its low scores for MVG abundance and nativeness, to Poor in the Lowland zone, which has slightly higher scores for MVG abundance and nativeness in both the Near Riparian and Lowland Floodplain domains. The Lowland zone has a greater influence on the valley condition index than the Slopes zone, due to its greater stream length.

Within the Lowland zone, the Near Riparian and Lowland Floodplain domains assess differing but slightly overlapping parts of the riverine landscape: the Lowland Floodplain domain is land that floods near part of the main river channel, whereas the Near Riparian domain is a continuous strip centred on all channels, and is larger in area.

**Table WIM 7: Wimmera 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 | 21 | 49 |
| Indicator | Abundance and diversity | 60 | 38 | 70 |
| Metric | LF stability | 0.76 | | 0.76 |
| Sub-ind. | NRLF richness | 100 | | 100 |
| Metric | NR richness | 1 | 1 | 1 |
| Metric | LF richness | 1 | | 1 |
| Sub-ind. | NRLF abundance | 54 | | 54 |
| Metric | NR abundance | 0.40 | 0.29 | 0.45 |
| Metric | LF abundance | 0.76 | | 0.76 |
| Indicator | Quality and integrity | 44 | 37 | 47 |
| Sub-ind. | NRLF nativeness | 54 | | 54 |
| Metric | NR nativeness | 0.40 | 0.29 | 0.45 |
| Metric | LF nativeness | 0.76 | | 0.76 |
| Sub-ind. | NR structure | 77 (71–83) | 82 (71–89) | 75 (68–82) |
| Sub-ind. | LF fragmentation | 46 | | 46 |

# WIMMERA VALLEY

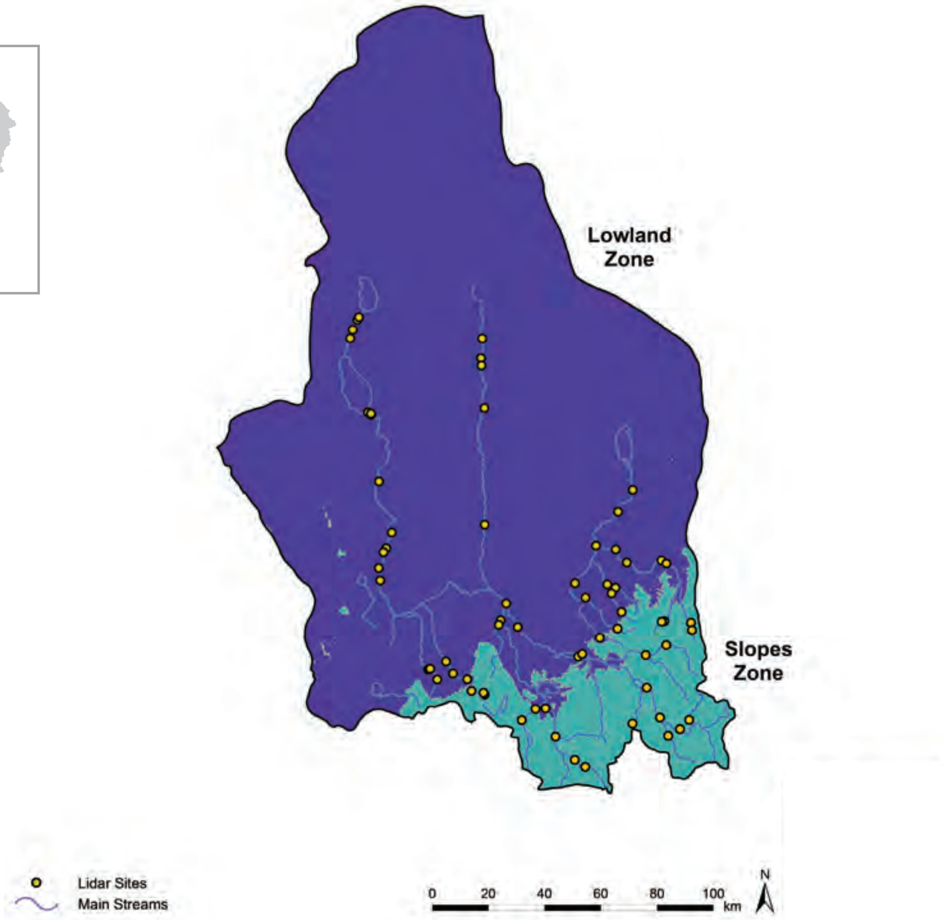
**Table WIM 8: The most abundant MVGs in the Near Riparian domain in the Wimmera Valley.**
Showing what percentage of the Near Riparian domain each MVG occupied in each zone under Reference Condition: restricted to MVGs that are at least 5% in area for any zone.

| Major Vegetation Groups | Zone | |
|---|---|---|
| | Slopes | Lowland |
| MVG | | |
| 3. Eucalypt Open Forests | 10 | |
| 5. Eucalypt Woodlands | 86 | 86 |

**Table WIM 9: Most abundant MVGs in the Lowland Floodplain domain in the Wimmera 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 | 93 | 2.83 | 0.27 |

# WIMMERA VALLEY



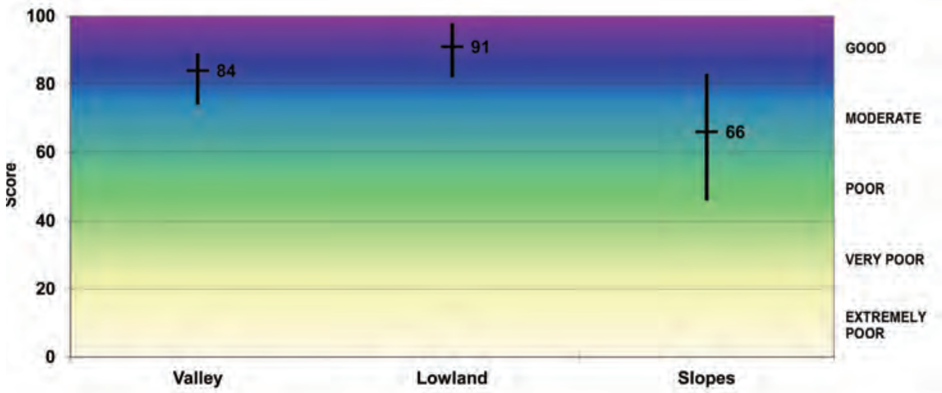




Figure WIM 5: Wimmera Valley map with LiDAR sites and zones coloured by SRA Physical Form Index (SR–PI) scores.

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

*The Physical Form of the Wimmera Valley river system was in Good condition, with an aggregate Physical Form Index score (SR–PI) of 84. 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 was characterised by elevated sediment loads since European settlement and associated sedimentation in the river channel and floodplain. There was also evidence of channel enlargement and simplification.*

The SRA Physical Form assessment considers physical form and processes along 1,396 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 98 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 WIM 5 shows values of the Physical Form Index (SR–PI) for the Wimmera Valley and Table WIM 10 shows the index, indicator, sub-indicator and metric values.

Analyses showed near Reference Condition for the Wimmera Valley with:

- SRA Physical Form Condition Index (SR–PI) = 84 (CL 74–89), indicating Good Physical Form condition
- the Channel Form indicator = 85 (CL 79–90), showing near Reference Condition
- the Bed Dynamics indicator = 46 (CL 37–54), showing a large difference from Reference Condition
- the Bank Dynamics indicator = 98 (CL 97–99), showing near Reference Condition
- the Floodplain indicator = 68 (CL 56–78), showing a moderate difference from Reference Condition.

***Slopes zone***

There were 19 LiDAR survey sites and 23 SedNet river segments in the Slopes zone of the Wimmera 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 (a few sites having large increases). Channel Width and Channel Sediment Deposition were modified from reference for approximately half of the Slopes zone. At these sites Channel Width was generally increased and there was a large increase in Channel Sediment Deposition across 40% of the zone for the post-European period. Channel Width Variability, Sinuosity, Meander Wavelength and Bank Variability were modified from reference for less than half of the Slopes 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 and Meander Wavelength across the zone and Bank Variability was generally increased indicating enhanced Bank Dynamics. These results are generally consistent with field observations (ID&A 2002). The streams of the Wimmera Slopes zone are extensively gullied, and downstream reaches are filled with coarse sediment. Erosion processes are exacerbated by salinity.

***Lowland zone***

There were 47 LiDAR survey sites and 75 SedNet river segments in the Lowland zone of the Wimmera 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 in more than half of the Lowland zone. At these sites Channel Depth was generally increased (many sites having large increases). Channel Sediment Deposition was modified from reference for approximately half of the Lowland zone. At these sites there was a large increase in Channel Sediment Deposition across 30% of the zone for the post-European period. Channel Width Variability, Sinuosity, Meander Wavelength and Bank Variability were modified from reference for less than half of the Lowland zone. At these sites Channel Width Variability was generally reduced, results show both increases and decreases in Sinuosity, Meander Wavelength and Bank Variability across the zone. Channel Width was largely unmodified from reference in the Lowland zone.

***Channel Form***

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. These results are generally not consistent with previous field observations (ID&A 2001, SKM 2006b). Channel expansion in the Slopes zone has been found to be almost ubiquitous.

There was little change from Reference Condition in Channel Form in the Lowland 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. These results are generally consistent with previous field observations (ID&A 2001). 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 and Lowland zones. There was considerable change from reference in Bed Dynamics in the Slopes and Lowland zones as a result of widespread sedimentation (40%–50% of the SedNet river segments) and increased sediment load (100% of the SedNet river segments). In both the Lowland and Slopes zones, indication of widespread sedimentation based on SedNet modelling is in contrast to evidence of bed degradation from measurements of Channel Form. This can be explained by erosion occurring in the upstream portion of the Slopes zone, with deposition in the downstream portion of streams in this zone.

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 and Lowland zones as a result of widespread sedimentation (100% of SedNet river segments).

**Table WIM 10: Wimmera 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) | 84 (74–89) | 66 (46–83) | 91 (82–98) |
| Indicator | Channel Form (volume and flow events) | 85 (79–90) | 84 (71–93) | 86 (80–91) |
| Sub-ind. | Cross-section Form | 79 (73–85) | 86 (75–96) | 76 (69–83) |
| Metric | Channel Depth (mean) | 1.22 (1.11–1.33) | 1.19 (1.00–1.45) | 1.23 (1.10–1.37) |
| Metric | Channel Width (mean) | 1.07 (1.02–1.13) | 1.11 (1.00–1.29) | 1.05 (1.00–1.11) |
| Sub-ind. | Cross-section Form (variability) | 93 (87–96) | 88 (75–97) | 95 (89–99) |
| Metric | Channel Width (CV) | 0.96 (0.91–0.98) | 0.93 (0.85–0.98) | 0.97 (0.94–1.00) |
| Sub-ind. | Channel Planform | 94 (91–96) | 89 (78–97) | 96 (94–97) |
| Metric | Sinuosity | 1.02 (1.00–1.03) | 1.01 (0.99–1.03) | 1.02 (1.00–1.04) |
| Metric | Meander Wavelength | 0.98 (0.95–1.01) | 1.00 (0.95–1.09) | 0.97 (0.93–1.00) |
| Indicator | Bed Dynamics | 46 (37–54) | 40 (21–57) | 49 (40–56) |
| Metric | Channel Sediment Ratio | 243 (186–302) | 291 (136–433) | 221 (159–288) |
| Metric | Channel Sediment Depth | 0.007 (0.004–0.01) | 0.01 (0.003–0.02) | 0.005 (0.003–0.008) |
| Indicator | Bank Dynamics | 98 (97–99) | 100 (100–100) | 98 (96–99) |
| Metric | Bank Variability (longitudinal) | 1.00 (0.99–1.02) | 1.03 (1.00–1.06) | 0.99 (0.97–1.02) |
| Indicator | Floodplain | 68 (56–78) | 60 (39–79) | 71 (60–84) |
| Metric | Floodplain Sediment Deposition | 2.00 (1.42–3.00) | 2.00 (1.27–4.00) | 1.95 (1.04–3.00) |

# WIMMERA VALLEY

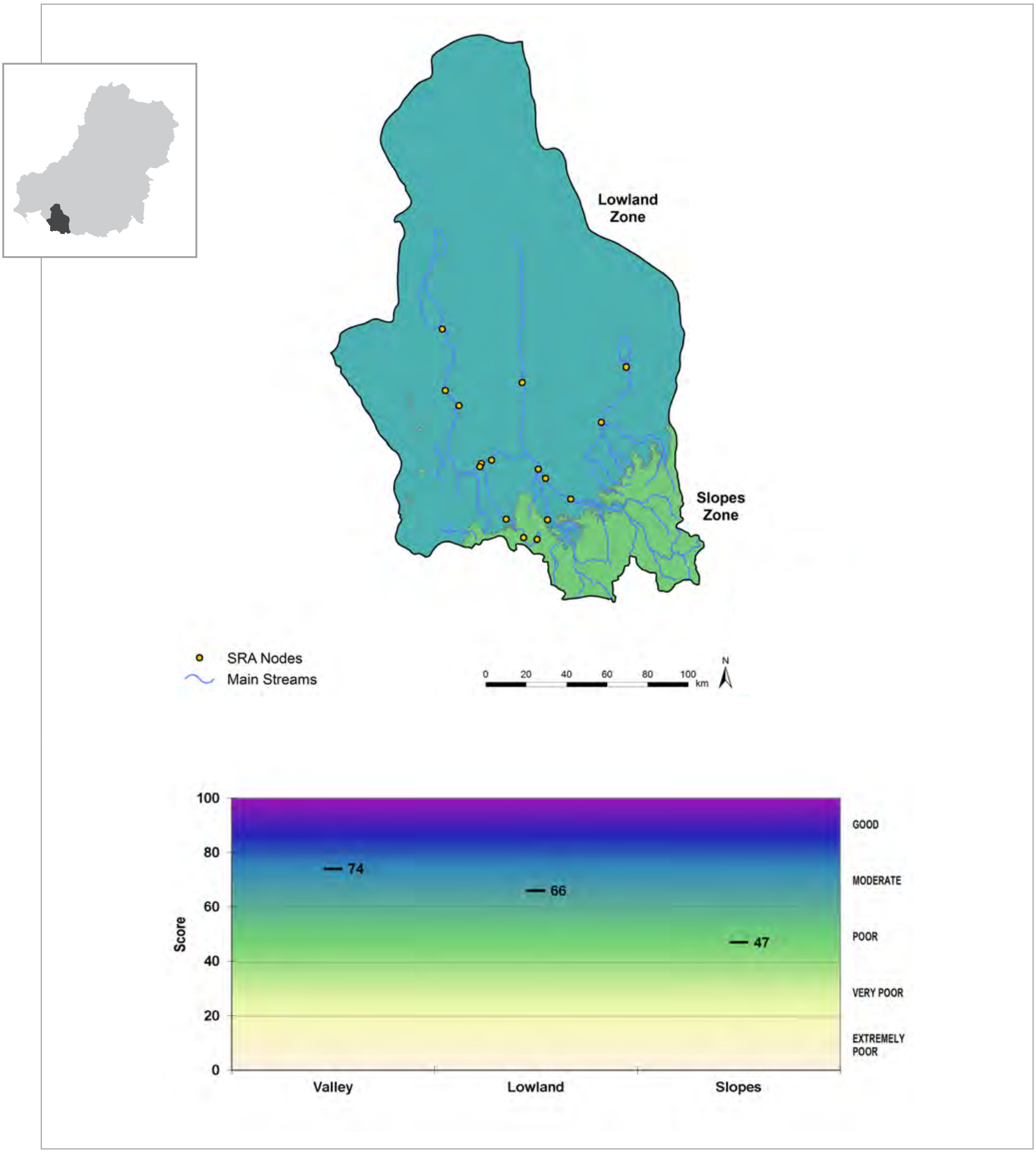



Figure WIM 6: Wimmera Valley map with zones coloured by SRA Hydrology Index (SR–HI) scores.
Graph shows SR–HI scores as horizontal bars.

*The Hydrology of the Wimmera Valley river system was in Moderate condition, with an aggregate Hydrology Index (SR–HI) score of 74. The Lowland zone was in Moderate condition. The Slopes zone was in Poor condition. The mainstem river system of the Wimmera Valley was rated in Moderate condition. Throughout much of the mainstem river system both high and low flows were reduced and the timing of seasonal flow variations was altered relative to Reference Condition. There were also some reaches with reduced mean flows and altered duration of cease-to-flow periods. The headwater streams of the Wimmera Valley were rated in Good condition. Throughout some of the headwater streams the amplitude of seasonal flow variations was increased relative to Reference Condition.*

Streams of the Wimmera Valley form a complex network, terminating inland. The Wimmera River terminates in a series of important wetlands including Ramsar-listed sites at lakes Hindmarsh and Albacutya. The Wimmera is highly regulated, with seven large storages (>15 GL) on tributaries but only one small storage, Mount Cole Dam, on the main channel. Approximately 120 GL of surface water is diverted annually for irrigation, but there is significant transmission loss and only about 40 GL is applied as irrigation water. Piping has been developed as an efficiency measure. Inter-basin diversions from the south-flowing Glenelg River are piped into the Wimmera Valley.

In the Wimmera Valley, hydrological condition is assessed using metrics of hydrological alteration available for 2,195 km of mainstem rivers and headwater streams. There are 364 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 Wimmera Valley there is 1,831 km of headwater stream (677 km in the Slopes zone; 1,154 km in the Lowland zone). 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 Wimmera Valley there is 1,240 km of these mid-size tributaries (141 km in the Slopes zone; 1,098 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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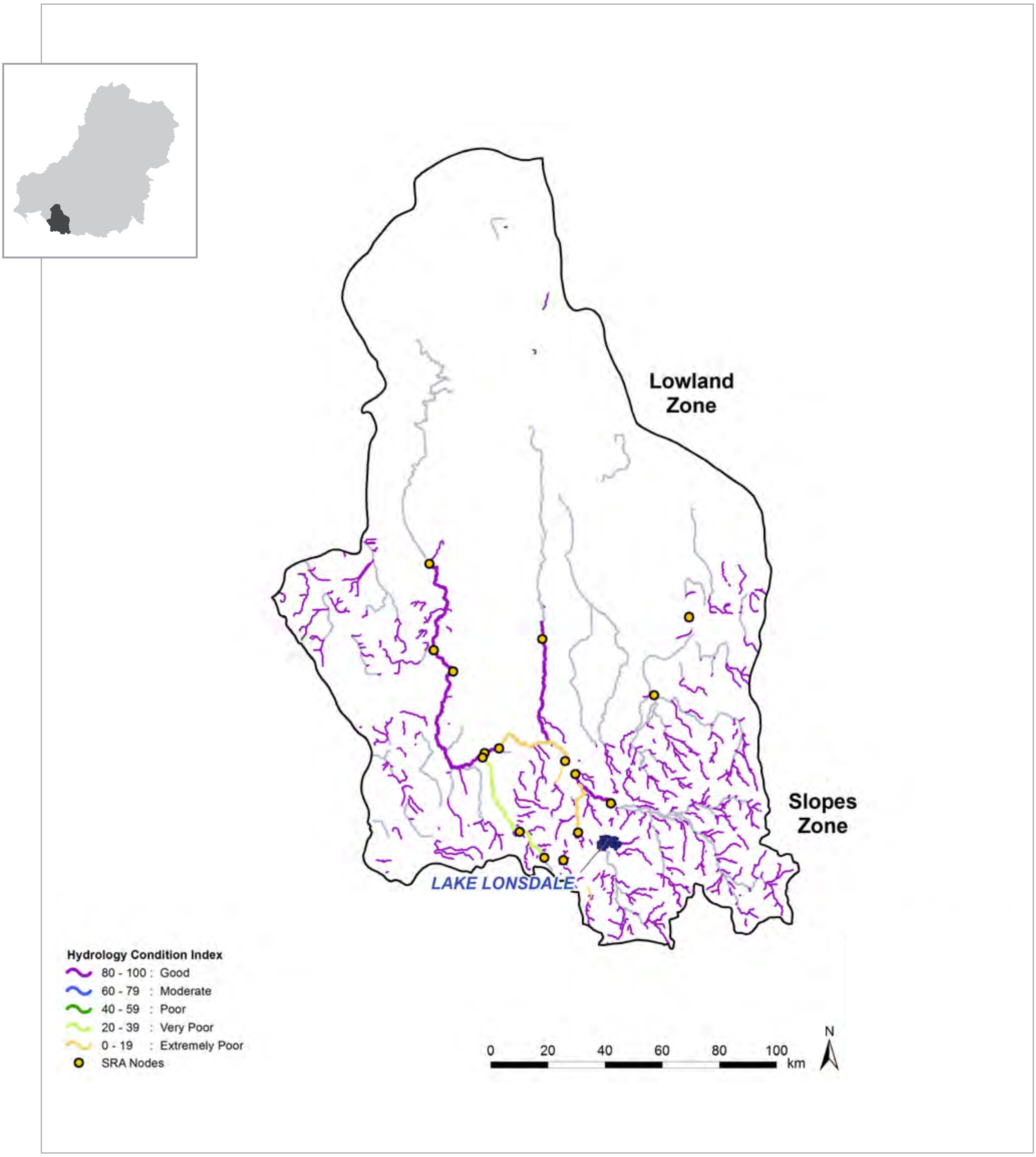


Figure WIM 7: Wimmera Valley map with reaches coloured by SRA Hydrology Index (SR–HI) scores.

Figures WIM 6 and WIM 7 show values of the Hydrology Condition Index (SR–HI) for the Wimmera Valley and its river network, and Table WIM 11 and WIM 12 show the index, sub-index, indicator and metric values. Analyses showed a moderate difference from Reference Condition for the Wimmera 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 = 47 and 66 indicating Poor 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) = 65, indicating Moderate hydrological condition.
- The In-Channel Flow Regime sub-index in the mainstem river reaches = 65, indicating Moderate condition and a moderate difference from Reference Condition for the flow regime within the channels.

***Flow Gross Volume***

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 5% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from reference in 26% 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 Slopes zone, most in the Lowland zone. In addition, results for the Flow Duration metric showed a very significant alteration from Reference Condition in 11% 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 increased flows). These river reaches with altered hydrology are distributed across the valley, with a small proportion in the Slopes zone, 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 very significant alteration from Reference Condition in 1% 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 Flow Duration 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 Slopes zone and some in the Lowland zone.

***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 35% of the mainstem river length (mostly associated with reduced flows) and a significant alteration from Reference Condition in 33% 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 Slopes zone, 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 (associated with both increased and reduced flows) and a significant alteration from reference in 19% 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.

***Low and Zero Flow Events***

The Low and Zero Flow Events 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 indicator showed a moderate difference from Reference Condition. Results for the Low Flow metric showed a very significant alteration from Reference Condition in 45% of the mainstem river length (mostly associated with reduced 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 a small proportion in the Slopes zone, most in the Lowland zone. Results for the Zero Flows Proportion metric showed a very significant alteration from Reference Condition in 34% of the mainstem river length (associated with both increased and reduced flows) and a significant alteration from reference in 4% 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. The Low Flow Spells metric could not be calculated for this valley.

In the headwater streams, the Low and Zero Flow Events 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 19% 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 a very significant alteration from Reference Condition in 1% 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.

#### *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 29% of the mainstem river length (mostly a reduced amplitude) and a significant alteration from reference in 6% 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 proportion in the Slopes zone and most in the Lowland zone. Results for the Seasonal Period metric showed a very significant alteration from Reference Condition in 9% of the mainstem river length and a significant alteration from reference in 39% of the mainstem river length. 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 Seasonality sub-indicator showed near Reference Condition. Results for the Seasonal Amplitude metric showed a very significant alteration from Reference Condition in 6% 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 some in the Slopes zone and some in the Lowland zone. Results for the Seasonal Period metric showed a significant alteration from reference in 1% of the headwater 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.

#### *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 28% of the mainstem river length (associated with both increased and reduced variability) and a significant alteration from reference in 16% 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.

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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 very significant alteration from Reference Condition in 1% of the headwater river length (mostly associated with reduced variability) and 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 Slopes zone and some in the Lowland zone.

***Summary: mainstem rivers***

The mainstem river system of the Wimmera Valley was generally characterised by minor alteration in Flow Variability, Flow Seasonality, Low and Zero Flow Events and High Flow Events and little or no alteration in Flow Gross Volume relative to Reference Condition. Throughout much of the mainstem river system both high and low flows were reduced and the timing of seasonal flow variations was altered. There were also some reaches with reduced mean flows and altered duration of cease-to-flow periods.

***Summary: headwater streams***

The headwater streams of the Wimmera 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 amplitude of seasonal flow variations was increased.

**Table WIM 11: Wimmera 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 | | | 47 | 66 |

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**Table WIM 12: Wimmera 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 (9–100)** | **99 (0–100)** |
| Sub-index | In-Channel Flow Regime | 65 (9–100) | 99 (0–100) |
| Indicator | In-Channel Flow Regime A (volume and flow events) | 63 (0–100) | 99 (0–100) |
| Sub-ind. | Flow Gross Volume | 85 (0–100) | 98 (0–100) |
| Metric | Mean Annual Flow | 0.81 (0–1.00) | 1.03 (0–1.16) |
| Metric | Flow Duration | 1.16 (1.00–1.68) | 0.99 (0.65–1.71) |
| Sub-ind. | High Flow Events | 73 (0–100) | 97 (0–100) |
| Metric | High Flow | 0.65 (0–1.00) | 1.05 (0.01–1.77) |
| Metric | High Flow Spells | | |
| Sub-ind. | Low and Zero Flow Events | 65 (10–99) | 96 (10–99) |
| Metric | Zero Flows Proportion | 0.94 (0–1.89) | 0.99 (0–1.01) |
| Metric | Low Flow | 0.64 (0–1.70) | 0.94 (0.01–1.38) |
| Metric | Low Flow Spells | | |
| Indicator | In-Channel Flow Regime B (seasonality & variability) | 74 (16–100) | 98 (0–100) |
| Sub-ind. | Flow Seasonality | 70 (11–100) | 91 (11–100) |
| Metric | Flow Seasonal Amplitude | 0.69 (0–1.00) | 1.17 (0–1.72) |
| Metric | Flow Seasonal Period | 0.78 (0.43–1.00) | 0.96 (0.49–1.00) |
| Sub-ind. | Flow Variability | 78 (30–100) | 90 (0–100) |
| Metric | Flow Variation | 1.18 (0.97–1.63) | 0.91 (0.14–1.00) |
| 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 |
| | | **25** | **66** | | | **99** |
| | | 25 | 66 | | | 99 |
| | | 21 | 65 | | | 99 |
| | | 24 | 88 | | | 98 |
| | | 0.22 | 0.83 | | | 1.03 |
| | | 1.45 | 1.15 | | | 1.01 |
| | | 9 | 76 | | | 97 |
| | | 0.09 | 0.67 | | | 1.08 |
| | | | | | | |
| | | 59 | 65 | | | 97 |
| | | 0.32 | 0.97 | | | 0.99 |
| | | 1.18 | 0.62 | | | 0.99 |
| | | | | | | |
| | | 44 | 74 | | | 97 |
| | | 14 | 73 | | | 92 |
| | | 0.07 | 0.72 | | | 1.16 |
| | | 0.47 | 0.79 | | | 0.96 |
| | | 99 | 77 | | | 90 |
| | | 0.97 | 1.19 | | | 0.91 |

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**MURRAY VALLEY - LOWER**

**MURRUMBIDGEE VALLEY**



**NAMOI VALLEY**



**OVENS VALLEY**

**PAROO VALLEY**



**WARREGO VALLEY**

**WIMMERA VALLEY**