MIDCOAST council

MANNING RIVER ESTUARY & CATCHMENT

RAPID SITE ASSESSMENT 2020

Annexure H

environment.nsw.gov.au

Cover photo: Nowendoc River at Nowendoc Road (site 64-05). Peter Serov (Stygoecologia)

This publication is the May 2020 revision and may be cited as:

Swanson, R. 2020. Manning River Estuary and Catchment RAPID SITE ASSESSMENT. A snapshot of stream condition in the Manning River Estuary and its catchment from the ground-truthing program. Environment, Energy and Science. NSW Government, Sydney.

Acknowledgements: Staff of MidCoast Council's Natural Systems Team assisted with the Rapid Site Assessments field work. Louise Duff and Karen Bettink undertook project management and peer review.

Find out more about your environment at:

www.environment.nsw.gov.au

Contents

Photos

Maps

Tables

Executive Summary

The Manning River Estuary is a significant natural asset in the Mid-Coast Region of NSW with environmental, social and economic values for the regional community. Its vast catchment covers 8,420 km^2 from the mountains to the sea. The ecological health of the Manning River Estuary is under pressure as a result of both past and present land management practices.

MidCoast Council (MCC) is preparing a Catchment Management Plan (CMP) for the Manning River Estuary. The CMP will set the long-term strategy for the coordinated management of the estuary, taking a whole-of-catchment approach. It will comply with the NSW Coastal Management Act 2016 and guide future investment to protect the catchment.

This report provides a valuable snapshot of waterway condition throughout the Manning River Estuary and its catchment. It is based on field data from a one-off program of 206 Rapid Site Assessments conducted in July-August 2019 during extreme drought conditions. It characterises land use, riparian, geomorphic and in-stream condition throughout the catchment and presents overall grades for each site and major subcatchment.

The Rapid Site Assessment program had two objectives. The primary objective was to ground-truth, or validate, spatial layers for a Risk Assessment of pressures on the estuary. The results of the ground-truthing exercise are presented in the Manning River Estuary and Catchment Risk Assessment (Swanson 2019).

A secondary objective was to observe and understand the catchment first-hand while gathering field data to characterise condition and threats, which is the subject of this report. It can be interrogated at different spatial scales from a single site or sub-catchment. Both reports – the Risk Assessment and the Rapid Site Assessments - will inform issues and actions developed to protect the ecological and community values of the system.

The Rapid Site Assessment methodology was developed by MidCoast Council and the Estuary and Catchments Team (ECT) of Environment, Energy and Science (EES); Department of Planning, Industry and Environment (DPIE). It was adapted from several established methods for riparian assessments to meet the objectives of the program. The Rapid Site Assessments were conducted by two field teams from both agencies using data collection proformas loaded onto Android tablets.

The Manning River Estuary catchment consists of 16 major subcatchments and 85 minor subcatchments, each of which are numerically coded by EES. In all, Rapid Site Assessments were conducted at 175 sites in the freshwater catchment and 31 sites in estuarine catchment. Sites were selected to give an even spread across the sub-catchments, favouring Crown Land sites where the adjacent land use was grazing. Crown Land sites were chosen because they afforded good access for the project team. Grazing land use was chosen because a preliminary risk assessment of the Manning River Estuary identified that sub-catchments with agricultural land use posed a high risk to estuary health and the need was identified to better understand impacts of agricultural diffuse-source run-off in the catchment (MCC 2018, Dela-Cruz et al. 2019). Grazing was the dominant land use at 85% of sites surveyed in the freshwater catchment and 42% of sites in the estuarine catchment.

To rate the condition of the catchment, a grading system was used. Scores for each parameter were summed to arrive at an Overall Condition score, then graded in bands from *Very Poor*, *Poor*, *Fair* (mid-range) to *Good* and *Excellent*.

Freshwater catchment condition

Rapid Site Assessments at freshwater sites covered the following attributes: Land Use Pressure, Instream Condition (including water quality), Riparian Condition and Geomorphic Condition.

Overall Condition scores ranged from *Poor* (on the Barrington River) to *Excellent* (on the Avon River). Most freshwater sites were in *Fair* condition (53%) or *Good* condition (38%). Sites in Burrell Creek and Dingo Creek catchments were, on average, rated in the best condition with Overall Condition scores of 89 and 79 (out of a maximum possible score of 125), respectively (Table A).

Geomorphology of streams is derived from components of geology, soil science and hydrology. The *Geomorphic Condition* assessment included questions on attributes of river substrate and bank structure / evidence of erosion. Geomorphology reflects the degree of exposure of riverbanks to the forces that cause and enhance erosion, including clearing and agricultural activities. Geomorphic Condition was only assessed at freshwater sites and was usually rated as *Good* or *Excellent*.

Riparian vegetation plays an important role in stabilising waterways, reducing the impact of run-off and providing food and habitat diversity for aquatic fauna. *Riparian Condition* at freshwater sites was mostly in *Fair* condition in the upper catchment or in *Good* condition in the lower catchment. The riparian zone was typically a narrow band (less than 10 metres wide) of River Oak *(Casuarina cunninghamiana)* trees, with exotic species dominating the shrub layer. The native green mat-rush (*Lomandra longifolia)* was present at many sites.

Instream Condition provides information on the health of the waterway. The assessment covered water quality as well as habitat diversity, condition and extent cover of filamentous algae and macrophytes, and rubbish/grease/oil. Water quality attributes were recorded *in situ* with a water quality multi-meter (temperature, dissolved oxygen, conductivity, pH, turbidity, and chlorophyll-a). Severe drought conditions – the worst on record –meant that water quality readings were in non-comparable water bodies. Fifteen percent of streams assessed were completely dry and 30% were isolated pools, often with very poor water quality. The remaining 55% of freshwater sites were flowing streams, typically with low-flow and good water quality, most likely due to the lack of the recent overland flow delivering nutrients and sediments from surrounding land use. It is inappropriate to score water quality readings taken from different types of water bodies (isolated pool versus flowing stream). Further, Guideline Values for turbidity, chlorophyll and pH do not exist for freshwater 'isolated pools'. For these reasons, water quality at freshwater sites could not be included in the score for the Instream Condition assessment. Water quality data collected during the field program was however used to ground-truth spatial layers used in risk assessments where possible (Swanson 2019).

Algae and macrophytes (aquatic plants) influence the oxygen and light present in the water column. An Instream Condition score included attributes relating to diversity of habitats available, and the presence of filamentous algae and macrophytes. Most sites in the catchment were rated as having *Poor* or *Fair* Instream Condition. The generally low scores are partly due to the heavy weighting assigned to estimates of macrophytes (presence/ distribution of macrophytes across the reach, and the presence/distribution of the separate growth forms of submerged, emergent and floating macrophytes). Macrophytes generally had patchy distribution at sites, with occasionally dense distributions in flowing streams, and all three growth forms were rarely present at a site. At sites where adjacent land use was dairy (common for the Manning River sites) there was often extensive cover of macrophytes fouled with epiphytic algae, which is an indicator of high nutrient concentrations (Schindler 2006).

Macroinvertebrates (aquatic insects, worms and snails) make an important contribution to ecosystem health, aiding decomposition and providing food for fish and other aquatic fauna. Macroinvertebrate sampling was not part of the Rapid Site Assessments due to time and budgetary constraints. The MidCoast Council Riverine MER project surveyed the freshwater

catchment farther south of the Manning River between the spring 2015 and the autumn 2016 and found that good in-stream habitat was retaining resilient macroinvertebrate assemblages at sites where condition was impaired to some extent. Loss of instream habitat is likely to alter benthic macroinvertebrate assemblages, favouring silt or fine sediment tolerant taxa adapted to silty stream beds. The diverse assemblages found in boulder and cobble reaches of the Wallamba and Myall Rivers (OEH 2016a) highlights the importance of preventing bank erosion and sedimentation through improvement of riparian land management practices.

Estuarine catchment condition

Rapid Site Assessments at estuarine sites covered Land Use Pressure, Instream Condition (including water quality), and Riparian Condition. Geomorphic Condition was not included in the Rapid Site Assessment for estuarine sites because this attribute was included in the program in order to validate a spatial layer of 'fragility' that was used in the Erosion Risk Assessment (Swanson 2019). The fragility rating was derived from the River Styles Framework which describes the sensitivity to disturbance for each style and is only applicable to freshwater streams. Water quality was included in the Instream Condition (and Overall Condition) score because water bodies were comparable as flows were more consistent in the estuary: 95% of the estuarine sites had moderate flows.

Overall Condition scores ranged from *Poor* to *Good* however most estuarine sites were in *Fair* condition. Sites in Dawson River and Manning River catchments were rated in the best condition on average, with Overall Condition scores of 39 and 33 (out of a maximum possible score of 69), respectively (Table A).

Riparian Condition scored poorly at estuarine sites, with the majority rated *Poor* or *Fair*, primarily due to the sparse distribution of riparian vegetation. Mangroves occur throughout the estuary and provide some protection of bank structure where they occur. Continuity of mangroves along the shoreline can be patchy and the band width rarely exceeded 10m. Even though present, mangroves at this density provide limited protection of shorelines from erosional forces of high flows and boat wash. *Casuarina (glauca, littoralis)* were the dominant native trees while native grasses/sedges were only present in patches.

Instream condition score for estuarine sites included attributes for water quality (turbidity, chlorophyll-a, pH), macrophytes (macroalgae, seagrass) and rubbish. Instream condition scores for each site ranged from *Poor* to *Good*. Most sites scored poorly, in part due to the absence of saltmarsh and seagrass. Water quality was good in the main channels of the estuary, although very high turbidity was recorded at two sites during windy conditions revealing the amount of loose sediment on the riverbed that is easily re-suspended. The impact of Acid Sulphate Soils was noted in the sediments, influencing an acidic pH for the waterway.

For further water quality results, MidCoast Council's Waterway and Catchment Report Cards can be found on Council's web site. The 2019 report card assessed five sites in the Manning Estuary: Upper Manning Estuary, Dawson River, Mid-Manning Estuary, Lower Manning Estuary and Farquhar Inlet. All sites scored a B (*Good*) rating.

Conclusion

Table A overleaf sets out the average scores for Overall Condition and attributes assessed for the major river/creek catchments of the Manning River Estuary. While the table gives a good overview of each catchment and how it relates to others, it is important to note that there was considerable variation in site condition within each of the catchments and at the site level within EES subcatchments. These variations can be seen in Tables A3-2 and A4-2.

Overall, sites in freshwater catchments were rated in better condition than the estuarine catchments, with most freshwater sites rated as *Fair* and *Good* condition while most estuarine sites were rated as *Fair* condition. However, the Overall Condition ratings of estuarine and

freshwater catchments should not be directly compared due to the different composition of the Rapid Site Assessment for freshwater and estuarine sites. In particular, Geomorphic Condition was only assessed at the freshwater sites and generally scored well, thus contributing to the higher scores and better condition ratings assigned to the freshwater sites.

At the time of the Rapid Site Assessment program in July-August 2019, the Manning Valley was experiencing the most severe drought on record. This is reflected in some of the data collected. An extended period of dry weather resulted in low-flow or no-flow in many streams assessed. Good water quality was recorded in all flowing perennial streams despite, in many cases, the surrounding land use that would be expected to transport pollutants (nutrients, sediment) in surface runoff. This suggests subsurface groundwater may be a primary source of water at baseflow in these systems. Isolated refuge pools in intermittent streams often had poor water quality and excessive algal / macrophyte growth. Generally low stocking rates were observed throughout most of the catchment during the field program suggesting that farmers have reduced stock due to the ongoing drought.

Stock impact on the riparian zone was found to be a widespread threat to stream/estuary health across the catchment. The condition of riparian vegetation was somewhat better in the freshwater subcatchments rating from *Fair* (upper catchment) to *Good* (lower catchment) while in the estuary the majority rated *Poor* or *Fair*. The width of the riparian zone rarely exceeded 10 m throughout the system.

Instream Condition scores in both the freshwater and estuarine subcatchments showed indicators of elevated nutrients. High nutrient loads come from fertilised pastures and crops, manure in pastures and on streambanks, and stock urinating and defecating in riparian zones and streams (McDowell and Wilcock 2005, Nennich et al. 2005)

Erosion of hillslopes and streambanks is a widespread pressure in the catchment leading to loss of structure in the riparian zone and loss of vegetation. There are extensive areas of hillslopes and pastures with barely any ground cover and limited vegetation across the catchment. Active erosion and gully erosion were also noted. Coupled with poor riparian vegetation these areas pose a risk to estuary health as large amounts of sediment are likely to be mobilised from the catchment when wetter conditions return.

The impact of land-clearing and agricultural run-off is influencing catchment health in both freshwater and estuarine catchments. Working with the farming community to improve land management practices will reduce the risk of nutrients and sediments, while continuing to manage Acid Sulphate Soils, will help protect ecosystem health in the Manning catchment.

Table A **Average scores for Overall Condition, Land Use Pressure, Geomorphic Condition [freshwater sites only], Instream Condition and Riparian Condition for all major river/creek catchments (number of EES subcatchments and total number of sites assessed are shown as # SC, # sites). Note Table A combines Table 3 (freshwater) and Table 15 (estuarine).**

Major River / Creek Catchment FRESHWATER (#SC, # sites)	Average Overall Condition score (max 125)	Average Land Use Pressure score (max 11)	Average Geomorp. score (max 29)	Average Instream Condition score (max 37)	Average Riparian Condition score (max 56)
Burrrell Creek (2, 9)	89	8	23	17	41
Dingo Creek (3, 14)	79	7	20	16	36
Manning River (5, 14)	77	8	23	17	29
Cattai Creek (1, 2)	77	6	25	18	28
Upper Manning River (3, 20)	76	6	23	16	31
Nowendoc River (5, 24)	75	7	23	14	31
Myall Creek (2, 5)	74	7	24	13	29
Avon River (2, 11)	73	7	22	16	28
Bowman River (1, 7)	71	6	23	14	27
Gloucester River (2, 13)	70	6	22	15	28
Lansdowne River (1, 7)	70	7	22	13	28
Barrington River (4, 19)	64	5	20	13	25
Barnard River (6, 19)	63	6	21	14	21
Cedar Party Creek (1, 5)	61	6	19	15	21
Freshwater Catchment Average	**72**	**6**	**22**	**15**	**29**

Major River Creek Catchment ESTUARINE (#SC, # sites)	Average Overall Condition score (max 69)	Average Land Use Pressure score (max 11)	Average Instream Condition score (max 23)	Average Riparian Condition score (max 35)
Dawson River (1, 3)	39	9	14	15
Manning River (6, 18)	33	7	13	13
Lansdowne River (2, 6)	29	5	11	12
Cedar Party Creek (1,1)	28	8	13	7
Cattai Creek (1, 3)	27	7	10	10
Estuarine Catchment Average	**32**	**6**	**13**	**13**

Background

This Rapid Site Assessment represents one step in the first two stages of MidCoast Council's development of the Manning River Estuary and Catchment Management Plan (CMP) under the New South Wales *Coastal Management Act* 2016.

As part of the Stage One CMP Scoping Study (2018), the project team undertook a literature review and gap analysis of issues and reviewed the State and regional-level risks in the NSW *Marine Estate Management Strategy Threat and Risk Assessment* (TARA) relevant to the Manning Estuary. The state-wide TARA guides management action to address threats and risks in NSW for environmental, social, cultural and economic benefits derived from the marine estate. The TARA was discussed at a workshop in December 2018 with the Manning Estuary Technical Woking Group (TWG) to reach consensus on prioritisation of threats and relative risk to the Manning Estuary. Through this process the project team identified that further research on agricultural diffuse-source run-off was a high priority.

Also during Stage One, a preliminary spatial risk assessment was completed by the Office of Environment and Heritage. It identified the relative risk of impact from nutrient and sediment loads in diffuse runoff on water quality in the Manning Estuary from each subcatchment. Land use in the catchment underpinned the preliminary spatial risk assessment but it didn't include other locally relevant data. The TWG recommended that the preliminary risk assessment be improved with updated land use data, additional risk assessments based on local data sets (e.g. septics risk hazards, pathogens monitoring data) and validation through an on-ground Rapid Site Assessment program. The purpose of the field program was to assess stream and riparian condition at sites with a range of land uses across the freshwater and estuarine catchments. A Rapid Site Assessment and refinement of the spatial risk assessment were therefore completed as in Stage Two of the CMP development process.

The Rapid Site Assessment program was developed to ground-truth (validate) the catchment pressures identified as a risk to ecological, social, cultural and economic values of the Manning River Estuary reported in the Stage One CMP Scoping Study (2018) and in *Manning River Estuary and Catchment RISK ASSESSMENT* (Swanson 2019). Rather than attempting a comprehensive health assessment of all habitats within the vast catchment, the core aim of the project was to inform and validate the spatial layers used in the risk assessments that would enable identification and prioritisation of threats to water quality. Both the Rapid Site Assessment program and the risk assessments were designed to support management planning by practitioners.

An extensive field program was conducted throughout the Manning River catchment and estuary from 29th July – 30th August, 2019 by the Estuary and Catchments Team (Environment, Energy and Science [formerly Office of Environment and Heritage]) in the Department of Planning, Industry and Environment (DPIE) and MidCoast Council, to collect data on land use, riparian, geomorphic and instream condition.

The land uses assessed during the site assessment program were not selected to obtain an objective determination of the relative impacts of all catchment pressures. Instead, the project aimed to obtain enough information on major land use classifications to validate the spatial risk assessment, with grazing types the focus due to the relative threat identified through TARA and the TWG rankings. Sites with land uses representing other risks were also assessed, including poultry, turf farms, golf courses, equine husbandry and forestry. The intent was to gain replicate site assessments of representative land use types across the catchment and estuary, rather than randomising site selections.

This Rapid Site Assessment report provides an overview of the field data collected during the program. It presents a valuable snapshot of condition and threats across the Manning catchment that can be interrogated at different spatial scales e.g. from site to major river catchment scale.

Field data collected from the Rapid Site Assessments was used to validate the Stage Two spatial risk assessment study *The Manning River Estuary and Catchment RISK ASSESSMENT* (Swanson 2019). That study produced several spatial layers of local threats/pressure data to assess risk to ecological and community values including:

- Nutrient/sediment risk = updated estuary health risk map
- Pathogen risk from livestock to
    - Drinking water quality
    - Secondary recreation
    - Aquaculture
- Erosion risk to riparian vegetation

Two additional studies on key threats to estuary health were included in the Risk Assessment report:

- Risk of environmental impacts from acidic runoff from acid sulphate soils on the Manning floodplain (Glamore et al. 2016)
- Pathogen/nutrient risk from on-site sewage management on water sources, sensitive receptors (DWC 2018a)

Each risk assessment is a spatial prioritisation tool that can be used to inform further investigations of the risk, and on-ground actions and management programs to mitigate the risk to ecological and community values of the estuary.

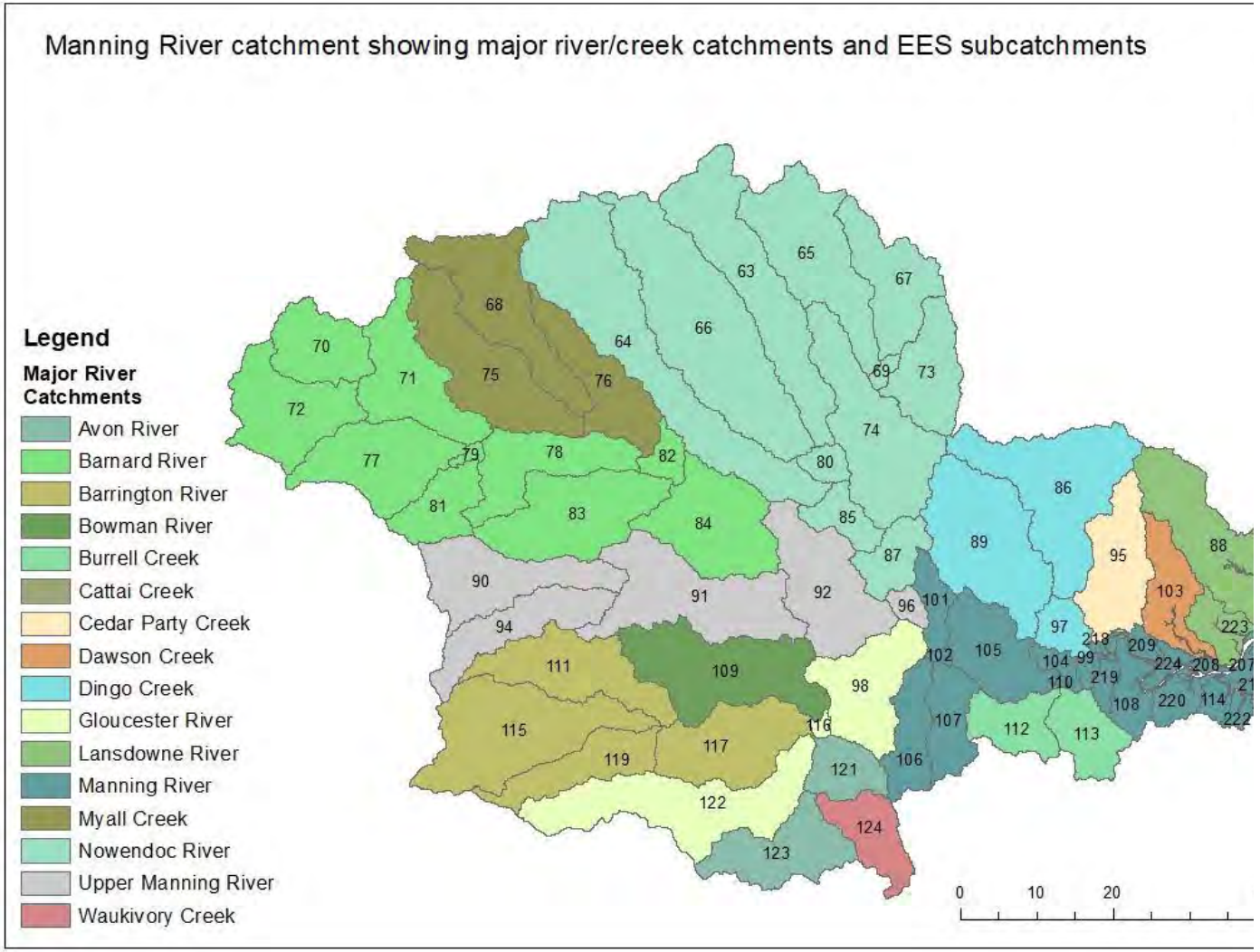
Following the Stage Two studies, further investigation to address priority risks can be identified as future actions in the CMP.

The Manning River Estuary Catchment

At 8,420 km^2 the catchment of Manning River estuary is very large and includes the following 16 major rivers/creeks as tributaries (Map 1):

- Nowendoc River
- Myall Creek
- Barnard River
- Upper Manning River
- Lower Manning River
- Barrington River
- Gloucester River
- Avon River
- Waukivory River
- Bowman River
- Burrell Creek
- Dingo Creek
- Cedar Party Creek
- Dawson River
- Lansdowne River
- Cattai Creek

Given its large size and the number of rivers and creeks in the catchment, a rapid method of site assessment was required.



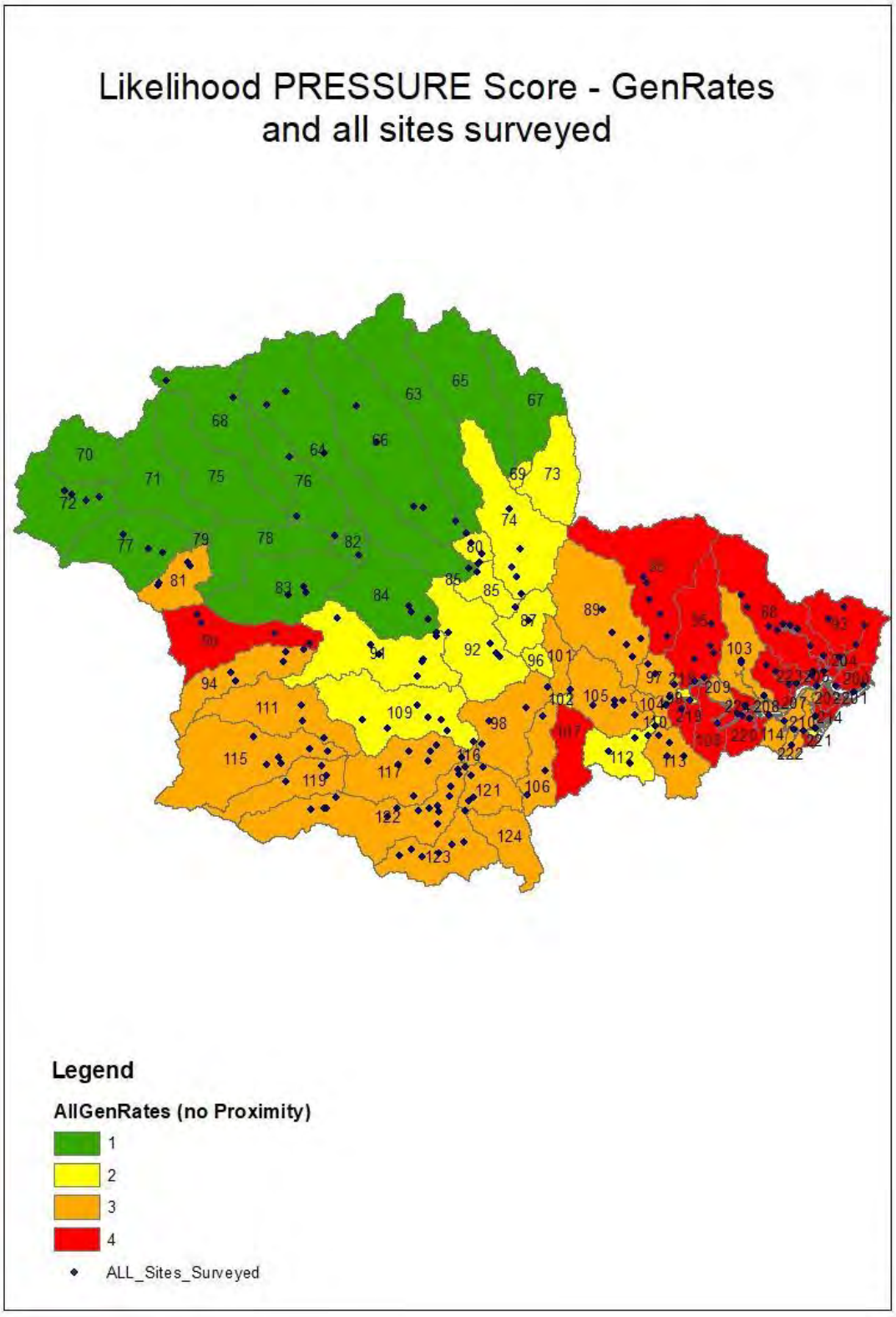
Map 1 **The major river/creek catchments (coloured) in the Manning River estuary catchment and constituent EES subcatchments (numbered)**

Method

The Rapid Site Assessment (RSA) methodology was developed by MidCoast Council and the Estuary and Catchments Team (ECT). The RSA was adapted from several established methods for riparian assessments to meet the objectives of the program (OEH 2015, 2016a, b; Turak et al. 2004, Jansen et al. 2005, Southeast Engineering and Environmental 2016). The Stage One CMP Scoping Study and the preliminary Estuary Health Risk Map for the Manning found diffuse run-off from rural subcatchments posed a high relative risk to the health of the estuary (MCC 2018). Similarly, vegetation condition and proximity to agricultural land were found to have the most impact on riparian condition and water quality in the Tuross Estuary (Southeast Engineering and Environmental 2016). Thus, the RSA methodology developed for this project assessed land use and agricultural pressure, riparian condition and instream condition including water quality. Geomorphic condition was included in the freshwater catchment assessments, as geomorphic features can reflect the degree of exposure to the forces that cause and enhance erosion, such as land clearing for grazing and other agricultural activities. Further detail on established methods and the rationale for the adapted RSA is presented in *Manning River Catchment and Estuary Management Program Stage 2: Ground truthing – Rapid Site Assessments* (MCC 2019)

Sites assessed and data collection

- Each of the 16 major catchments of the Manning were divided into smaller drainage units (85 subcatchments) based on 3rd order streams using Strahler stream order and given a unique identifying number (Map 1). All sites assessed were 3rd order streams or above.
- 44 of the 85 EES subcatchments were surveyed by Rapid Site Assessment. There was an emphasis on surveying subcatchments that rated as high to moderate risk to estuary health in the preliminary Estuary Health Risk Map (MCC 2018). A small number of low-risk subcatchments were included for comparative purposes (Map 2)
- Potential sites for RSA were selected for even spread across EES subcatchments with an emphasis on areas with agricultural land uses, however, other major land use classes were included (i.e., rural residential, urban and forested areas). The following sites were prioritised for inclusion:
    - Water quality sampling sites (Mid Coast Council Water Services)
    - Freshwater macroinvertebrate sampling sites
    - Publicly accessible sites (e.g. bridge and road crossings, parks, boat ramps)
    - Council and Crown Lands
    - Sites where property owner permissions have been granted through other projects
- 175 freshwater sites and 31 estuarine sites were assessed across the catchment (Table 1, Maps 3 – 8). Typically, 4 – 6 sites were assessed per subcatchment, with a minimum of 3 in each subcatchment surveyed, with three exceptions (68 – 2 sites, 82 – 1 site, 87 – 1 site).
- RSA were completed electronically on-site using Open Data Kit (ODK) forms setup by ECT on Android tablets. Field data collected in RSA's was uploaded daily to a database, removing the need for manual data entry.
- Rapid Site Assessments included site location information including site coordinates and photographs taken upstream, downstream and across stream.
- At each site a 100 m reach was defined and visually assessed. The assessment of Riparian Condition considered the whole reach and included both banks. Where a reach had a mix of intact native vegetation and exotic vegetation or cleared patches, an average outcome was estimated for the whole reach.



Map 2 **The distribution of sites for Rapid Site Assessments against background of 'Likelihood risk scores' based on TN, TP, TSS generation rates (kg/y/ha; 1 – low risk, 4 – high risk) from the preliminary Estuary Health Risk Map.**

Table 1 Rapid Site Assessments - number of sites assessed in each major river/creek catchment

Major River / Creek catchment	Site Count in Major Catchment (freshwater)	Site Count in Major Catchment (estuarine)
Avon River	11	
Barnard River	19	
Barrington River	19	
Bowman River	7	
Burrell Creek	9	
Cattai Creek	2	3
Cedar Party Creek	5	1
Dingo Creek	14	
Gloucester River	19	
Lansdowne River	7	6
Manning River	14	18
Myall Creek	5	
Nowendoc River	24	
Upper Manning River	20	
Dawson River		3
Total Sites	**175 (Freshwater)**	**31 (Estuarine)**

Appendix 1 provides location maps for all of the sites assessed during the program.

Site attributes assessed

Four attributes were selected that provide an assessment of pressure or ecological condition and severity of impact, with each variable rated by a pressure/condition index score. The four attributes assessed were:

- Land Use Pressure
- Geomorphic Condition (freshwater catchment only)
- Instream Condition
- Riparian Condition

An overview of the variables assessed for each attribute is given below with further detail on variable function and how it was measured in the RSA provided in ***Appendix 2 Table A2-1***.

Land Use Pressure

Adjacent land use and stock impact on the riparian zone were assessed in the RSA. Intensive agricultural land use such as dairy farming and cropping can lead to elevated concentrations of nutrients in receiving waterways (Chittleborough 1983, McDowell and Wilcock 2007) thus surrounding land use at a site will be an indicator of potential nutrient pollution. Irrigation and fertilisation of adjacent pastures was also noted in the Land Use category. Agricultural pressure, including stock impact through direct access to a waterway, can have detrimental impacts to

water quality. This may be through nutrient inputs from animal waste or increased turbidity and sedimentation due to increased erosion as a result of destabilising riparian vegetation and wearing of banks by cattle tracks.

Geomorphic Condition (freshwater catchment only)

Geomorphic Condition was assessed by surveying type and extent of riverbed substrates, bank structure /vegetation / slope / evidence of erosion. These aspects of Geomorphic Condition can reflect the degree of exposure of riverbanks to the forces that cause and enhance erosion, including land clearing for grazing and other agricultural activities.

Instream Condition

Assessment of the condition of the instream zone can provide information on the health of a waterway, such as the available habitats for biota and water quality. Instream condition assessment at freshwater sites included the type and diversity of aquatic habitats, and the presence/absence of macrophytes, large woody debris (LWD), leaf litter and filamentous green algae. Instream Condition assessment at estuarine sites included the distribution of seagrass and macroalgae. *In situ* water quality parameters were recorded at all sites with a water quality multi-meter including temperature, dissolved oxygen (% saturation and concentration), conductivity, pH, turbidity, and chlorophyll-a. The presence/absence of rubbish, odour and grease and oil were also noted.

Riparian Condition

Vegetation along a river or estuary bank serves multiple purposes related to water quality. The riparian zone plays a vital role in stabilising stream banks and regulating sediment and nutrient inputs from landscape activities. It provides habitat and energy supply for instream fauna, and both directly influences and is influenced by a water body. The condition of the riparian zone therefore provides a good indication of the overall health of a waterway. Variables assessed for Riparian Condition in the freshwater catchment included the extent, connectivity, diversity and disturbance of the canopy, understorey (shrubs) and groundcover layers. Habitat availability such as presence of hollow bearing trees and woody debris were also assessed. At estuarine sites, Riparian Condition assessed the extent and distribution of native trees/shrubs, groundcover including native sedges/grasses, mangroves and saltmarsh.

Appendix 2 provides the full list of variables assessed for each attribute, variable function and how they were measured.

Scoring methodology and analysis

- The full questionnaire used for Rapid Site Assessment (RSA) is in ***Appendix 3***.
- For each attribute (Land Use Pressure, Instream Condition, Geomorphic Condition, Riparian Condition), each variable was rated by a pressure/condition index score representing worst (0, 1) to best (4,5) condition (based on OEH 2015 and OEH 2016a). Presence/absence criteria were scored 0 or 1 with 1 assigned for better condition. See ***Appendix 2*** for a full description of attribute variables that were scored in the RSA.
- For each attribute, the scores of each variable were summed together to get the attribute score for the site (Tables A5-2, A6-2). Attribute scores for Land Use Pressure, Geomorphic Condition, Instream Condition and Riparian Condition were graded from *Very Poor* to *Excellent* using the scale shown below and in Tables A5-1 and A6-1.

Pressure Grade (Land Use Pressure)	
Excellent = Very Low Pressure	**≥ 80% of the total possible score**
Good = Low Pressure	**60 – 79% of the total possible score**
Fair = Moderate Pressure	**40 – 59% of the total possible score**
Poor = High Pressure	**20 – 39% of total possible score**
Very poor = Very High Pressure	**<20% of total possible score**

Condition Grade (Geomorphic, Instream, Riparian Condition)	
Excellent	**≥ 80% of the total possible score**
Good	**60 – 79% of the total possible score**
Fair	**40 – 59% of the total possible score**
Poor	**20 – 39% of total possible score**
Very poor	**<20% of total possible score**

- Attribute scores for Land Use Pressure, Geomorphic Condition (freshwater sites only), Instream Condition and Riparian Condition were summed for an Overall Condition score for each site. Thus, the Overall Condition score includes a 'pressure' component. Overall Condition scores were graded from *Very Poor* to *Excellent* using the grading scale shown in Tables A5-1 (freshwater) and A6-1(estuarine).
- Land Use Pressure scores were compared to Condition scores at each site to see if scores were correlated (Graph 1).
- Scores for each attribute and Overall Condition were averaged for all sites in each major river/creek catchments and are shown in Table 2 (freshwater) and Table 14 (estuarine). Broad findings for each major river/creek catchment are discussed in *Overview of Land Use Pressure, Geomorphic, Instream and Riparian Condition.*
- There was a lot of variation between site scores at this scale thus catchment averaged scores should be interpreted with caution. Individual site scores presented in Tables A5-2 and A6-2 provide the best overview of the range of condition in each river/creek catchment and EES subcatchment.
- Attribute scores were averaged for EES subcatchments in order to ground-truth (i.e. validate) the spatial layers developed for the catchment as part of this project. Spatial layers show local data or modelled data at a subcatchment scale based on 3rd order streams. Examples of spatial layers developed in this study include modelled generation rates for pollutant loads in surface runoff from each subcatchment (e.g. total nitrogen load per year per hectare), modelled hillslope erosion and stock intensity which was based on annual stock returns of landholders provided to Local Land Services. Spatial layers were used in risk assessments of catchment pressures (e.g. diffuse pollution, erosion) on ecological and community values of the Manning River estuary (e.g. water quality, drinking water). Those analyses are presented in the Risk Assessment report (Swanson 2019).

Limitations of this study

Some aspects of the design and implementation of the Rapid Site Assessments and subsequent analysis may have confounded some findings of this study.

- Site selection was not randomised or stratified due to time and resource constraints. Site selection was based on land use, established monitoring locations and ease of access, with an emphasis on assessing condition across the whole catchment.
- During the field program, sites on public or Crown Land were prioritised for ease of access due to time constraints. Many of these sites were in agricultural areas but the survey location was on Crown Land, rather than in adjacent private property which may have positively skewed the data.
- The Rapid Site Assessments developed for the freshwater and estuarine catchments are distinct and therefore scores are not directly comparable because:
    - the relative weighting of the attributes (Land Use Pressure, Instream Condition, Riparian Condition) in the Overall Condition score is different for freshwater and estuarine sites;
    - Geomorphic Condition was not assessed at estuarine sites as the variables assessed were primarily applicable to freshwater streams;
    - the variables assessed for Instream Condition and Riparian Condition assessments at freshwater and estuarine sites were slightly different reflecting the biota typically found in freshwater and estuarine systems e.g., distribution of macrophytes and filamentous green algae were in the Instream Condition assessment for freshwater sites whereas the distribution of macroalgae and seagrass were in the Instream Condition assessment for estuarine sites;
    - Further, the Instream Condition assessment for estuarine sites included scores for water quality (turbidity, chlorophyll-a and pH) whereas water quality could not be scored for freshwater sites and was excluded from the Instream Condition score for freshwater sites for the reasons given below.
- Water quality was assessed at freshwater sites but was not scored as part of the Instream Condition assessment for the following reasons:
    - Fifteen percent of streams assessed were completely dry (26 sites)
    - Thirty percent of streams assessed were ‘isolated refugia pools’ often with very poor water quality (44 sites)
    - The remaining 105 freshwater sites were flowing streams, typically with low-flow and good water quality, most likely due to the lack of the recent overland flow delivering nutrients and TSS from surrounding land use
    - It is inappropriate to compare water quality in different types of water bodies (flowing versus isolated pools) in order to grade water quality
    - A default trigger value for chlorophyll-a is not available for upland rivers, only for lowland rivers (Table 3.3.4 in ANZECC and ARCMANZ 2000)
    - Water quality was included in the scoring of estuarine sites because water bodies sampled were comparable (i.e., moderate flow, except for two sites without water). This allowed water quality data to be compared to NSW Trigger Values and graded accordingly (OEH 2016b).
- Considering these factors, it was not possible to include a score for water quality in the Instream Condition assessment at freshwater sites. However, water quality data collected during the program was used to ground-truth relevant spatial layers used in the Risk Assessment (Swanson 2019). In order to use the field data collected during the program for ground-truthing of spatial layers developed as part of this study, it was necessary to

calculate average scores for each EES subcatchment. Average scores for EES subcatchments should be interpreted with caution because:

- There was high variability in ecological condition at sites within a subcatchment as shown in Tables A5-2, A6-2
- Different numbers of sites were assessed in subcatchments, ranging from 1 – 14 sites per subcatchment, but usually 4 – 6 sites were assessed in each subcatchment.

- Attribute scores were averaged across each major river/creek catchment to allow for broad discussion of field data and observations from each catchment. It is important to keep in mind the large variability of ecological condition at sites at the catchment scale, and that averages were derived from differing numbers of sites.

Results: Overview of Major Catchments

Nowendoc River Catchment

Site assessments

- 5 subcatchments were assessed
- Upper catchment 64 (5 sites), 66 (6 sites) – Map 7
- Lower catchment 74 (5 sites), 80 (4 sites), 85 (3 sites), 87 (1 site) – Map 5
- Total of 24 sites assessed
- Sites in Nowendoc catchment (on average) scored marginally better than the whole catchment average (freshwater) for all categories (see Table 3)

Observations

Land use

- Steep forested areas across catchment
- Upland montane swamps on the flat tablelands have been drained using trenches dug in boggy areas to drain paddocks thus lowering the shallow water tables and removing permanent water from the system
- These interventions reduce the water storage capacity of the landscape, remove permanent water and result in high flow regimes, which increase the impact of run-off.
- Upper areas of catchment have been cleared extensively for grazing around Nowendoc (64) and Cooplacurripa (66)
- Fire used commonly for pasture improvement to stimulate new grass growth (64, 74, Photo 10)
- Numerous springs sighted with most impacted by cattle (66, Photo 4)

Erosion

- Erosion due to clearing of the riparian zone and cattle access to streams is a major issue in 64, 66 (Photo 5, 8)
- Hill slope erosion evident on cleared slopes (bedrock base, thin layer of soil, Photo 10)
- Shallow (rill) erosion and gully erosion on cleared slopes (64, 66, 80, Photo-Cover)
- Streambank erosion present (64, 66, 74; Photo 1, 3, 9)

Cattle access/impact

- Large numbers of cattle were observed in paddocks (64, 66) or feedlots (66-08). Large amounts of manure were observed on bare slopes, close to streams with little to no riparian vegetation (66-08)
- Cattle have extensive access to watercourses in grazing areas (64-05; Photo 1, 6, 9) including permanent springs (66-08) and known turtle habitat.
- High nutrient loads in streams in grazing areas were indicated by excessive algal growth and exotic weed growth in watercourses (64, 66, 74; Photo 4, 11).
- Bare steep slopes with low stocking rates of cattle were observed throughout 74 (Photo 4).

- Cattle were consistently observed accessing watercourses throughout 66, 74 (Photo 6, 7, 9). Large quantities of manure were observed close to streambank (Photo 7).

Riparian and stream condition

- Riparian vegetation primarily consisted of tussock grasses in upper 64, 66 although some streams have remnant to good native vegetation (Photo 1, 2)
- Bedrock dominated streams in lower 64, 74, 80, 85. Watercourses in better condition downstream in gorges with dense canopy of native riparian vegetation and good water quality (Photo 3, 12).
- Sand-based substrate was observed in lower 66 at the bottom end of the catchments. Large sand slugs observed at 66-03 filling pools and slowing flow (Photo 5)

Photo 1 Nowendoc River at Nowendoc Road, site 64_05

Photo 2 Nowendoc River catchment - Mukki Creek, site 64-07

Photo 3 Nowendoc River, site 64-01. Bedrock substrate.

Photo 4 Nowendoc River catchment - Cooplacurripa River, site 66-04

Photo 5 **Nowendoc River catchment – Cooplacurripa Valley. Bare steep eroding slopes, cattle access, excessive algal and macrophyte growth (site 66-03)**

Photo 6 **Nowendoc River catchment - Cooplacurripa River (Nowendoc Road), site 66-04**

Photo 7 **Nowendoc River catchment - Cooplacurripa River (Nowendoc Road), site 66-04. Large amounts of manure on banks with sparse riparian vegetation**

Photo 8 **Nowendoc River catchment - gully erosion in Cooplacurripa Valley**

Photo 9 **Nowendoc River catchment – Rowleys River, subcatchment 74**

Photo 10 **Nowendoc subcatchment 74 – bare slopes, burnt pasture**

Photo 11 **Rowleys River downstream of site 74-01. Excessive algal and macrophyte (Azolla) growth.**

Photo 12 **Nowendoc River at Dalrae - bedrock substrate, site 85-01. Good riparian vegetation however some cattle access (note grazed Lomandra in foreground)**

Myall Creek Catchment

Site assessments

- Two subcatchments were assessed, 68 (2 sites) and 76 (3 sites) – Map 7
- Total 5 sites assessed

Site assessments in Myall Creek catchment on average scored below 'whole catchment' average for instream condition but had better scores in other categories (Overall Condition, Land Use, Geomorphic and Riparian Condition, see Table 3)

Observations

Land use

- Steep forested areas across catchment
- A lot of plantation forestry, pine and hardwood (SC68, Photo 13)
- Extensively cleared slopes for grazing in upper subcatchments
- Fire used commonly for pasture improvement to stimulate new grass growth
- Numerous springs sighted with most impacted by cattle (68, Photo 15)

Erosion

- Shallow erosion in cleared areas

Cattle access/impact

- Cattle access to all sites in grazing areas (76-01, Photo 14). One site heavily impacted (68-01, Photo 14)

Riparian and stream condition

- Typically, native canopy with exotic species dominating shrub layer and ground cover. Some regeneration of remnant native species e.g. *Callistemon sp.*
- Good flow in streams due to recent snow melt
- No flow at heavily impacted site, high nutrient loads with many exotic weeds (68-01, Photo 15).

Photo 13 Myall Creek catchment. Cleared land (foreground) and plantation forests (background)

Photo 14 Myall Creek, site 76-01. Manure on banks, cattle access.

Photo 15 Myall Creek, site 68-01. Heavily impacted site.

Photo 16 Myall Creek, site 68-01 showing algal growth and milky turbid water

Barnard River Catchment

Site assessments

- Six subcatchments were assessed
- Upper catchment 72 (4 sites), 77 (3 sites), 81 (4 sites) – Map 6
- Lower catchment 83 (3 sites), 84 (4 sites), 82 (1 site) – Map 6
- Total of 19 sites assessed
- Site assessments in Barnard River catchment were among the poorest scores (on average) for Riparian Condition and Overall Condition scores (see Table 3)

Observations

Land use

- Grazing dominant land use in all subcatchments
- Extensive clearing in the Barnard catchment, with whole valleys cleared up to the ridgelines in 83.
- Council procured large property in upper catchment (Glen Almond) where landscape condition is improving

Erosion

- Active erosion was observed in 82
- Bare slopes subject to hillslope erosion in catchment (81, 83, 84, Photo 20)

Cattle access / impact

- Large cattle station (Glenrock) - low stocking rate, manure on slopes, remaining stock were in the creek lines (77-05)
- High cattle activity noted in streams (82-01), extensive algal mats suggesting high nutrient loading (Photo 21)
- Cattle accessing groundwater fed springs, extensive Azolla in nutrient-rich pools (77-02, 83-01, 84-03, Photos 22, 24)

Riparian and stream condition

- Good stream flow in upper catchment (72). Some streams and springs in upper catchment are in good condition with wetlands macrophytes/sedges and diverse in-stream fauna (field observations, 72-11, Photo 27)
- No flow in Schofield Creek, only water is permanent spring fed pools (Photo 18)
- Orham Creek completely dry (Photos 19-20). Many riverine Casuarinas have died off in areas without groundwater fed springs (77-05, 81-08; Photo 17, 18)
- Drought and the subsequent increase in cattle usage have heavily impacted streams and riparian vegetation in the catchment (Photo 23, 26)
- Groundwater springs are sustaining wildlife during drought and often have very poor water quality, excessive algal growth (82-01, 84-03) due to cattle access (Photo 21, 22, 24-26).

- Riparian vegetation was often extensively cleared or in poor condition throughout catchment (Photos 17 - 20). Mainly exotic species however remnant bottlebrush noted at 84-05 (Photo 25, 26)

Photo 17 **Barnard Catchment, Unnamed Creek on Glenrock Station, site 77-04. Note dead riparian vegetation due to lack of rain and no groundwater fed springs**

Photo 18 **Barnard River catchment - Schofield Creek (Hunter Rd), site 77-05. Banks completely denuded of vegetation**

Photo 19 Barnard River catchment, Orham Creek (site 81-01). Bare banks and hillslopes and dead riparian vegetation due to no flow or groundwater fed springs

Photo 20 Barnard River catchment, Orham Creek (site 81-01), Glenrock. Extensive and often complete clearing of all native vegetation on hillslopes and riparian zones.

Photo 21 Barnard River at Corroboree Flat (site 82-01). Excessive algal growth.

Photo 22 Barnard River catchment - Curricabark River, site 83-01. Excessive algal growth and pugging on spring banks with no riparian vegetation

Photo 23 **Barnard River catchment – Curricabark Valley (subcatchment 83). Cattle in springs outflow, clearing of riparian zones.**

Photo 24 **Barnard River crossing, site 84-03. Note eroding hillslope, excessive macrophyte (Azolla) growth and cattle access and no flow conditions.**

Photo 25 Barnard River upstream of Bretti Reserve, site 84-04. No flow conditions.

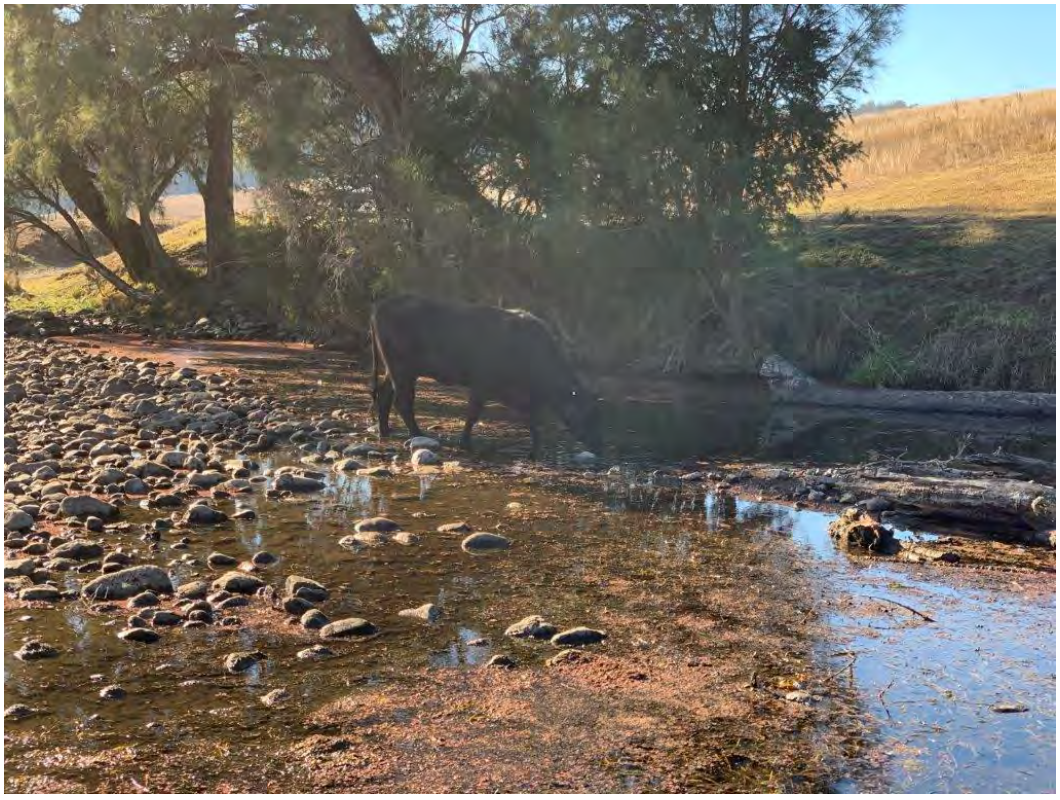


Photo 26 Barnard River at Bretti Reserve, 84-05. No flow, excessive macrophyte (Azolla) growth, cattle accessing river for water. Dry bare slopes and banks

Upper Manning River Catchment

Site assessments

- Six subcatchments were assessed
- Upper catchment 90 (4 sites), 94 (5 sites) – Map 6
- Lower catchment 91 (6 sites), 92 (5 sites) – Map 5
- Total of 20 sites assessed
- Sites assessments in Upper Manning River catchment on average scored better than the 'whole catchment' average in most categories (see Table 3)

Observations

Land use

- Upper catchment - historical widespread clearing for pine plantations which have recently been cleared for pasture and lots of new infrastructure installed (fencing/stockyards, Photo 27)
- Extensive clearing to ridgelines and across streams in some areas
- Mid-lower catchment - extensively cleared slopes in valleys surrounded by steep forested terrain

Erosion

- Erodible bare slopes across catchment. Shallow rill erosion and gully erosion (91-14, Photo 31)
- Active stream-bed erosion noted at 92-04

Cattle Access / Impact

- Cattle accessing upland swamps (94-07, Photo 33) and streams (90-03, 91-14, 92-05)
- Large quantities of manure on bare slopes (90)

Riparian and stream condition

- Good water quality and flows in Upper Manning (94-06) and Pigna Barney River (90-08)
- Good water quality and flows, intact riparian vegetation at 92-05. Bedrock and cobble armoured bed.
- Extensive macrophyte beds in some streams (91-04, 92-05; Photo 30)
- Excessive algal growth in some reaches of Upper Manning (91-06, 91-14; Photo 29, 31-32)
- Upper catchment (90, 94) streams cloudy due to land clearing and high pH most likely as a result of extensive limestone deposits (90-06, Photo 28)

Photo 27 **Upper Manning River catchment. Historically Long Swamp was cleared for plantation forestry. Currently clearing forestry for pasture/farming infrastructure**

Photo 28 **Upper Manning River catchment – site 90-06. Stream cloudy due to land clearing upstream. High pH due to limestone deposits**

Photo 29 Upper Manning River catchment - Little Manning River, site 91-06. Eutrophic zone with excessive algal and macrophyte (Azolla) growth

Photo 30 Upper Manning River, near Woko National Park, site 91-04

Photo 31 Upper Manning River, 91-14. Note shallow rill and gully erosion on adjacent slopes

Photo 32 Upper Manning River, 91-14. Cattle access to stream, grazed Lomandra on banks

Photo 33 Upper Manning River at Watergate Camp - Upland swamp, site 94-07

Bowman River Catchment

Site assessments

- 1 subcatchment was assessed – 109 (7 sites) – Map 8
- Total of 7 sites assessed
- Site assessments in Bowman catchment on average were on par with the 'whole catchment' average in most categories (see Table 3)

Observations

Land use

- Half of catchment is forested, half is cleared for grazing pastures
- Some groundwater extraction evident.

Erosion

- Active erosion of banks at downstream sites (109-03)

Cattle access/impact

- Cattle accessing streams that were assessed

Riparian and stream condition

- One of the drier catchments. Spring fed pools in headwaters provide good water quality and high aquatic biodiversity (field observations) (109-10) but streams downstream have dried out (Photo 34)
- Isolated pools in grazing areas are in very poor condition, e.g., Craven Creek, extensive algal growth and exotic weeds dominate riparian vegetation (Photo 35)

Photo 34 Bowman River - one of the drier catchments, site 109-05

Photo 35 Bowman River on Kia Ora Rd, 109-03. Isolated pools with high nutrient loads, excessive macrophyte (Azolla) growth

Barrington River catchment

Site assessments

- Three subcatchments were assessed
- Upper catchment 111 (4 sites), 115 (5 sites), 119 (3 sites) – Map 6
- Lower catchment 117 (7 sites) – Map 8
- Total of 19 sites assessed
- Site assessments in Barrington catchment were among the poorest scores (on average) scoring below the whole catchment in all categories (see Table 3)

Observations

Land use

- Western portion of 115, 119 is forested (50% of subcatchments), grazing (modified pastures and native vegetation) are the other primary land use comprising approximately a third of catchment.
- Intensive cattle and dairy farming, cropping throughout lower catchment (117), with high fertiliser use and irrigation of pastures with large scale infrastructure (e.g. pivots, Photo 43).

Erosion

- Extensive areas of steep cleared hill slopes throughout catchment prone to erosion (Photo 38).
- Severe gully erosion in subcatchment 117 (Photo 47)

Cattle access/impact

- Moderate stocking rates throughout catchment due to access to irrigation (Photo 43, 44)
- Gloucester water source flows through kms of cattle farming pastures – very high counts of faecal coliforms in offtake water (median 3100 total coliforms/100ml, based on weekly sampling since 2017 by MidCoast Water)
- Large quantities of manure noted on hill slopes in 115, 119 (Photo 38)
- Large dairy farm in 117, cattle cross river twice a day for milking (Photo 42)

Riparian and stream condition

- Permanent streams coming off Barrington range (Photo 36). Barrington River is the sole water source for Gloucester water supply.
- In August 2019, Barrington River was the primary water source for Manning River (and offtake at Bootawa Dam) due to no flow in other rivers in the upper catchment as a result of the extended drought. By December 2019, the Barrington River had stopped flowing resulting in no flow in the Manning River (Water NSW Flow Data)
- Good stream structure – cobble/boulder/bedrock dominant substrate. Streams with armoured beds that are resilient to erosion (Photo 37, 40)
- Good water quality at sites in upper catchment/ macrophytes observed (Photo 36)
- No flow or isolated pools in tributaries (Photo 44).
- Poor water quality/riparian condition of tributaries in grazing/farming areas (Photo 47)

- Copeland Creek dry at 117-07, landowner said creek usually low flow all the time even in dry periods (Photo 44). The landowner upstream (117-08B) has diverted flow by digging big holes into creek line to access groundwater.
- Site 117-08B was assessed. An isolated pool has formed from digging into creek line and the soil removed from creek line lies next to it (Photo 45, 46). It was a heavily impacted site in very poor due to cattle access. This property (117-08B) should be investigated as this is highly illegal within the Water Sharing Plans and has led to no flow in the creek downstream at 117-07.

Photo 36 Barrington River - Moppy Creek Rd crossing, site 115-07

Photo 37 Barrington River at Moppy Rd crossing, site 115-09

Photo 38 Barrington River catchment, unnamed creek in subcatchment 119

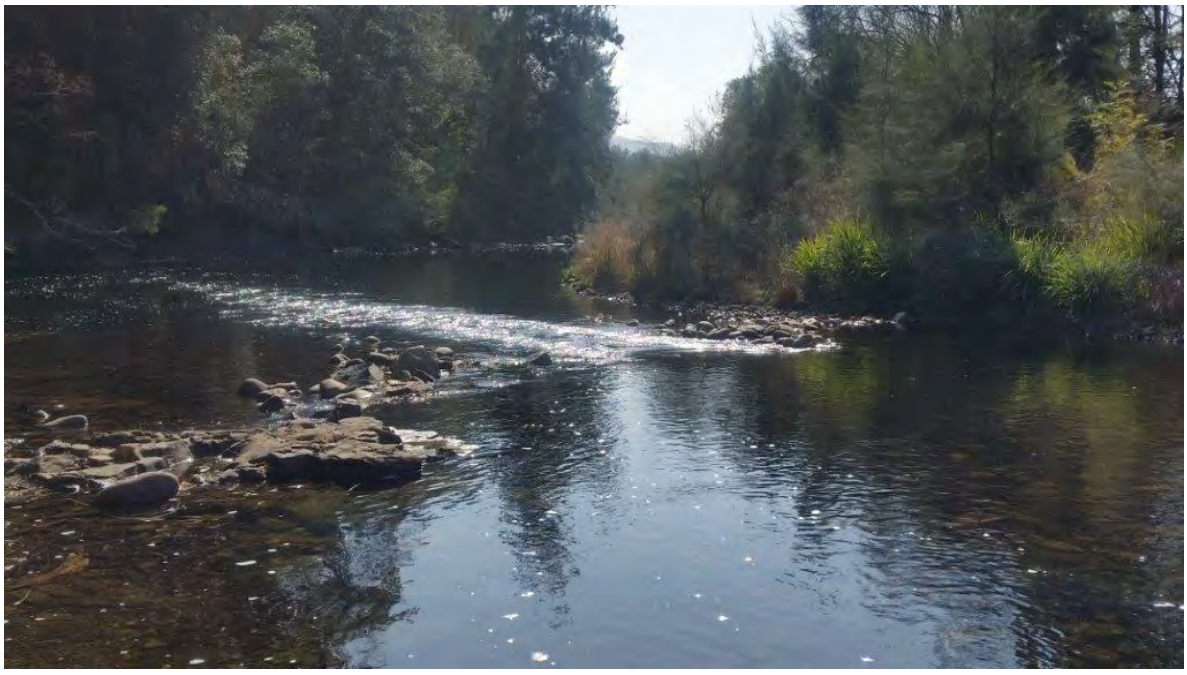


Photo 39 Barrington River at Barrington Bridge, site 117-01

Photo 40 **Barrington River at Relf's Landing, site 117-04. Note bedrock dominated river bed and extensive weed growth on left bank**

Photo 41 **Barrington River subcatchment 117. Large dairy farm with irrigated pastures (near site 117-04).**

Photo 42 **Barrington River, site 117-05. Hundreds of dairy cattle cross the river twice daily for milking.**

Photo 43 **Barrington River subcatchment 117. Large irrigated property with irrigation pivots and stockpile of chicken manure to fertilise pastures.**

Photo 44 **Barrington River catchment – Copeland Creek, site 117-07. Beef cattle and irrigated pastures. Creek dry at time of sampling, which landowner says usually always runs even in dry times. Flow has ceased due to illegal actions upstream at site 117-08B**

Photo 45 **Barrington River catchment – Copeland Creek, site 117-08B. Isolated pool of water with very poor water quality and algal blooms. This pool has formed from landowner digging into creek bed (see Photo 46)**

Photo 46 **Barrington River catchment – Copeland Creek, site 117-08B. Spoil from landowner digging into creek bed. Very poor water quality in isolated pool due to cattle access**

Photo 47 **Barrington River subcatchment 117- site 117-08. Dry unvegetated creek line (foreground), bare steep hillslopes and severe gully erosion (background)**

Gloucester River catchment

Site assessments

- Three subcatchments were assessed
- Upper catchment 122 (15 sites) – Maps 6, 8
- Lower catchment 98 (4 sites) – Map 5
- Total of 19 sites assessed
- Sites assessments in Gloucester River catchment on average were on par with 'whole catchment' average in all categories (see Table 3)

Observations

Land use

- Upper catchment is forested (Gloucester Tops)
- Intensive cattle and dairy farming, cropping throughout lower catchment (below Faukland). Widespread use of fertiliser and irrigation on pastures – infrastructure noted throughout catchment (pivots, pumps, hoses).
- Poultry farm and fish farm.
- SC 98 completely cleared for pasture/farming

Erosion

- Bare slopes, eroding hillslopes with cattle tracks widespread in 122 and 98 (Photo 49, 50)

Cattle access/impact

- Large number of farms with moderate stocking density observed in lower subcatchment 122 (Photo 55)
- Cattle are accessing streams, isolated pools (Photo 53) and runoff from fertilised irrigated properties is impacting on water quality in Gloucester River (Photo 56)

Riparian and stream condition

- All sites in the Gloucester tops are in excellent condition with good flow and good water quality (Photo 48)
- Poor condition starts at first Faukland crossing. Reduced flow or no flow due to extraction for irrigation, transition from native to exotics (Photo 54), rapid deterioration of bank structure (Photo 57). Extensive macrophyte beds present along the lower section of the river (Photo 56).
- Creek lines are dry and unvegetated (122-14, Photo 51)
- No riparian vegetation, degraded banks and poor water quality near Gloucester STP (Photo 56), extensive algal mats downstream.

Photo 48 Gloucester River at Gloucester Tops, site 122-21. Good riparian vegetation and water quality

Photo 49 Gloucester Lookout (subcatchment 122) – bare slopes, cattle tracks (right hand side).

Photo 50 Gloucester River catchment, near site 122-14. Eroding hillslopes, cattle tracks.

Photo 51 Gloucester River catchment – Berrico Creek, site 122-14. Dry unvegetated creek line in adjacent pasture. Eroding hillslopes.

Photo 52 **Gloucester River catchment, site 122-07. Unvegetated creek line, typical of catchment.**

Photo 53 **Gloucester River catchment. Sandy Creek, site 122-02. Isolated pool with cattle access, unvegetated banks**

Photo 54 **Gloucester River, Wellards Lane crossing, site 122-01. Riparian vegetation infested with balloon vine.**

Photo 55 **Gloucester River subcatchment 122, Dairy farm at Faukland**

Photo 56 Gloucester River – near Gloucester Sewage Treatment Plant, site 122-03

Photo 57 Gloucester River. Macrophyte beds, Azolla and excessive filamentous algal growth indicate high nutrient loads.

Photo 58 Gloucester River catchment - Buliac Creek, site 98-03b. Isolated pool with excessive algal and macrophyte growth.

Photo 59 Gloucester River at Callaghan Creek Rd, site 98-01. A lot of filamentous algal growth downstream of intensive farming in Gloucester (Barrington 117 and Avon 121) and Gloucester STP discharge

Avon River catchment

Site assessments

- Two subcatchments were assessed
- Upper catchment 123 (7 sites) – Map 8
- Lower catchment 121 (4 sites) – Map 8
- Total 11 sites assessed
- Sites assessments in Avon River catchment on average scored on par with the 'whole (freshwater) catchment' average in all categories (see Table 3)

Observations

Land use

- Forested areas and a large mine in subcatchment 123
- Grazing and intensive cattle farming throughout catchment (Photo 61)

Erosion

- Hill slope erosion in 123 (Photo 63)
- Streambank erosion in 123 (Photo 62)

Cattle access/impact

- Moderate stock numbers and cattle accessing the rivers/creeks (Photo 63)

Riparian and stream condition

- No flow in many streams, not many headwaters (Photo 60, 62, 63)
- Highly impacted permanent spring fed pools with no flow and high nutrients (algae) in lower catchment (Photo 62)
- Good riparian vegetation in upper catchment (Photo 60). Exotic species dominate riparian vegetation in lower catchment

Photo 60 Upper Avon River, site 123-14

Photo 61 Avon River catchment – irrigated fertilised pasture (note pivot at rear)

Photo 62 **Avon River - Jacks Road crossing, site 121-04. Very poor bank condition, isolated pools with poor water quality**

4

Photo 63 **Avon River catchment – unnamed creek, site 123-03. Cattle access and minimal riparian vegetation. Gully erosion and bare eroding hills.**

Burrell Creek catchment

Site assessments

- Two subcatchments were assessed - 112 (4 sites), 113 (5 sites) – Map 4
- Total 9 sites assessed
- Sites assessments in Burrell Creek catchment on average had the highest Overall Condition scores due to Good Riparian Condition and Excellent Geomorphic Condition at most sites (see Table 3)

Observations

Land use

- Half of catchment is forested, the rest is cleared for low intensity grazing

Erosion

- Extensively cleared slopes in lower catchment (112-03)

Cattle access/impact

- Low impact of cattle on streams except for one site (112-03)

Riparian and stream condition

- Most sites no flow, isolated spring-fed pools with high nutrients (algal growth) and elevated conductivity (Photo 66, 67)
- Stable banks with minor erosion and undercutting at most sites. Banks in poor condition at 113-05 (Photo 68)
- Minimal disturbance of riparian zones with good longitudinal continuity ((Photo 64, 65)
- Native vegetation generally well represented in canopy, shrub layer and groundcover

Photo 64 Burrell Creek catchment, Bo Bo Creek, Gloucester Rd crossing site, 112-02. Good riparian vegetation. No flow, isolated pools.

Photo 65 Burrell Creek – Mulligans Lane, site 112-03. No flow, cobble bed, good riparian vegetation

Photo 66 **Burrell Creek - Kimbriki Rd crossing 112-01. Good stream structure and riparian zone. Nutrient-rich isolated pools. Algal bloom decomposing on surface**

Photo 67 **Burrell Creek catchment - Kimbriki Crossing, site 112-01.**

Photo 68 Burrell Creek - Bo Bo Creek Buckets Way crossing, site 113-05. Eroding vertical banks and exotic shrub and ground cover vegetation.

Dingo Creek Catchment

Site assessments

- Three subcatchments were assessed - 86 (5 sites), 89 (5 sites), 97 (4 sites) – Map 4
- Total 14 sites assessed
- Sites assessments in Dingo Creek catchment on average scored better than the whole catchment average for riparian condition and near average scores for other categories (Land Use, Geomorphic and Instream Condition, see Table 3)

Observations

Land use

- Sixty percent of the upper subcatchment 86 is forest and a third is cleared for low intensity grazing.
- Subcatchments 89 and 97 have more intensive cattle farming, animal production including a large poultry farm at the downstream end of Dingo Creek.
- Fertilised pastures and irrigation noted adjacent to sites in 97.

Erosion

- Forest in upper catchment is steep and prone to erosion (Nearmap).
- Bare pastures were common in 89.
- Streambank erosion noted in 89 (tributaries) and at 86-01 (Photo 75)

Cattle access/impact

- Cattle access evident at some sites (86-01, 97-06; Photo 75).
- Effects of fertiliser use for pastures/crops were evident at many sites (e.g. algal growth, Photo 75, 76)

Riparian and stream condition

- Upstream sites in 86 (Gunyah Rd crossing, Bobin) and 89-04 (Cappara Ck, Hoads Bridge) had extensive riparian vegetation, very low flow but good water quality (Photos 69, 70)
- Cobble dominant substrate (<30% cover) at most sites. Bedrock dominated at site 97-07 (Photo 72)
- A lot of algal growth in Dingo Creek in 89 and 97, and at Marlee site in 86.
- Extraction from Dingo Creek for domestic use noted frequently (Photo 71)
- No flow / isolated pools in tributaries (Deep Ck, Betibombi Ck, Big Run Ck; Photo 74).

Photo 69 **Dingo Creek at Millers Rd crossing, site 86-15. Very low flow. Good riparian vegetation in upper catchment sites.**

Photo 70 **Dingo creek at Gunyah Rd crossing, site 86-06. Good riparian vegetation.**

Photo 71 **Dingo Creek – Wherrol Flat Bridge, site 97-07. Very low flow, extraction of water for domestic use noted frequently. Steep banks with good canopy layer but exotic shrub layer and no ground cover.**

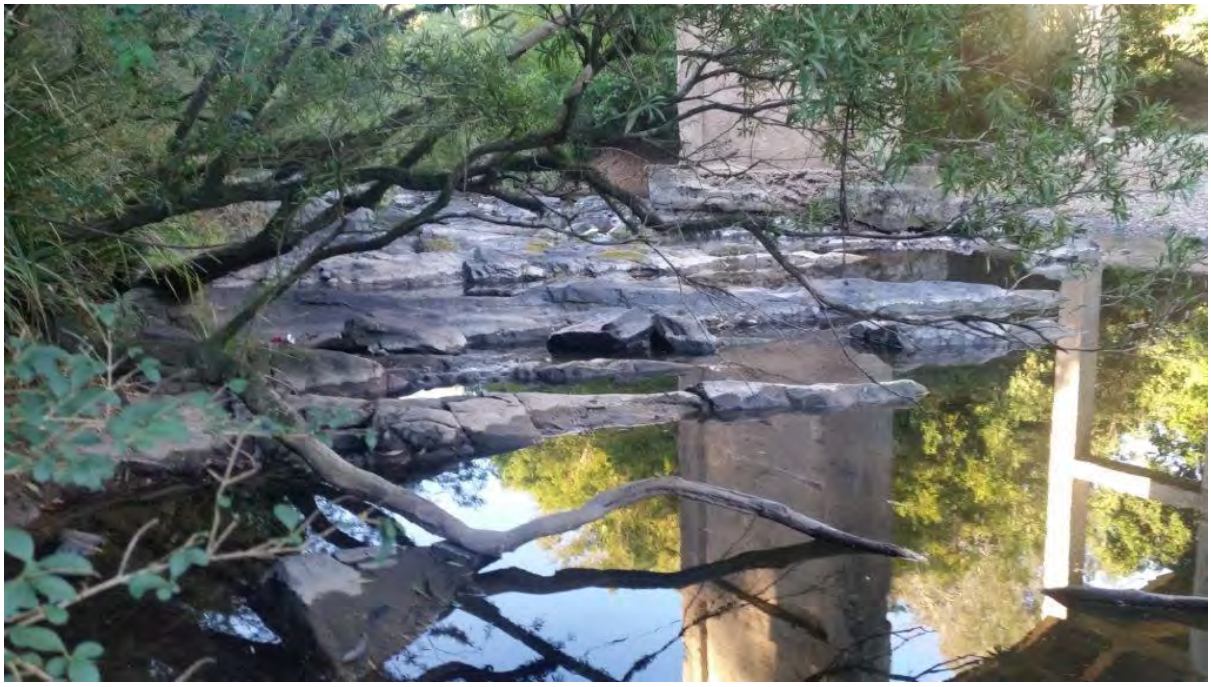


Photo 72 **Dingo Creek – Wherrol Flat Bridge, site 97-07. Bedrock substrate, very low flow.**

Photo 73 **Dingo Creek, site 97-06, adjacent to Ashlea Farm (beef cattle). Very low flow, high nutrient load indicated by excessive algal growth in isolated pools.**

Photo 74 **Dingo Creek catchment – Deep Creek - site 89-01. No flow, riparian vegetation dominated by exotics (Willow and Privet)**

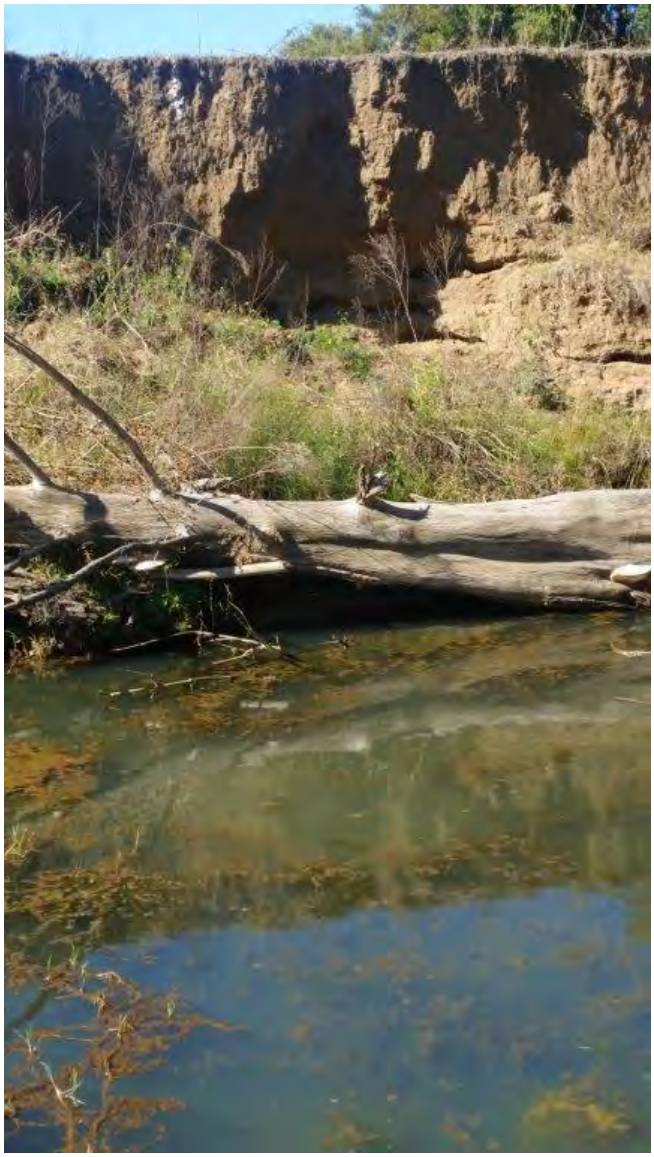


Photo 75 Dingo Creek at Middlebrook Rd crossing, site 86-01. Cattle access, vertical banks with heavy erosion. Low flow. Excessive algal growth in isolated pools.

Photo 76 Dingo Creek at Middlebrook Rd crossing, site 86-01. Excessive algal growth and exotic macrophytes in isolated pools with high nutrient loads

Cedar Party Creek

Site assessments

- 1 subcatchment was assessed - 95 (5 sites- freshwater, 1 site-estuarine) – Map 4
- Total 6 sites assessed
- Sites assessments in Cedar Party Creek freshwater catchment on average had the poorest scores for Overall, Geomorphic and Riparian Condition in the whole catchment (see Tables 3, 15).

Observations

Land use

- The majority of the catchment is used for grazing of modified pastures (one-third, <5% with high fertiliser use) or grazing native vegetation (one-third).
- Intensive land use in the catchment includes a large poultry farm, an abattoir (Wingham Meatworks) and a sawmill.

Erosion

- Streambank erosion (slumping, undercutting) at small unnamed creeks (95-02, 95-07). Undercutting/steep banks at other sites
- Bank erosion on Manning River at confluence with Cedar Party Creek (Photo 82)

Cattle access/impact

- Cattle access is impacting condition at two sites (95-02, 95-07)

Riparian and stream condition

- Estuarine site at Wingham bridge (Salinity 10ppt) cloudy appearance to water. Good riparian vegetation although mostly exotic species (Photo 77)
- Typically, unvegetated creek lines (pasture grass was the only riparian vegetation) on private properties (Photo 78)
- Sand/silt dominant substrate cover at all sites
- Two sites on Killabakh Ck good riparian vegetation but no flow, isolated pools with poor water quality (Photo 79, 80)
- Riparian vegetation at downstream end of Cedar Party Creek is dense but dominated by exotic species, e.g. balloon vine (Photo 81)
- Good riparian vegetation on shoreline of subcatchment 95 at Manning River

Photo 77 **Cedar Party Creek at Wingham Bridge, site 95-03. Cloudy water (pH 6.8) but good riparian vegetation.**

Photo 78 **Cedar Party Creek catchment, unnamed creek near Youngs Rd, site 95-06. Unvegetated creek lines on private property**

Photo 79 **Cedar Party Creek catchment, – Killabakh Creek, site 95-08. Good riparian vegetation but no flow, turbid pools of water with decomposing algal bloom**

Photo 80 **Cedar party Creek catchment – Killabakh Creek, site 95-11. Good riparian vegetation but no flow, turbid pool of water. Adjacent land use cleared, unvegetated creek lines similar to Site 95-07**

Photo 81 **Cedar Creek, near confluence with manning River. Riparian vegetation infested with exotic weeds such as balloon vine**

Photo 82 **Cedar Party Creek confluence with Manning River (eroding banks)**

Lansdowne River

Site assessments

- Two subcatchments were assessed – 88 (6 sites- freshwater, 3 sites-estuarine); 223 (1 site-freshwater, 3 sites-estuarine) – Map A1-1
- Total 13 sites assessed
- Sites assessments in Lansdowne River freshwater catchment on average had the poorest scores for Instream Condition but scores for the other categories (Land Use, Geomorphic and Riparian Condition) were on par with the whole catchment average (see Tables 3, 15).

Observations

Land use

- One third of subcatchment 88 is forest and one-third is grazing modified pastures with high fertiliser use on 10% of the pastures/crops in the subcatchment.
- Intensive land use in the subcatchment includes dairy farming, a large poultry farm and a turf farm.
- Half of subcatchment 223 is Grazing Modified Pastures and approximately 20% of all pastures are heavily fertilised.

Erosion

- Dry bare pastures with minimal groundcover were noted in 88 (Photo 87).

Cattle access/impact

- Cattle access to creek/river noted at one site in 88 and two sites 223.
- Cattle in riparian zone /on riverbank common siting during boat trip (Ghinni Ghinni Creek, Photo 90)

Riparian and stream condition

- Good riparian vegetation at some sites with native canopy and usually exotic shrub layer (Photo 84, 86, 88).
- Poor riparian vegetation at Dickensens Creek (Photo 89)
- Steep banks with erosion and undercutting at some sites (Photo 86)
- Lansdowne river at Lansdowne Bridge, low flow, water milky appearance with extensive cover of Azolla. Steep banks, thick riparian shrub layer mostly exotic
- Water quality impacted by acid runoff from acid sulphate soils at several sites (low pH, milky appearance), red hue to sediments (Photo 84-86).
- No flow / isolated pools at most sites. Algal blooms evident in isolated pools adjacent to dairy/poultry farm/turf farm (88-10) and at site 88-09 suggestive of algal blooms (Photo 83).
- Filamentous/epiphytic algae noted at several sites, suggestive of high nutrient load (Photo 85)

Photo 83 **Lansdowne River, site 88-10. Adjacent to dairy farm, turf farm and poultry farm. Large isolated pool with surface scum indicative of algal bloom**

Photo 84 **Lansdowne River, site 88-10. Adjacent to dairy farm, turf farm and poultry farm. Isolated pool with reddish hue indicative of iron release from acid sulphate soils**

Photo 85 **Lansdowne River catchment, unnamed creek at Lansdowne Road, site 88-02. Milky appearance in isolated pool indicative of acidic input. High nutrient load, thick epiphytic algal growth.**

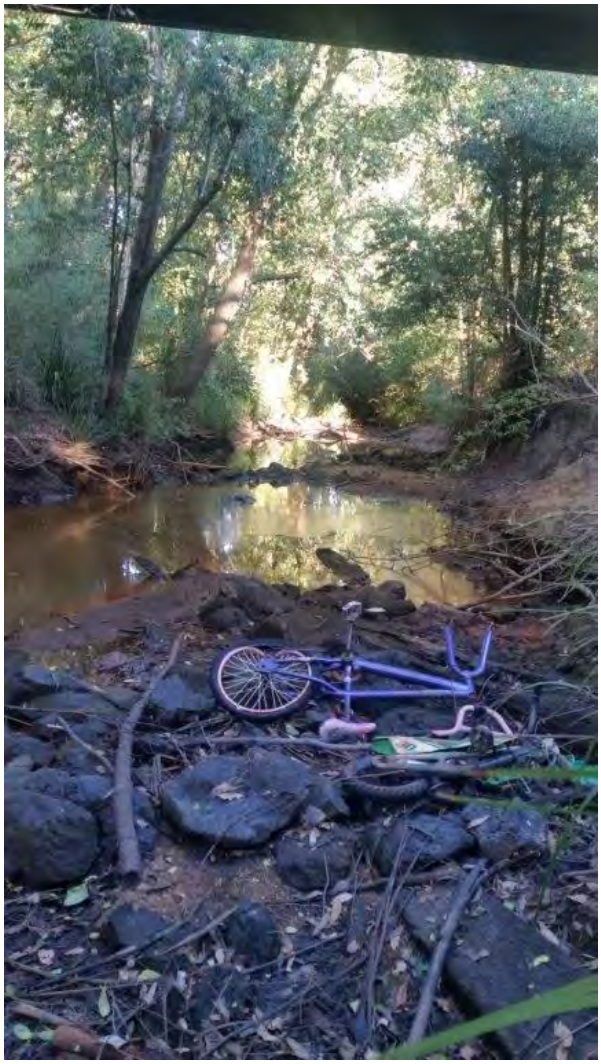


Photo 86 **Lansdowne River catchment - Cross Creek, site 88-06. Acid sulphate soils, erosion of banks, rubbish (road crossing).**

Photo 87 Lansdowne catchment 88. Cleared pastures with low stocking density.

Photo 88 Lansdowne River catchment - Pontibark Creek, site 223-01. Good diversity of native canopy layer. No flow, undercutting of banks.

Photo 89 **Lansdowne River catchment, Dickensens Creek, site 223-02. Very low flow, cattle access, poor riparian vegetation.**

Photo 90 **Lansdowne River catchment – Ghinni Ghinni Creek. Cattle access to banks of creek was a common sighting.**

Dawson River

Site assessments

- One subcatchment was assessed – 103 (3 sites- estuarine) – Maps 3, 4
- Total 3 sites assessed

Sites assessments in Dawson River catchment on average had the best scores for all categories (Land Use, Instream and Riparian condition, see Table 15)

Observations

Land use

- The majority of the Dawson River catchment is forested.
- Grazing, rural residential and urban areas are other land use, including Dawson Cemetery and Dawson STP.
- Logging (native forestry) occurs in the catchment

Erosion

- Not observed.

Cattle access/impact

- Not observed.

Riparian and stream condition

- Mangroves at all sites
- Two sites in Conservation Areas (Brimbin Nature Reserve and Tommy Owens Creek) were well vegetated and good water quality, with bedrock as dominant substrate.

Photo 91 Dawson River – Cemetery site 103-02. Mangroves and good riparian vegetation.

Photo 92 Dawson River at Brimbin Reserve. Extensive native riparian vegetation and good water quality.

Cattai Creek

Site assessments

- One subcatchment was assessed – 93 (2 sites- freshwater, 3 sites- estuarine) – Map A1-1
- Total 5 sites assessed
- Freshwater site scores in Cattai Creek were on par or above the whole catchment average (see Table 2), however, estuarine sites scored poorly for Instream Condition and Riparian Condition (see Tables 3, 15)

Observations

Land use

- The majority of the Cattai Creek catchment is forest (Photo 94, 96). Grazing and rural residential are other main land uses.
- Extensive areas are impacted by acid sulphate soils (ASS, Photo 94). Restoration Action Plan at Big Swamp is restoring connection of the floodplain to the estuary (Glamore et al. 2016).
- Council bought back acid impacted lands and have restored Cattai Wetlands (Photo 93)

Erosion

- Streambank erosion observed at Holey Flat Creek (93-06).

Cattle access/impact

- Cattle accessing Pipeclay Canal at two sites (93-03, 93-01B).

Riparian and stream condition

- Riparian vegetation in good condition at one site only (Pipeclay Creek at Fords Rd crossing, no flow for some time).
- Cattai Wetlands – extensive native riparian vegetation. Very low pH (<4) after recent rainfall, acid runoff from acid sulphate soils (Photo 93).
- Pipeclay Canal – manmade canal, impacted by acid runoff from acid sulphate soils. Acidic pH 5 and turquoise hue from aluminium released from ASS. Rust coloured sediments. Riparian vegetation only consisting of pasture grass (Photo 94)
- Holey Flat Creek no flow, very poor bank structure (Photo 95).

Photo 93 **Cattai Creek wetlands, site 93-04. Water very acidic at time of sampling (pH<4) as creek was completely dry until recent rainfall.**

Photo 94 **Cattai Creek catchment - Pipe Clay Canal, site 93-01B. Turquoise hue to water (aluminium) and rust coloured sediment (iron) from acid sulphate soils. Manure and cattle grazing on banks.**

Photo 95 **Cattai Creek catchment - Holey Flat Creek, site 93-06. No flow, banks in very poor condition. Water extraction plumbing.**

Photo 96 **Cattai Creek – upper catchment. Lush riparian vegetation at site 93-05. Did not sample, vegetation too thick and no flow.**

Manning River

Site assessments

- Nine subcatchments were assessed Freshwater subcatchments – 106 (3 sites), 105 (6 sites) and 99 (3 sites). Estuarine subcatchments – 200 (3 sites), 205 (4 sites), 210 (3 sites), 220 (3 sites), 222 (2-estaurine sites, 1-freshwater site), 224 (3 sites) – Maps 3-5
- Total 31 sites assessed.
- Site assessments in the Manning River scored on average close to the whole catchment average in all categories, for both freshwater and estuarine sites (see Tables 3, 15).
- In addition to the Rapid Site Assessments, a day was spent on the estuary observing the catchment from the water. Subcatchments at the mouth of the second entrance at Old Bar, in Scotts Creek and downstream of Mamboo Island were not assessed from the water (211, 212, 221, 210-eastern shore, 200, 201, 202)
- Photos presented in this section start at upstream freshwater catchments (subcatchment 106) and progress downstream to estuary.

Observations

Land use

- Grazing modified pastures is the dominant land use is most subcatchments.
- Large dairy farms, cropping, irrigation and high fertiliser use in subcatchment 99.
- Beef and dairy cattle farming in 205, 210.
- Urban residential areas in lower estuary (200-Harrington, 224-Taree).

Erosion

- Heavily grazed, cleared slopes in upstream subcatchments (105,106). Hillslope and gully erosion in 105 (photo).
- Bank erosion along the main channels is a major issue in the estuary. Photographs of bank erosion were taken from the water and includes subcatchments that were not included in the Rapid Site Assessments.

Cattle access/impact

- Cattle accessing waterways in 106 (Bakers Creek); 99, 104, 105, 205 (Manning River). Note sheep accessing waterway in mid estuary (subcatchment unknown, Photo 112). A dead sheep was spotted on the shore.
- From the water - many pastures along the river/estuary are not fenced off and cattle access the banks, graze on riparian vegetation (if any) and impact on bank structure and regeneration of vegetation (108, 88, 93, 223, 224).

Riparian and stream condition

- 106 – Bakers Creeks, highly impacted permanent spring fed pools with no flow, very little intact riparian vegetation (Photo 97)
- Good water quality in the Manning River and throughout the estuary at most sites due to no recent inputs from overland flow (Photo 98, 210, 222). Reaches near dairy farming however

were severely eutrophic, with excessive macrophyte growth and algal growth (subcatchments 99, 105; Photos 101, 102, 105)

- Tributaries / creek lines usually had poorer water quality than main channel of river/estuary due to localised runoff from adjacent land use, reduced flows and cattle access (Photo 120, 122)
- In December 2019, the Manning River had stopped flowing (WaterNSW Flow Data) as a result of ongoing drought and water extraction to fight recent bushfires in the area.
- Fencing of pastures from river banks was rarely seen during the boat survey. Upstream of Taree (downstream of Wingham), dry bare pastures lead straight to the riverbank with very little riparian vegetation and eroding banks in (subcatchments 108, 209; Photos 106, 107). Farther downstream in the estuary, cattle frequently have access to banks however some protection of bank structure is provided by mangroves (subcatchments 224, 223, 88)
- Cedar Party Creek (95) at Manning Rivers had extensive riparian vegetation but was dominated by exotic shrubs. Riparian vegetation in the downstream of Cedar Party Creek is completely overgrown with balloon vine and other exotic weeds (Photo 81).
- One section of the riverbank at 209 is overgrown with Bamboo and a giant reed (Photo 108).
- Good native riparian vegetation occurs in some sections of subcatchment 220 including native grasses (220 Glenthorne, Photo 110)
- Banks are severely eroded along the shoreline of subcatchments 114 (Photo 113) which has led to the loss of riparian vegetation (Photo 114). Bank erosion in South Channel subcatchment 210 (Oxley Is.) adjacent to dairies (e.g. site 210-04, Photo 116). Landowners noted their frustration at not being allowed to intervene and prevent further erosion.
- Banks are severely eroded along the shoreline of subcatchments 205 and 207. Rock revetments have been built to minimise further erosion from storm surges and boat wash (Photo 119).
- Localised erosion where a section of bank (~10 metres) is completely gone was noted at subcatchments 95 (Cedar Party, Photo 82) and at 208 (Dumaresq Is., Photo118)
- Mangroves occur throughout the estuary and provide some protection of bank structure where they occur (88, 93, 220, 222, 224; Photos 115, 122, 124). Continuity of mangroves along the shoreline can be patchy and the band width rarely exceeded 10m. Even though present, mangroves at this density provide limited protection of shorelines from erosional forces of high flows and boat wash

Photo 97 **Manning River catchment – Bakers Creek at Bakers Creek Rd, site 106-2. High nutrients evident by prolific floating fern (Azolla). Typha near bridge.**

Photo 98 **Manning River, site 105-14. Good native riparian vegetation and water quality. Cattle access river here (Lomandra grazed, pugging, macrophytes and algae near shore).**

Photo 99 Manning River – site 105-1. Irrigated fertilised pastures at large dairy farm

Photo 100 Manning River – site 105-1. Hillslope and bank erosion

Photo 101 Manning River – site 105-1. Eutrophic zone as indicated by excessive macrophyte (submerged) and epiphytic algae.

Photo 102 Manning River – site 105-1. Shoreline of macrophyte Azolla and manure

Photo 103 **Manning River, site 105-3. Bare eroding hillslopes and gully erosion. No riparian vegetation**

Photo 104 **Manning River at Killawarra Bridge, site 104-1 (Pilot run). Cattle accessing river on left bank impacting on bank condition. Riparian vegetation on left bank dominated by exotic species. Filamentous algae and macrophytes in river.**

Photo 105 **Manning River site, 99-01. Former site for Bootawa Dam offtake. Heavy macrophyte growth fouled with epiphytic algae. Spotted a platypus at this site. Large dairy on left bank (top of image) side with cattle access to riverbank just downstream of image.**

Photo 106 **Manning River (Mondrook, subcatchment 108). Dry pastures with eroding banks. Cattle access riverbanks throughout subcatchment 108 (boat survey). Poor bank condition and little riparian vegetation for most of shoreline of subcatchment 108**

Photo 107 **Manning River (subcatchment 209). Bare pastures, cattle accessing river bank, no riparian vegetation**

Photo 108 **Manning River (subcatchment 209). Riverbank overgrown with bamboo and a giant reed**

Photo 109 Manning River – Cedar Party Creek subcatchment 95. Good riparian vegetation, predominantly native canopy and exotic shrubs.

Photo 110 Manning River – (subcatchment 220). Good riparian vegetation – native canopy and ground cover.

Photo 111 **Manning River catchment – Sitts Creek (Glenthorne), site 220-1 (estuarine site) Pneumatophores webbed in decomposing algae. No flow. Good cover of saltmarsh on left bank (top left). Adjacent pasture fenced off. Right bank (not shown). Cleared pasture in very poor condition adjacent to this site beyond a thin band of immature woody riparian vegetation.**

Photo 112 **Manning River (subcatchment unknown). Bare pastures, no riparian vegetation. Sheep grazing (dead sheep on riverbank upstream).**

Photo 113 Manning River South Channel (subcatchment 114). Heavy erosion of banks has led to loss of riparian vegetation (Photo 111)

Photo 114 Manning River South Channel (subcatchment 114). Erosion of banks (photo 110) has led to loss of riparian vegetation.

Photo 115 **Manning River South Channel (subcatchment 222). Banks are eroding but mangroves appear to be providing some protection of banks**

Photo 116 **Manning River South Channel (Oxley Is. subcatchment 210). Pastures, no fencing. Steep banks with minimal riparian vegetation, exotic shrubs. Eroding banks.**

Photo 117 Manning River South Channel (Oxley Is. subcatchment 210). Dairy farm at site 210-04.

Photo 118 Manning River – Dumaresq Is. (subcatchment 208). Bank collapse, building/domestic waste along shoreline, possible attempt to prevent further erosion.

Photo 119 Manning River – Jones Is. subcatchment 205. Severe erosion of banks – rock revetment to reduce wash, further erosion.

Photo 120 Manning River/Lansdowne River catchment – creek line leading directly to estuary (Jones Is. site 205-03). Cattle access and dense growth of filamentous algae. Poor land practice on this property with much potential to improve.

Photo 121 **Manning river/Lansdowne River subcatchment 88 (downstream at estuary). Cattle have access to river bank, with eroding banks and minimal riparian vegetation**

Photo 122 **Manning river/Cattai Creek subcatchment 93 (downstream at estuary). Cattle have access to river bank, with eroding banks**

Photo 123 Manning River/Cattai Creek – Mamboo Is. Dense distribution of mangroves.

Photo 124 Manning River/Ghinni Ghinni Creek (subcatchment 223) - wake of a river dolphin, cattle on banks

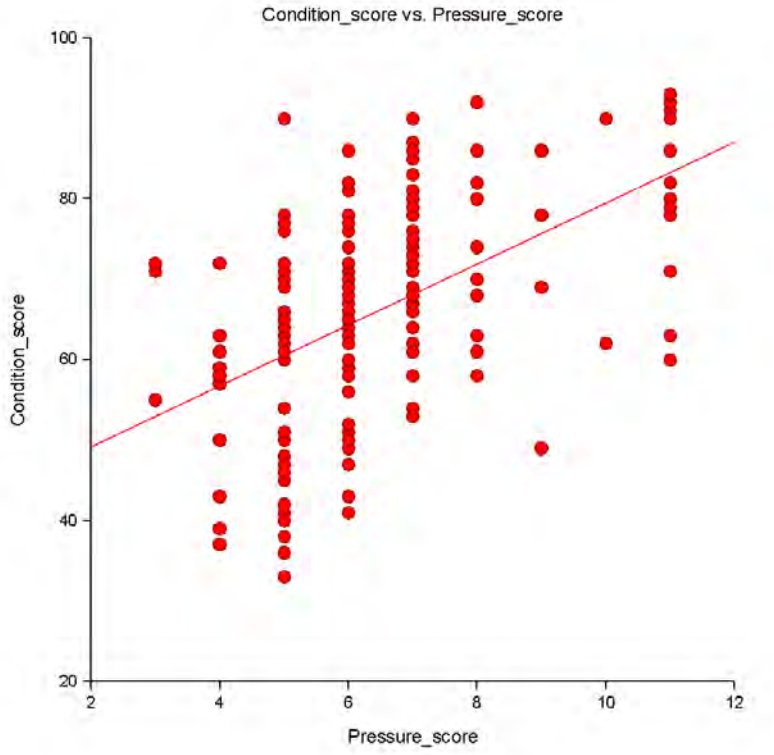
Results: Correlation between Pressure and Condition Scores

Attribute scores for Land Use Pressure, Geomorphic Condition (freshwater only), Instream Condition and Riparian Condition were summed together for an Overall Condition Score (Table A3-2, A4-2). The Overall Condition score thus includes a pressure component.

Land Use Pressure scores were plotted against Condition scores at each site to assess any relationship between Land Use Pressure and ecological condition. Attributes for Condition were combined for analysis and were also analysed separately.

In the freshwater catchment, there were positive, significant correlations between Land Use Pressure and combined Condition scores for Geomorphic, Instream, Riparian Condition (correlation = 0.50, Graph 1). Land Use Pressure correlated with Geomorphic Condition (correlation = 0.41) and Riparian Condition (correlation = 0.49) but not with Instream Condition (correlation = 0.10) at freshwater sites.

Land Use Pressure and ecological condition at the estuarine sites were only weakly correlated (not significant); Land Use Pressure and combined Condition scores (Instream and Riparian, correlation 0.26), Land Use Pressure and Instream Condition (correlation = 0.24) and Land Use Pressure and Riparian Condition (correlation = 0.17). Only 31 sites were assessed in the estuarine catchment compared to 175 sites in the much larger freshwater catchment. The relationship between Land Use Pressure and ecological condition of estuary sites may have been stronger if more sites were assessed.



Graph 1 Land Use Pressure scores plotted against (combined) Condition scores (summed Instream, Geomorphic and Riparian Condition scores) for each freshwater site (significant, positive correlation = 0.50, r^2 = 0.25). Note that higher Land Use Pressure scores means less pressure and higher condition scores represent better condition.

The correlation of 0.50 between Land Use Pressure scores and Condition scores demonstrates that ecological condition of freshwater streams in the Manning catchment is related to land use pressure at the site. The R-squared value of 0.25 reflects the proportion of the variation in Condition scores that can be accounted for by variation in the Land Use Pressure score. Thus, other factors in addition to land use pressure at the site contribute to its ecological condition and may include river flows and roadworks.

Variables assessed for the Land Use Pressure score were land use type, stock impact at the site and fertilisation and/or irrigation of surrounding pastures, with higher scores representing *less* Land Use Pressure. Diffuse flows (surface runoff) from different land use types transport pollutants to receiving waters. Surface flows from modified/intensive land use typically have elevated levels of nutrients or TSS, especially if pastures are fertilised and irrigated, which can impact water quality in the stream or estuary. Stock accessing riparian zones and streambanks has a direct impact on Riparian and Instream Condition through grazing and trampling. The previous section *Overview of the Major River /Creek catchments* highlights the types of land use and agricultural pressures observed and recorded in each catchment throughout the field program that could be contributing to poor ecological condition of streams in some areas.

Results: land use pressure, riparian, geomorphic and instream condition

Freshwater catchment

Scores for each attribute (Overall Condition, Land Use Pressure, Geomorphic Condition, Instream Condition, Riparian Condition) were averaged for each major river/creek catchment are shown in Table 3. It is important to note that there was considerable variation in site condition within each major freshwater catchment and within each EES subcatchment. This variation is apparent in scores for each site presented in Table A3-2 (freshwater sites). Whole catchment average scores are useful for summarising and comparing across the major/river catchments however individual site data should be interrogated for a complete perspective of condition in each subcatchment (Table A3-2).

Scores for each attribute at each site are presented in Maps A3-1 – A3-10 (freshwater sites) which illustrate the variation in condition at the subcatchment scale.

Table 2 **Average scores for Overall Condition, Land Use Pressure, Geomorphic Condition, Instream Condition and Riparian Condition for all major freshwater river/creek catchments (number of EES subcatchments and total number of sites assessed are shown as # SC, # sites)**

Major River / Creek Catchment FRESHWATER (#SC, # sites)	Average Overall Condition score (max 125)	Average Land Use Pressure score (max 11)	Average Geomorp. score (max 29)	Average Instream Condition score (max 37)	Average Riparian Condition score (max 56)
Burrrell Creek (2, 9)	89	8	23	17	41
Dingo Creek (3, 14)	79	7	20	16	36
Manning River (5, 14)	77	8	23	17	29
Cattai Creek (1, 2)	77	6	25	18	28
Upper Manning River (3, 20)	76	6	23	16	31
Nowendoc River (5, 24)	75	7	23	14	31
Myall Creek (2, 5)	74	7	24	13	29
Avon River (2, 11)	73	7	22	16	28
Bowman River (1, 7)	71	6	23	14	27
Gloucester River (2, 13)	70	6	22	15	28
Lansdowne River (1, 7)	70	7	22	13	28
Barrington River (4, 19)	64	5	20	13	25
Barnard River (6, 19)	63	6	21	14	21
Cedar Party Creek (1, 5)	61	6	19	15	21
Freshwater Catchment Average	**72**	**6**	**22**	**15**	**29**

Overall Condition Score

The Overall Condition score is the sum of scores for Land Use Pressure, Geomorphic Condition, Instream Condition and Riparian condition for each major river/creek catchment (Table 3). Thus, Overall Condition scores have a 'pressure' component which has ~10% weighting in the score. The Instream Condition score has 30% weighting in the Overall Condition score while Riparian Condition is the major component with 45% weighting in the score. Overall Condition scores for each freshwater site are shown in Table A3-2 and ranged from 38 out of possible 125 points (*Poor*, site 119-03, Barrington River) to 104/125 (*Excellent*, site 123-14, Avon River). Most freshwater sites were in *Fair* condition (53%, Score 51-75) or *Good* condition (38%, Score 76-99, Table A3-2).

Note that it is not appropriate to apply grades to scores averaged across whole river/creek catchments (or subcatchments) due to high variability in condition across the large catchments, and the different number of sites assessed in each major catchment/subcatchment (Table 1).

Summary below refers to average scores for major river/ creek catchments. Subcatchment averages are also shown for Stock Impact scores.

- Freshwater catchment average – Score 72/125 (see Table 3)
- Best catchments – Burrell Creek (score 89), Dingo Creek (score 79)
- Worst catchments – Barnard River (score 63), Barrington River (score 64), Cedar Party Creek (score 61)

Land Use Pressure

The Land Use Pressure attribute included the variables of land use type (max 5 points), stock impact (max 4 points) and fertilisation / irrigation of adjacent pastures (1 point each). Higher scores were assigned to land use that has lower impact (i.e., less pressure) on waterway health, for example conservation/forested areas scored '5' while dairy farms scored '1' (Appendix 2).

Scores for Land Use Pressure at each site were assigned grades as shown in Table A3-2 and Maps A3-2, A3-7. Land Use Pressure at most freshwater sites was graded as *Fair* (Score 5-6, Table A3-1) with Land Use Pressure scores ranging from 4 - 11 (Table A3-2).

Summaries below refer to average scores for major river/ creek catchment and subcatchment averages are also shown for stock impact scores.

Land Use Pressure score

- Freshwater catchment average – score 6 (max 11, Table 3)
- Best catchments – Burrell Creek and Manning River (score 8)
- Worst catchments – Barnard River (score 5)

Land use type

Grazing was the dominant land use at sites surveyed in the freshwater catchment (85%). Other land use types are shown below. The preliminary Estuary Health Risk Map pointed to subcatchments with primarily agricultural land use as posing the highest risk to estuary health. Sites with grazing and more intensive land use were thus targeted in the Rapid Site Assessments.

- Grazing = 149/175 sites
- Native Forest / Conservation Area = 13/175
- Dairy = 6/175 sites
- Rural residential = 4/175

- Forestry plantation = 2/175 sites
- Native forestry = 1/175

Stock impact

Cattle farms are widespread throughout the Manning catchment and cattle frequently have access to streams. Stock graze on riparian vegetation and seek shade along the creek lines, trampling soft banks and drinking from streams. Cattle access to riparian zones and streams leads to poor bank structure, reduced vegetation and poor water quality. Scoring applied to stock impact are given in Table 4.

Table 3 Scoring applied to livestock impact used in Land Use Pressure assessment (note lower scores assigned for more impact)

Score	Impact of livestock on riparian zone
1	Stock consistently accessing waterway, degraded banks, manure present
2	Many tracks, heavily grazed or no understory
3	Few tracks, grazed groundcover
4	No evidence

- Average stock impact scores for sites in each major river / creek catchment and EES subcatchments are shown in Table 5.Freshwater catchment average – score 2.5
- Best catchments – Lansdowne River (score 3.9) and Burrell Creek (score 3.3)
    - Best subcatchments (score 4) – 222 (Manning), 223 (only one site- Lansdowne/Ghinni Ck)
- Worst catchments – Barnard River (score 1.8), Myall Creek and Barrington River (scored 2.2)
    - Worst subcatchments (score ≤ 1.3) – 82, 83, 84 (Barnard), 98 (Gloucester)

Irrigation/Fertilisation of pastures

Approximately 20% of adjacent land use was either irrigated (31/175 sites) or fertilised (35/175 sites) at freshwater sites surveyed in the Rapid Site Assessments.

Table 4 Average stock impact scores for each major river/creek catchment and constituent subcatchment with lower scores representing more impact

Catchment/ subcatchment	Average of stock impact score (max 4)	Catchment/ subcatchment	Average of stock impact score (max 4)
Avon River	**2.5**	Gloucester River	**2.6**
121	2.2	98	1.3
123	2.8	122	2.9
Barnard River	**1.8**	Lansdowne River	**3.9**
72	2.5	88	3.8
77	2.3	223	4.0
81	1.8	Manning River	**3.1**
82	1.0	99	3.7
83	1.3	105	3.3
84	1.3	106	2.0
Barrington River	2.2	222	4.0
111	2.0	Myall Creek	**2.2**
115	2.2	68	3.0
117	2.4	76	1.7
119	2.0	Nowendoc River	2.3
Bowman River	2.4	64	1.6
109	2.4	66	1.8
Burrell Creek	**3.3**	74	3.2
112	3.8	80	1.8
113	3.0	85	3.0
Cattai Creek	2.5	Upper Manning River	**2.3**
93	2.5	90	2.3
Cedar Party Creek	**2.6**	91	2.3
95	2.6	92	1.8
Dingo Creek	**3.2**	94	2.6
86	3.6		
89	2.8		
97	3.3		
Freshwater catchment average			**2.5**

Riparian Condition

Erosion of hillslopes and streambanks is a widespread pressure across the catchment as it can lead to loss of streambank structure in the riparian zone resulting in the loss of riparian vegetation. Riparian vegetation provides critical ecosystem services including stabilising banks and reducing the amount of pollutants entering the waterway. Riparian vegetation also serves as a physical buffer, slowing down overland flow before it enters the stream. Hillslope erosion contributes large amounts of sediment to waterways in the catchment following rainfall. An intact riparian vegetation zone captures some of the sediment.

Variables assessed for Riparian Condition included the extent of the riparian zone as defined by longitudinal continuity, width, and disturbance. The scores assigned to each variable reflect the level of impact on the riparian zone (Table 6). Average scores for each major river/creek catchment for longitudinal continuity, width, and disturbance are shown in Table 7.

Percent cover and type of riparian vegetation (native/exotic) in canopy, shrub and ground cover layers were also assessed. The scores assigned to each variable reflect the extent of vegetation cover in each layer, and percent native cover (Table 8). Average scores for each major river/creek catchments for extent and type of cover are shown in Table 9.

Scores for Riparian Condition for each site and assigned grades are shown in Table A3-2 and Maps A3-5 and A3-10 (Appendix 3). Riparian Condition was graded as *Fair* (Score 23 - 33) or *Good* (Score 34 – 44) at most freshwater sites (Table A3-1, A3-2). Scores for Riparian Condition ranged from 6 (poorest site 123-06) to 52 (best site 123-14) which were both in the Avon River catchment.

Summaries below refer to average scores for major river/ creek catchments.

Riparian Condition score (all variables)

- Freshwater catchment average – score 29 (out of 56, Table 3)
- Best catchments – Burrell Creek (score 41) and Dingo Creek (score 36)
- Worst catchments – Barnard River and Cedar Party Creek (scored 21)

Longitudinal continuity

- Freshwater catchment average – score 2.6 ~ *50% continuous* (Table 7)
- Best catchments – Burrell Creek (score 3.7), Dingo Creek (score 3.8)
- Worst catchments – Barnard (score 1.5), Avon (score 2.1)

Riparian width

Effects of the 1978 flood were evident throughout the catchment. Flooding caused extensive gouging of the streambanks (exacerbated by extensive clearing along riverbanks). In many areas where clearing has occurred in the past, the riparian zone has been recolonised almost exclusively by a monoculture of Casuarinas (1-3 m band) however, remnant rainforest species (e.g., river red gum, bottlebrush *Callistemon spp.*) occur in pockets along the rivers as second stage colonisation

Bands of riparian vegetation were often less than 10 m wide across the catchment, with a whole catchment average of 10 m wide approximately (score 1.5), falling well short of the recommended 30 m band for provision of effective ecosystem services (shading, buffer/filtration of pollutants from overland flow) (Table 7)

- Freshwater catchment average – score 1.5 ~ *10 m wide*
- Best catchments – Lansdowne (score 2.6)

- Worst catchments – Cattai, Barnard, Bowman (score 1.0), Barrington (score 1.2)

Disturbance (tracks, erosion, cleared, trampled)

- Freshwater catchment average – score 2.2 ~ *50 - 75% disturbed* (Table 7)
- Worst catchments – Barnard (score 0.9), Myall Creek (1.6), Gloucester (score 1.7)
- Best catchments – Burrell Creek, Dingo Creek, Lansdowne (score > 3.5)

Canopy, Shrub, Ground Cover (%) – Native v Exotic

Canopy layer

Most sites had reasonable canopy cover and native species dominated the canopy but typically there was low diversity, with only 1-2 species e.g., *Casuarina* predominantly. Other natives present included- forest red gum, grey box and lilly pilly. Camphor laurel was a common exotic species.

Canopy Cover

- Freshwater catchment average – score 2.0 ~ *50% cover* (Table 9)
- Best catchments – Burrell Creek, Dingo Creek (score 2.6-2.8)
- Worst catchments – Barnard (score 1.0), Upper Manning - Avon (score 1.5-1.6)

Canopy Nativeness

- Freshwater catchment average – score 3.6 ~ *cover more than 75% native* (Table 9)
- All catchments scored >3.0

Shrub layer

Shrub layer was less extensive and where present usually exotic species (privet, *Lantana*). Note that *Lomandra* were grouped into shrub layer in this assessment, as they were typically of large size.

Shrub % cover

- Freshwater catchment average – score 1.7 ~ *25 - 50% shrub layer intact* (Table 9)
- Best catchments – Burrell Creek, Cattai Creek (score 3.0-3.2)
- Worst catchments – Barnard (score 0.7), Barrington (score 0.9) and Gloucester (score 1.5)

Shrub layer nativeness

- Freshwater catchment average – score 2.2 ~ *cover 50 - 75% exotic* (Table 9)
- Best catchments – Burrell Creek, Nowendoc, Upper Manning (score > 3.0)
- Worst catchments – Barrington, Bowman and Lansdowne (score 1.3)
- 7 catchments scored less than 2.0 ~ *cover 50 - 75% exotic*

Groundcover

Ground cover where present was typically dominated by exotic species (e.g. wandering dew, mist flower, blue billy goat, pasture grass). Note that *Lomandra* was **not** classed as ground cover in this assessment as they were typically of large size

Groundcover % cover

- Freshwater catchment average – score 2.8 ~ *50% ground cover* (Table 9)

**Note that a high score (4) could also be assigned for "ground cover sparse due to dense canopy"* (Table 8)

- Worst catchments – Cattai (score 0), Cedar Party (score 1.0), Lansdowne (score 1.4)

Most catchments scored >3.0

Ground cover nativeness

- Freshwater catchment average – score 1.3 ~ *cover up to 75% exotic* (Table 9)
- Best catchments – Burrell Creek, Nowendoc, Upper Manning (score > 3.0)
- Worst catchments – Barrington, Bowman and Lansdowne (score 1.3)
- 7 catchments scored less than 2.0 ~ *cover 50 - 75% exotic*

Table 5 Scores assigned to variables in the riparian zone were based on level of impact and were used in the assessment of the attribute Riparian Condition

Variable	Description	Score
Longitudinal continuity of riparian vegetation	No riparian vegetation	0
	Up to 25% continuous	1
	25 to 50% continuous	2
	50 to 75% continuous	3
	More than 75% continuous	4
Width of riparian vegetation (at thinnest point)	No riparian vegetation	0
	Up to 10m	1
	Between 10 and 20m	2
	Between 20 and 30m	3
	Continuous with bushland	4
Disturbance, % disturbed (tracks, erosion, cleared, trampled)	100% disturbed, tracks, erosion, trees and shrubs cleared	0
	More than 75% disturbed	1
	50 to 75% disturbed	2
	25 to 50% disturbed	3
	Less than 25% disturbed	4

Table 6 Average score for variables in the riparian zone (continuity, width and disturbance) for each major river/creek catchment

Major river/ creek catchment	Average of Longitudinal Continuity	Average of Riparian Width	Average of Riparian Disturbance
Avon River	2.1	1.5	2.0
Barnard River	1.5	1.0	0.9
Barrington River	2.4	1.2	1.9
Bowman River	2.7	1.0	2.3
Burrell Creek	3.7	2.3	3.7
Cattai Creek	3.5	1.0	3.5
Cedar Party Creek	2.0	1.2	1.8
Dingo Creek	3.8	1.8	3.6
Gloucester River	2.4	1.4	1.7
Lansdowne River	3.7	2.6	3.9
Manning River	3.1	2.1	2.6
Myall Creek	2.2	1.4	1.6
Nowendoc River	2.9	1.4	2.3
Upper Manning River	2.6	1.7	2.0
Freshwater Catchment Average	**2.6**	**1.5**	**2.2**

Table 7 Scores assigned to variables in the riparian zone relating to extent of cover and percent cover of native/exotic species used in the assessment of Riparian Condition

Variable	Description	Score
Nativeness (% of Canopy, Shrub, Ground Cover that is Native)	Cover 100% exotic	0
	Cover up to 75% exotic	1
	Cover 50 to 75% exotic	2
	Cover 25 to 50% exotic	3
	Cover more than 75% native	4
Canopy % cover	No canopy - cleared	0
	Canopy sparse, <25% cover	1
	Canopy disturbed, 25 to 50% cover	2
	Canopy slightly disturbed, 50 to 75% cover	3
	Canopy greater than 75% cover	4
Shrub layer % cover (equivalent descriptors/scoring for % Ground Cover)	No shrub layer - cleared	0
	No shrub layer due to dense natural canopy	4
	Less than 25% of shrub layer remaining	1
	25 to 50% of shrub layer intact	2
	50 to 75% of shrub layer intact	3
	More than 75% of shrub layer intact	4

Table 8 Average score for riparian zone variables (% cover and nativeness of canopy, shrub and ground cover) for each major river/creek catchment

Major River/Creek Catchment	Average Canopy % Cover	Average Canopy Native-ness	Average Shrub Layer % Cover	Average Shrub Native-ness	Average Ground Cover % Cover	Average Ground Cover Native-ness
Avon River	1.6	2.9	2.3	1.8	2.9	1.4
Barnard River	1.0	3.8	0.7	1.7	2.5	0.9
Barrington River	2.2	3.7	0.9	1.3	3.2	1.2
Bowman River	2.6	3.6	2.0	1.4	3.7	0.3
Burrell Creek	3.2	3.6	2.8	3.2	2.7	2.4
Cattai Creek	3.0	4.0	2.0	1.5	0.0	0.0
Cedar Party Creek	2.2	3.2	1.6	1.6	1.0	0.2
Dingo Creek	2.9	3.9	2.6	2.5	2.3	2.1
Gloucester River	1.7	3.6	1.5	2.2	3.3	1.3
Lansdowne River	2.7	3.1	2.1	1.3	1.4	1.1
Manning River	2.1	3.9	1.8	2.4	2.2	0.4
Myall Creek	2.6	3.2	1.6	2.4	3.4	1.8
Nowendoc River	2.2	3.5	2.0	3.1	3.3	1.6
Upper Manning River	1.5	4.0	1.7	3.0	3.2	1.5
Freshwater Catchment Average	**2.0**	**3.6**	**1.7**	**2.2**	**2.8**	**1.3**

Geomorphic Condition

The geomorphology of streams is derived from components of geology, soil science and hydrology. The Geomorphic Condition assessment included variables pertaining to riverbed substrate and bank structure which can reflect the severity of bank erosion and if the erosion is active. Scores assigned to variables assessing Geomorphic Condition are shown in Tables 10 and 12. Catchment average scores for each major river /creek catchment for riverbed and bank structure variables are shown in Tables 11 and 13, respectively. The function of these variables and how they were scored are discussed briefly in each section. Geomorphic Condition scored the highest grades of all the attributes in the Rapid Site Assessments. Geomorphic Condition at most sites was rated as *Good* (Score 17 – 22) or *Excellent* (Score 23 – 29; Table A3-2, Maps A3-4, A3-8). Scores for Geomorphic Condition ranged from 10 to 29 (Table A3-2).

Summaries below refer to average scores for each major river/creek catchment.

Geomorphic Condition scores (all variables)

- Freshwater catchment average – score 22/29 (Table 3)
- Best catchments – Cattai Creek (only 2 sites, score 25), Myall Creek (score 24); Bowman River, Burrell Creek, Manning river, Nowendoc River and Upper Manning River all scored 23
- Worst catchments – Cedar Party Creek (score 19), Barrington River and Dingo Creek (score 20)

Dominant substrate cover

The upper reaches of river systems are characterised by bedrock dominated substrate. Bedrock armouring of riverbed and riverbanks provides protection against erosional forces. As you move farther downstream, substrates become progressively smaller, from bedrock to boulder, to cobbles, to pebbles etc. This occurs due to weathering of the substrates from physical forces (e.g., river flow). Estuaries, being at the mouth of the river systems, have fine substrates (sand or silt/clay) due to the culmination of physical forces (flow) acting on substrates in upstream reaches over millennia.

Higher scores were attained when the dominant substrate covers a greater area with highest score of '5' given for >75% cover of dominant substrate (Table 10)

- Freshwater catchment average – score 3.6 (Table 11)
- Most catchments scored an average of 3 or above *(>45% cover of dominant substrate*)
- Dingo Creek had the lowest average score of 2.1 (*30-45% cover of dominant substrate*)

Riffle/pool sequence

Alternation of riffles and pools provides habitats with characteristics suitable for different types of organisms. More variety in instream habitats increases the diversity of organisms in the system. The presence of riffles and pools in a stream are dependent on riverbed form which is derived from substrate characteristics (type and extent cover).

Score 4 = frequent alternation of riffles and pools, score 3 = long pools with infrequent short riffles (Table 10)

- Freshwater catchment average – score 3.4 (Table 11)
- Best catchments – Myall Creek (score 4.0), Cattai Creek (only 2 sites, score 4.0), Upper Manning River (score 3.8)Worst catchments – Dingo Creek, Lansdowne River, Manning River (Score 2.9)

Sediment accumulation

Accumulation of fine sediments indicates erosional forces are at play. The formation of gravel bars is indicative of a changed physical structure in the channel due to forces of flow on substrates upstream.

Score 3 = some gravel bars but little sand/silt, score 4 = Little or no accumulation of loose sediments (Table 10)

- Freshwater catchment average – score 3.7 (Table 11)
- All subcatchments had an average score of 3.1 or higher.
- Best catchments – Cattai Creek (only 2 sites, score 4), Cedar Party Creek (score 4), Barrington and Manning Rivers (score 3.9).
- Worst catchments – Burrell Creek (score 3.1)

Bank structure

Bank structure on average was in *Good* condition, however there were some sites with poor bank structure (Table 13).

Score 3 = Banks firm but mainly held by grass and herbs, score 4 = banks fully stable held by trees and shrubs (Table 12)

- Freshwater catchment average – score 3.1 (Table 13).
- All catchments scored on average above 2.7. Barrington River scored 2.7.
- Best catchments – Burrell and Cattai Creeks (scored 4), Lansdowne River (score 3.6).

Bank undercutting

Bank undercutting occurs frequently on bends and constrictions but rarely across the whole reach.

Score 4 = None, or restricted by tree roots, score 3 = only on curves and at constrictions, score 2 = frequent along all parts of stream (Table 12)

- Freshwater catchment average – score 3.2 (Table 13)
- Best catchments – Upper Manning River (score 3.6) and Manning River (score 3.5)
- Worst catchments – Cedar Party Creek (score 2.6), Barrington River and Dingo Creek (scored 2.9)

Bank erosion

Streambank erosion is an issue across the catchment. At most sites only minor erosion was evident. Vertical banks are a sign of active erosion. Each bank was scored separately in the Rapid Site Assessments (average of right bank and left bank scores used in this summary).

Score 3 = banks with minor erosion evident, score of 2 = banks not vertical but erosion evident, score 1 = banks vertical with some undercutting.

- Freshwater catchment average – score 2.6 (Table 13)
- Best catchments – Burrell Creek, Nowendoc River (score 3.1), Upper Manning River (score 3.0)
- Worst catchments – Cedar Party Creek (score 1.0), Barnard River (1.8), Avon River (2.1)

Table 9 Scores assigned to riverbed/channel substrate variables used in the assessment of Geomorphic Condition

Variable	Description	Score
Dominant substrate % cover	15-30%	1
	30-45%	2
	45-60%	3
	60-75%	4
	>75%	5
Riffle/pool sequences within reach	Frequent alternation of riffles and pools	4
	Long pools with infrequent short riffles	3
	Natural channel without riffle / pool sequence	2
	Artificial channel; no riffle / pool sequence	1
Channel sediment accumulation	Little or no accumulation of loose sediments	4
	Some gravel bars but little sand or silt	3
	Bars of sand and silt common	2
	Braiding by loose sediment	1

Table 10 Average scores for geomorphic variables relating to riverbed/channel substrate for each major river/creek catchment

Major river/creek catchment	Average of Dominant Substrate Cover score	Average of Riffle Pool Sequence score	Average of Channel Sediment Accumulation score
Avon River	4.6	3.3	3.6
Barnard River	4.2	3.7	3.7
Barrington River	3.3	3.5	3.9
Bowman River	4.1	3.6	3.7
Burrell Creek	3.1	3.7	3.1
Cattai Creek	4.0	4.0	4.0
Cedar Party Creek	4.4	3.0	4.0
Dingo Creek	2.1	2.9	3.6
Gloucester River	3.5	3.0	3.6
Lansdowne River	4.1	2.9	3.7
Manning River	3.6	2.9	3.9
Myall Creek	4.6	4.0	4.0
Nowendoc River	3.2	3.5	3.8
Upper Manning River	3.4	3.8	3.4
Freshwater catchment average	**3.6**	**3.4**	**3.7**

Table 11 Scores assigned to bank condition variables that were included in the Geomorphic Condition assessment

Site Attribute	Description	Score
General assessment of bank structure across site	Banks fully stabilised by trees, shrubs etc.	4
	Banks firm but held mainly by grass and herbs	3
	Banks loose, partly held by sparse grass etc.	2
	Banks unstable, mainly loose sand or soil	1
Bank undercutting assessed for whole site	None, or restricted by tree roots	4
	Only on curves and at constrictions	3
	Frequent along all parts of stream	2
	Severe, bank collapses common	1
Extent of erosion of left/right bank	Banks with slumping and undercutting	0
	Banks vertical with some undercutting	1
	Banks not vertical but erosion evident	2
	Banks with minor erosion evident	3
	No erosion evident, or vertical bedrock constrained banks	4

Table 12 Average scores for bank condition variables for each major river/creek catchment

Major River catchment	Average Bank Structure score	Average Bank Undercutting score	Average Right Bank Erosion score	Average Left Bank Erosion score
Avon River	2.8	3.2	1.9	2.2
Barnard River	2.8	3.4	1.9	1.7
Barrington River	2.7	2.9	2.2	2.0
Bowman River	3.3	3.3	2.9	2.4
Burrell Creek	4.0	3.4	3.2	2.9
Cattai Creek	4.0	3.5	3.0	2.5
Cedar Party Creek	2.8	2.6	1.0	1.0
Dingo Creek	3.3	2.9	2.8	2.6
Gloucester River	3.1	3.0	2.7	2.6
Lansdowne River	3.6	3.0	2.1	2.0
Manning River	3.4	3.5	2.6	2.9
Myall Creek	3.2	3.4	2.6	2.6
Nowendoc River	3.1	3.2	3.1	3.0
Upper Manning River	3.3	3.6	3.1	2.8
Freshwater catchment average	**3.1**	**3.2**	**2.6**	**2.5**

Instream condition

The presence of diverse habitats, large woody debris (LWD), macrophytes, leaf litter, filamentous green algae, odour and grease and oil were included in the instream condition assessment (Table 14). Water quality variables were recorded *in situ* with a water quality multi-meter (temperature, dissolved oxygen (% saturation, mg/L, conductivity µs/cm, pH, Turbidity NTU, chlorophyll µg/L) but was not included in the Instream Condition score for freshwater sites.

Most sites in the catchment were rated as being in Poor (8-14) or Fair condition (15-22, Table A4-2, Maps A4-3, A4-8). Only 3 sites were rated as Good (23 – 29). The low scores are partly due to a potential 16 points (out of 35) being assigned to macrophytes (presence/distribution of any macrophytes 0-4 points, presence/ distribution of submerged /emergent /floating macrophytes - 0-4 points for each). There were patchy and dense distributions of macrophytes in some flowing streams, and extensive cover of macrophytes fouled with epiphytic algae at sites adjacent to intensive land use (e.g. dairy farms on Manning River).

Summaries below refer to average scores for major river/ creek catchments.

Instream Condition scores (all variables)

- Freshwater catchment average – score 15 (Table 3)
- Best catchments – score 17 (Burrell Creek, Manning River), score 18 (Cattai Creek, only 2 sites)
- Worst catchments – score 13 (Barrington River, Myall Creek)

In-channel habitats, large woody debris, leaf litter

Streams with a variety of habitats (riffles, pools, substrate, overhanging vegetation, large woody debris, leaf litter) can support a higher diversity of organisms.

In channel habitats

Score 3 = 3 – 4 habitat types present

- Freshwater catchment average – score 2.8 (Table 14)
- Best catchments – score 3.7 (Dingo Creek), score 3.5 (Cattai Creek, only 2 sites)
- Worst catchments – score 2.0 (Barnard River, Bowman River)

Large Woody Debris

Score 1 = Low distribution 1-10%

- Freshwater catchment average – score 1.0 (Table 14)
- Best catchments – score 1.4 (Cedar Party, Lansdowne), score 4.0 (Cattai Creek, only 2 sites)
- Worst catchments – score 0.6 – 0.8 (Nowendoc, Barrington and Gloucester)

Leaf Litter

Score 1 = Low distribution 1-10%

- Freshwater catchment average – score 1.3 (Table 14)
- Best catchments – score 3.9 (Burrell Creek), score 3.0 (Cattai Creek, only 2 sites)
- Worst catchments – score 0.6 – 0.8 (Nowendoc River and Myall Creek)

Filamentous Green Algae

Filamentous green algae are a sign of high nutrient inputs from overland flow or groundwater, typically associated with land use. Agricultural land use including high intensity dairy and cattle farming have led to high phosphate in waterways. Geological factors can also contribute to nutrient loads in waterways. Basalt caps are across most of the headwaters in the Manning catchment. Basalt produces nutrient soils through binding of phosphorous. Weathering and erosion of these soils releases phosphorous into the waterways contributing to poor water quality.

Filamentous green algae were common in both perennial streams and isolated pools in non-flowing streams but typically a low distribution. Site assessments occurred after a long dry period with little or no inputs of nutrients from overland flow.

Score 4 = none, score 3 = low distribution 1-10%, score 2 = moderate distribution 11-20%

- Freshwater catchment average – score 3.2 (Table 14)
- Best catchments – Burrell Creek, Cattai Creek (score 4.0)
- Worst catchments – Bowman, Nowendoc and Myall Creek (score 2.6)

Macrophytes

Macrophytes are a source of food, habitat and oxygen to waterways. Not all waterways are suitable for macrophytes (for example, fast flowing systems). Eutrophic waters lead to overgrowth of macrophytes which can impact on water quality when they breakdown, contributing to the organic load in the system.

Low abundance of macrophytes were growing in perennial streams. Excessive submerged macrophyte growth occurs in eutrophic waters, typically in the vicinity of large dairy farms (Rowley River – Nowendoc catchment, Manning River, photos). Azolla was the most common macrophyte (photos)

Score of 2 = moderate distribution 11-20%, score 1 = low distribution 1-10%

- Freshwater catchment average – score 0.8 (Table 14)
- Best catchments – Manning River (score 2.1)
- Worst catchments – Burrell Creek, Lansdowne River (score 0.1) Cattai Creek (score 0)

Odours / Oil-Grease/ Rubbish

- Unpleasant odours were rarely reported but all reports (except one) related to manure. One report of odour of decaying organic matter.
- Oil and grease slicks were rarely seen but noted at a few sites (88-10, 106-01, 86-01, 89-02)

Minimal rubbish was observed in waterways/riparian zone at most sites most likely due to the lack of recent overland flow which delivers gross pollutants to waterways.

Score 3 = low amount of rubbish

- Freshwater catchment average – score 2.8 (Table 14)
- All catchments on average scored between 2.4 – 3.0 except Cattai scored 1.5 (but only 2 sites)

Table 13 Average scores for instream variables, that were included in the assessment of Instream Condition, for each major river/creek catchment

Major catchment	Average of In-channel Habitats	Average of Large Woody Debris	Average of Leaf Litter	Average of Filamentous Green Algae	Average of Macrophytes	Average of Instream Odours	Average of Instream Rubbish	Average of Instream Grease Oil
Avon River	2.3	1.0	1.6	3.5	1.2	1.0	2.6	1
Barnard River	2.0	0.8	0.9	3.4	0.8	0.9	2.9	1
Barrington River	2.7	0.7	0.9	3.3	0.3	0.9	2.8	1
Bowman River	2.0	1.3	1.7	2.6	1.0	0.9	2.7	1
Burrell Creek	3.3	1.0	3.9	4.0	0.1	0.9	2.7	1
Cattai Creek	3.5	4.0	3.0	4.0	0.0	1.0	1.5	1
Cedar Party Creek	3.2	1.4	1.6	3.6	0.4	0.8	2.4	1
Dingo Creek	3.7	1.1	1.2	3.3	0.7	1.0	3.0	0.9
Gloucester River	2.4	0.8	1.1	3.2	1.0	0.9	2.6	1
Lansdowne River	2.3	1.4	2.1	3.3	0.1	1.0	2.6	0.9
Manning River	3.1	1.1	0.9	2.6	2.1	1.0	2.9	0.9
Myall Creek	2.8	1.0	0.8	2.6	0.4	1.0	3.0	1
Nowendoc River	3.3	0.6	0.7	3.0	0.8	1.0	2.9	1
Upper Manning River	2.9	1.0	1.3	3.0	1.1	1.0	2.8	1
Freshwater catchment average	**2.8**	**1.0**	**1.3**	**3.2**	**0.8**	**0.9**	**2.8**	**1.0**

Estuarine catchment

The estuarine portion of the Manning River catchment is much smaller than the freshwater portion. The catchments for Dawson River, Cedar Party Creek and Cattai Creek consist of one EES subcatchment, and the Lansdowne River catchment has two EES subcatchments. Manning River has over 20 EES subcatchments (Map 1) and Rapid Site Assessments were done in 6 of these subcatchments. Average scores (Overall Condition, Land Use, Instream Condition and Riparian Condition) for each major river/creek catchment in the estuary are shown in Table 15.

Scores and grades for each estuarine site are shown in Table A4-2 and in Maps A4-1 – A4-4 There was less variability in scores for estuarine sites within each subcatchment possibly due the smaller catchment size.

Table 14 Average scores for Overall Condition, Land Use Pressure, Instream Condition and Riparian Condition for each major river/creek catchment (number of subcatchments and sites assessed shown - #SC, #sites)

Major River Creek Catchment (#SC, # sites)	Average Overall Condition score (max 69)	Average Land Use Pressure score (max 11)	Average Instream Condition score (max 23)	Average Riparian Condition score (max 35)
Dawson River (1, 3)	39	9	14	15
Manning River (6, 18)	33	7	13	13
Lansdowne River (2, 6)	29	5	11	12
Cedar Party Creek (1,1)	28	8	13	7
Cattai Creek (1, 3)	27	7	10	10
Estuarine Catchment Average	**32**	**6**	**13**	**13**

Overall Condition Scores

The Overall Condition score is the sum of scores for Land Use Pressure, Instream Condition and Riparian Condition for each major river/creek catchment in the estuary (Table 15). Thus Overall Condition scores have a 'pressure' component with ~16% weighting in the score. Instream Condition scores have 33% weighting in the Overall Condition scores while Riparian Condition is the major component with 51% weighting in the score. for each estuarine site are shown in Table A4-2 and ranged from 19/69 (*Poor*, site 223-03) to 42/69 (*Good*, sites 103-01 and 200-02). Most Overall Condition scores for estuarine sites were graded as *Fair* condition (Score 28 – 41).

- Estuarine catchment average – Score 32 (max 69, Table 15)
- Best catchments – Dawson River (score 39), Manning River (score 33)
- Worst catchments – Lansdowne River (score 29), Cattai Creek (only 1 site = score 27, Cedar Party Creek (only 1 site = score 27)

Average scores for Land Use Pressure, Riparian Condition and Instream Condition for each major river/creek catchment in the estuary are summarised in the following sections along with subcatchment averages.

Land Use Pressure

The Land Use Pressure attribute included land use type (max 5 points), stock impact (max 4 points) and irrigation/fertilisation of adjacent pastures (1 point each). Higher scores were assigned to land use that has lower impact (i.e., less pressure) on waterway health, for example conservation/forested areas scored '5' while dairy farms scored '1' (Appendix 2).

Scores for Land Use Pressure at the site were assigned grades as shown in Table A4-2 and Map A4-2 (Appendix 4). Most estuarine sites were graded as either *Fair* (Score 5-6) or *Excellent* (Score 9-11) for Land Use Pressure (Table A4-1). Land Use Pressure scores at estuarine sites ranged from 4 - 11 (Table A4-2).

Land Use Pressure score

- Estuarine catchment average – score 6/11 (Table 15)
- Best catchment – Dawson River (score 9)
- Worst catchment – Lansdowne River (score 5)

Land use type

Grazing was the dominant land use at sites surveyed in the estuarine catchment (42%) followed by rural residential land use (23%). Other land use types are shown below. The preliminary estuary risk map pointed to subcatchments with primarily agricultural land use as posing the highest risk to estuary health. Sites with grazing and more intensive land use were thus targeted in the Rapid Site Assessments.

- Grazing = 13/31 sites
- Rural residential = 7/31 sites
- Urban = 5/31 sites
- Dairy = 3/31 sites
- Conservation Area/Forest = 3/31 sites

Stock Impact

Cattle farms are widespread throughout the Manning estuary and stock frequently have access to riverbanks. Stock seek shade in, and graze on, riparian vegetation, trampling soft banks. Stock access to the riparian zone leads to poor bank structure, reduced vegetation and poor water quality. Scoring applied to stock impact at estuarine sites was the same as freshwater sites (Table 4).

Stock access to riverbanks was noted frequently during a boat survey of the river/estuary on 27/8/19 (Photographs 106, 107, 112, 121, 122, 124). Stock access to riverbanks was observed far less frequently at estuarine sites surveyed in the Rapid Site Assessments. This result is due to sites being located on Crown Land, and/or situated in a wide range of land uses including urban, rural residential and forested areas. Average stock impact scores for sites in each estuarine subcatchment are shown in Table 16.

Table 15 Average scores for stock impact for each estuarine subcatchment (# sites shown). Note higher scores were assigned for less impact.

Catchment	Subcatchment (# sites)	Average of stock impact score
Cattai Creek	SC 93 (3)	2.7
Cedar Party Creek	SC 95 (1)	4.0
Dawson River	SC 103 (3)	4.0
Lansdowne River	SC 223 (3)	2.3
	SC 88 (3)	3.7
Manning River	SC 200 (3)	4.0
	SC 205 (4)	3.5
	SC 210 (3)	4.0
	SC 220 (3)	3.7
	SC 222 (2)	4.0
	SC 224 (3)	4.0
Estuarine catchment average		**3.6**

- Estuarine catchment average – score 3.6
- Best catchments – Six subcatchments scored 4.0 with no evidence of stock accessing the riparian zone however these were predominantly urban or forested subcatchments (200 – Harrington, 224 – Taree, 103 – Dawson River), 95 – Cedar Party Creek (1 site only), 210 – Oxley Isl. and 222 – Bohnock
- Worst catchments – score 2.3 (223 – Ghinni)

Irrigation/Fertilisation of pastures

There was no evidence of irrigation of adjacent pastures/crops at any estuarine sites in the Rapid Site Assessments. Approximately 30% of adjacent land use was deemed to be fertilised (10/31).

Riparian Condition

Estuarine catchments scored poorly for Riparian Condition. Riparian Condition scores for sites ranged from 9 to 15 from a possible 35 with the majority rated as in *Poor* or *Fair* condition (Table A4-2). Poor scores were primarily the result of sparse distribution and/or narrow band width of riparian vegetation, with native grasses/sedges scoring the lowest.

Scores assigned to attributes of riparian zone in estuarine assessments are shown in Table 17. Average scores for riparian zone variables for EES subcatchments are shown in Table 18. Note that data for 95 – Cedar Party is from one estuarine site only (compared to 5 freshwater sites for the same subcatchment).

Saltmarsh

Saltmarsh makes an important contribution to fish lifecycles and water quality. Distribution of saltmarsh identified through the Rapid Site Assessments was very low. Small patches of saltmarsh were noted at 4 of the 31 sites assessed in the Manning estuary (EES subcatchments 200 – Harrington, 205 – Jones Is., 210 – Oxley Is., 220 – South Taree, 88 – Lansdowne.

Sporobolus (saltwater couch), *Suaeda*, *Tetragonia (*warrigal greens) and *Juncus* (sea rush) were the saltmarsh species noted in site assessments.

Percent of shoreline consisting of saltmarsh

Score 1 = 1-25% of shoreline consisting of saltmarsh

- Estuarine catchment average – score 0.2 (Table 18)
- Best saltmarsh cover was found in subcatchment 200 – Harrington (score 0.7)
- Saltmarsh were not observed at sites assessed in subcatchments 103 – Dawson River), 222 – Bohnock), 224 – Taree, 223 – Ghinni, 93 – Cattai and 95 – Cedar Party

Mapping of wetland communities in MidCoast Council LGA was recently undertaken in by ELA (ELA 2019). Coastal saltmarsh has patchy distribution throughout the Manning Estuary however sites surveyed by Rapid Site Assessment were generally in areas without saltmarsh (see Map 9).

Mangroves

Mangroves play an important role stabilising shorelines, recycling nutrients and reducing sediment inputs and turbidity. They are critical habitat for many fish species. Mangroves are widely distributed throughout the Manning estuary however continuity along the shoreline can be sparse and the band width rarely exceeded 10m.

Percent of shoreline consisting of mangroves

Score 2 = 26-50% of shoreline consisting of mangroves, score 1 = 1-25%

- Estuarine catchment average – score 1.8 (Table 18)
- Best subcatchments - 224 – Taree (score 3.0) and 88 – Lansdowne (score 2.7)
- Worst subcatchments - 210 – Oxley Isl. (score 1.0), 220 – South Taree (score 1.0), 95 – Cedar Party (score 0)

Width of mangroves

Score 1 = <2 m width of continuous mangrove cover from shoreline, score 2 = 2-6 m width, score 3 = 6-10 m width

- Estuarine catchment average – score 1.5 (Table 17)

- Best subcatchments - 205 – Jones Is. (score 2.5) and 222 – Bohnock (score 2.5)
- Worst subcatchments - 200 – Harrington (score 1.0), 223 – Ghinni (score 1.0), 95 – Cedar Party (score 0)

Native Trees/Shrubs

Mangroves (*Avicennia marina*) and *Casuarina* were the dominant native tree species in the estuary. *Eucalyptus, Banksia* and lilli pilly were also present. Native shrubs were not common.

Percent of shoreline consisting of native trees/shrubs

Score 2 = 26-50 % percent of shoreline consisting of native trees/shrubs, score 3 = 50-75%

- Estuarine catchment average – score 2.7 (Table 18)
- Best subcatchments - 103 – Dawson River (score 4.0), 205 – Jones Is. (score 3.5), 222 – Bohnock (score 3.5)
- Worst subcatchments - 93 – Cattai (score 1.7); 200 – Harrington, 210 – Oxley Is., 220 – South Taree, 95 – Cedar Party (score 2)

Width of native trees/shrubs

Score 2 = 2-6 m width of continuous native trees/shrubs cover from shoreline, score 3 = 6-10 m width, score 4 = 11-20 m width, score 5 = >20 m width

- Estuarine catchment average – score 2.7
- Worst subcatchments – 210 – Oxley Isl. (score 1.7); 200 - Harrington, 88 – Lansdowne, 93 – Cattai (score 2.0)
- Best subcatchments – 103 – Dawson River (score 4.3)

Native Groundcover/Grasses/Sedges

Native groundcover including grasses/sedges were sparse at most estuarine sites. *Lomandra* was the most common species. *Phragmites* and saltmarsh species were occasionally present.

Percent of shoreline consisting of native groundcover/grasses/sedges

Score 1 = 1-25 % percent of shoreline consisting of native groundcover/grasses/sedges, score 2 = 26-50 %

- Estuarine catchment average – score 0.8 (Table 18)
- Best subcatchments – 103 – Dawson River (score 1.7), 93 – Cattai (score 1.7)
- Worst subcatchments - 224 – Taree (score 0.3); 222 – Bohnock, 223 – Ghinni, 95 – Cedar Party (score 0)

Width of shoreline consisting of native groundcover/grasses/sedges

Score 1 = <2 m width of continuous native trees/shrubs cover from shoreline

Score 2 = 2-6 m

- Estuarine catchment average - score 0.9 (Table 18)
- Best subcatchment - 88 – Lansdowne (score 2.3)
- Worst subcatchments - 223 – Ghinni (score 0), 222 – Bohnock (score 0) and 95 - Cedar Party (score 0)

Exotic Vegetation

Introduced vegetation was scored as per other vegetation types because any riparian vegetation (native or not) is likely to have benefits for riparian and bank condition, and stream health (there are exceptions of course e.g. willows). Higher scores mean high percentage of introduced vegetation on shoreline.

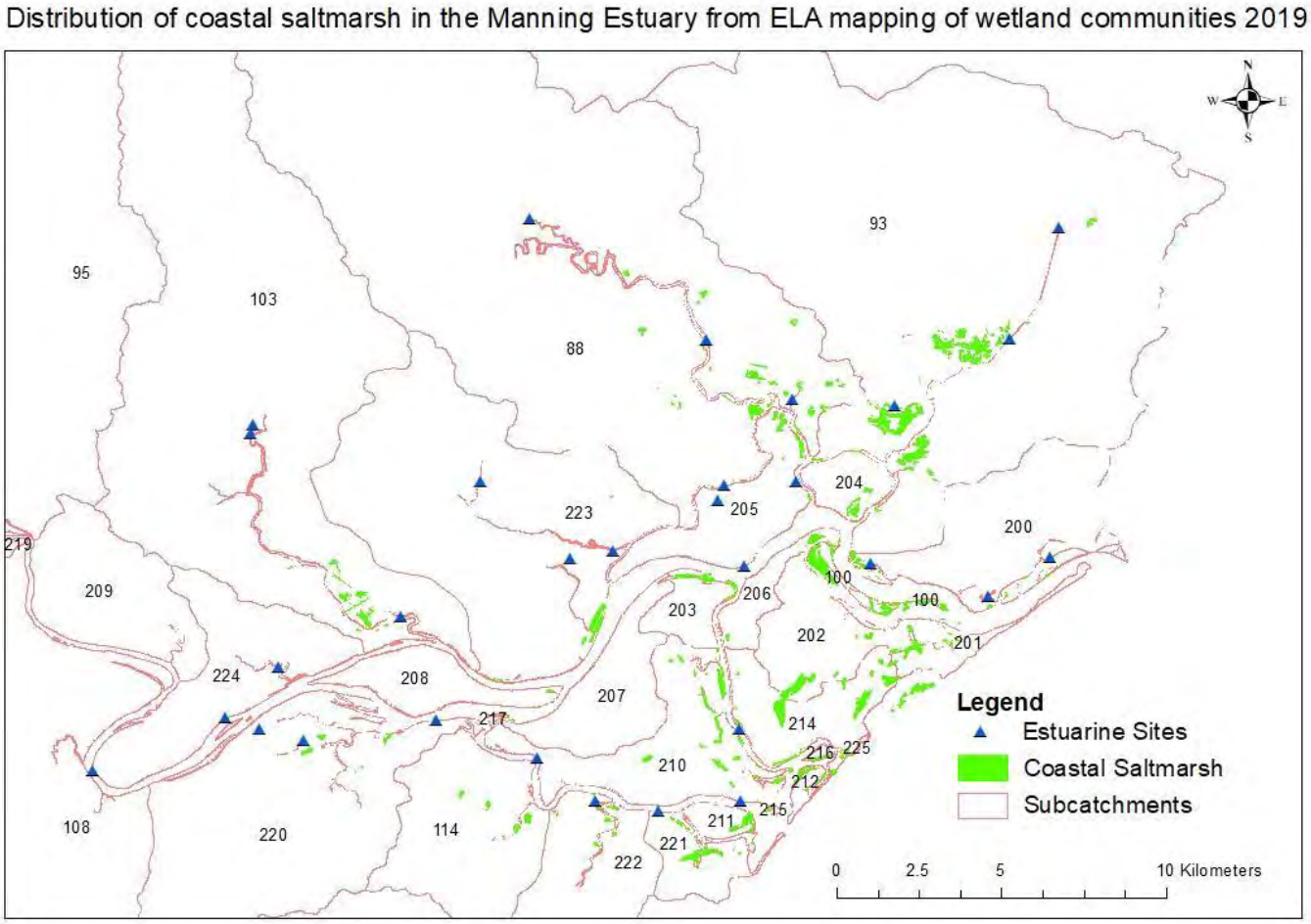
Most subcatchments scored 2.0 or above meaning that 26-50% of shoreline consisted of exotic species.

Lantana and pasture grasses were the dominant exotic vegetation in the estuary. Other weeds noted at estuarine sites were privet, camphor laurel, coastal morning glory, ground asparagus, tobacco tree and Madeira vine.

Percent of shoreline consisting of exotic vegetation

Score 2 = 26-50 % percent of shoreline consisting of native groundcover/grasses/sedges, score 3 = 51-75 %

- Estuarine catchment average – score 2.0 (Table 18)
- Subcatchment with the least exotic vegetation - 103 – Dawson River (score 0.3).
- Subcatchments with the most exotic vegetation - 210 – Oxley Is., 220 – South Taree, 93 – Cattai (score 2.7)



Map 3 ELA mapping of wetland communities in the Manning River Estuary (ELA 2019)

Instream condition

Instream Condition score for estuarine sites includes water quality (turbidity, chlorophyll-a, pH), macrophytes (macroalgae, seagrass) and rubbish, grease/oil (Table 19). Scores for Instream Condition ranged from 6 to 16 (out of 23) with grades from *Poor* to *Good* condition.

Water Quality

Turbidity and chlorophyll-a are used as indicators of estuary health in state-wide monitoring of estuaries and internationally (OEH 2016b). Turbidity and chlorophyll-a concentrations typically increase after rainfall as surface runoff delivers sediment and nutrients to waterways. Water quality recorded in main channels of the estuary /rivers during the Rapid Site Assessments could therefore be considered as 'best case scenario' due to lack of recent inputs from rainfall.

Turbidity

High turbidity leads to reduced light for algae and macrophytes and smothering of organisms. Scoring of turbidity was based on the NSW Trigger Value for turbidity of 3 NTU (Rivers, Salinity > 25ppt; OEH unpublished*).

Score 4 = turbidity<1 NTU, score 3 = turbidity 1-3 NTU, score 2 = turbidity 3.1 - 6.5, score 1= turbidity > 6.5

- Estuarine catchment average – score 2.5 (Table 19)
- Best subcatchments - 220 – South Taree (score 3.5), 103 – Dawson River (score 3.3)
- Worst subcatchments – 222 – Bohnock (score 1.5), 205 – Jones Is. (score 1.8).

Note that very high turbidity was recorded at two sites in 205 during windy conditions. This result shows that the estuary acts as a sediment 'sink' - sediment that has settled on the riverbed is easily resuspended during windy conditions (Manning River at Croki, turbidity > 100 NTU).

Chlorophyll-a

Chlorophyll-a concentrations are a proxy for the abundance of microalgae in the water column. High chlorophyll-a concentrations indicate high nutrient inputs as microalgae grow in response to dissolved inorganic nutrients (nitrate, ammonium and phosphates). Scoring of chlorophyll-a was based on the NSW Trigger Values for chlorophyll of 2.7 µg/L (Rivers, Salinity > 25ppt; OEH unpublished*).

Score 4 (<1 µg/L chl-a), score 3 (1-2.7 µg/L chl-a), score 2 (2.8-3.9 µg/L chl-a), score 1 (>4 µg/L chl-a).

- Estuarine catchment average – score 2.6 (Table 19)
- Worst subcatchments - 205 – Jones Is. (score 1.5), 93 – Cattai (score 1.7)
- Best subcatchments – 200 – Harrington (score 4), 223 – Ghinni (score 3.5)

Note that grab samples were not collected for chlorophyll-a analyses due to the cost limitations. Chlorophyll-a concentrations were taken from a water quality probe using fluorometry which is less accurate than analysing chlorophyll-a in grab samples. Nevertheless, data from the probe provides a reasonable estimate of chlorophyll-a concentrations when there is minimal interference from colour in the water column from dissolved organic matter (fDOM).

fDOM concentrations were high at some sites which would have led to an overestimation of chlorophyll-a concentrations in estuary water however, in these instances, chlorophyll-a reading was very high (>20 µg/L) but the likely 'true' concentration of chlorophyll-a would still be high

(>10 µg/L). The overestimation of chlorophyll-a at some sites due to the interference of colour had no bearing on scores assigned for chlorophyll-a, as the lowest score of '1' was assigned if chlorophyll-a exceeded 4 µg/L.

pH

Scoring of water quality included pH due to widespread acid sulphate soils (ASS) in the Manning floodplain. Acidic runoff has the potential to impact on the ecology of the estuary and assets such as oyster farms. Scoring of pH was based on the NSW Trigger Values for pH (upper limit) 8.5 and (lower limit) 7.5 (Rivers, Salinity > 25ppt, OEH unpublished*).

Score 4 (pH>7), score 3 (pH 6-7), score 1 (pH<6)

- Subcatchments impacted by acid runoff = 93 (Cattai Creek, score 1), 88 (Lansdowne, score 2.7, Table 19)

Macroalgae and seagrass

Macroalgae and seagrass provide food, shelter and oxygen for organisms in the estuary. Seagrass beds reduce turbidity by trapping suspended sediments and stabilising the riverbed, reducing resuspension of sediments to the water column.

A small amount of macroalgae was seen at two sites in 200 – Harrington and seagrass/wrack (dead leaves) were noted at one site in 200 – Harrington (Table 19). These were the only observations of macroalgae /seagrass/wrack at estuarine sites assessed, contributing to the low scores for instream condition of estuarine sites (potential 6 points).

Seagrass does occur throughout the Manning Estuary however sampling sites were not located in these areas. EES have been monitoring seagrass distributions in the estuary since 2015. In 2018/19, seagrass distributions increased in the lower estuary near Harrington but had disappeared from one location in the mid-estuary at Taree (MidCoast Council's Waterways Report Card). The increase in seagrass distribution in the lower estuary is likely to be due lower turbidity during the drought and thus more light for growth. The cause for the decline in seagrass in the mid-estuary is not known but may be linked to changes in salinity and temperature as a result of the drought.

Rubbish and Grease/Oil

Rainfall delivers gross pollutants (rubbish) and organic pollutants (grease/oil) from roads etc. No rubbish was recorded at over half of the estuarine sites during the assessments. Only one site scored the lowest score of 1 (Dawson Cemetery). Grease/oil was observed at two creeks in 88 – Lansdowne (Table 19).

** NSW Trigger Values were revised in 2018 and differ slightly to those in OEH 2016b. The revised trigger values have been recommended to be used for NSW estuaries in the revision of ANZECC guidelines to be published later this year*

Table 16 Scores assigned to riparian zone variables used in the assessment of Riparian Condition at estuarine sites

Scoring of riparian vegetation attributes					
% of the shoreline consisting of native trees and shrubs? Same question and scoring for mangroves, native grasses/sedges, exotic vegetation	None (0 %)	0	Width of continuous tree and/or shrub cover (m)? Same question/scoring for mangroves, native grasses/sedges	<= 2m	1
	Low (1 - 25 %)	1		3-5m	2
	Moderate (26 - 50 %)	2		6-10m	3
	High (51-75 %)	3		11-20m	4
	Very High (> 75 %)	4		>20m	5

Table 17 Average scores for Riparian Condition (Grade, Yellow=*Fair*, Orange=*Poor*) and riparian zone variables for estuarine subcatchments

Catchment (subcatchment)	Average Riparian Condition score max 35 (grade)	Average of percent saltmarsh score	Average of percent mangrove score	Average mangrove width score	Average of percent native trees shrub score	Average of native tree shrub width score	Average of percent native ground cover score	Average of native ground cover width score	Average of percent exotic veg score
Dawson River (103)	**15**	0	2.3	1.7	4.0	4.3	1.7	1	0.3
Manning (205)	**15**	0.3	2.5	2.5	3.5	2.8	1	1	2.5
Lansdowne (88)	**15**	0.3	2.7	2	3	2	1	2.3	1.3
Manning (224)	**14**	0	3	2	3.3	3.3	0.3	0.3	2
Manning (220)	**13**	0.3	1	1.3	2	3.3	0.7	1.3	2.7
Manning (222)	**13**	0	2.5	2.5	3.5	3	0	0	1.5
Manning (200)	**11**	0.7	1.3	1	2	2	0.7	1	2.3
Manning (210)	**10**	0.3	1	1.3	2	1.7	0.7	0.7	2.7
Cattai Creek (93)	**10**	0	0.7	0.3	1.7	2	1.7	1	2.7
Lansdowne (223)	**9**	0	1.3	1	2.7	2.3	0	0	2
Cedar Party (95)	**7**	0	0	0	2	3	0	0	2
Estuarine catchment average		**0.2**	**1.8**	**1.5**	**2.7**	**2.7**	**0.8**	**0.9**	**2.0**

Table 18 Average scores for Instream Condition (Grade, Green = *Good*, Yellow = *Fair*) and instream variables for estuarine subcatchments

Catchment (subcatchment)	Average Instream condition max 23 (grade)	Average pH score	Average Turbidity score	Average Chlorophyll-a score	Average Macroalgae present score	Average Seagrass/ wrack score	Average Instream Rubbish score	Average Instream Grease Oil score
Manning (200)	**17**	4	2.7	4	0.7	0.3	4	1
Manning (210)	**15**	4	3	3	0	0	3.7	1
Dawson River (103)	**14**	4	3.3	3.3	0	0	2.7	1
Manning (222)	**14**	4	1.5	3	0	0	4	1
Manning (224)	**13**	3.7	3	2.7	0.3	0	2.7	1
Lansdowne (223)	**13**	3.5	2	3.5	0	0	4	1
Cedar Party (95)	**13**	3	3	2	0	0	4	1
Manning (220)	**12**	4	3.5	2	0	0	3.3	1
Manning (205)	**11**	3.3	1.8	1.5	0	0	3	1
Lansdowne (88)	**10**	2.7	2	2	0	0	3	0.3
Cattai Creek (93)	**10**	1	2.3	1.7	0	0	4	1
Estuarine catchment average	**13**	**3.3**	**2.5**	**2.6**	**0.1**	**0.0**	**3.4**	**0.9**

Subcatchment /site scale analysis - Nowendoc catchment

Field data collected in Rapid Site Assessments can be interrogated at different scales - the whole river catchment, EES subcatchment as well as the site scale (spreadsheet of all responses to every question in RSA from each site has been provided to Council). A selection of scores from the Rapid Site Assessments in the Nowendoc River catchment are presented in Table 20 – 22 to illustrate the variation in scores at site and subcatchment scales.

Overall Condition

In subcatchment 64, Overall Condition scores ranged from *Poor* (score 46), *Fair* (score 53) to *Good* (scores 77, 87, and 90; Table 19). All sites in subcatchment 85 were rated in *Good* condition and 5 out of 6 sites in subcatchment 74 were rated in *Good* condition.

Table 19 Overall Condition scores for all sites assessed in 5 EES subcatchments of the Nowendoc River catchment, grade indicated (Green = *Good*, Yellow = *Fair*, Orange = *Poor*).

Overall Condition score	EES subcatchments In Nowendoc River catchment				
	64	66	74	80	85
46	1				
47		1			
53	1				
55				1	
57			1		
64				1	
67				1	
72		1			
74		1			
75		1			
76			1		
77	1				
78				1	1
83		1			
85			1		
87	1		2		
88		1			
89			1		
90	1				
93					1
97					1
Sites per subcatchment	**5**	**6**	**6**	**4**	**3**

Stock Impact

Table 21 shows the scores for 'impact of livestock on riparian zone' assigned to each site assessed in EES subcatchments of the Nowendoc River catchment. In subcatchment 64 for example, 3 sites scored '1' and one site each scored '2' or '3' for stock impact. Stock impact was highest in subcatchment 64 as 3 sites scored 1, indicating that stock are consistently accessing the riparian zone and streams (Table 21). Stock impact in subcatchments 66 and 80 was also high with 3 sites scoring 2 (many tracks, heavily grazed, no understory, Table 21).

Table 20 Scores and descriptions for attribute 'Impact of livestock on riparian zone' showing scores assigned to each site assessed in EES subcatchments in the Nowendoc River catchment.

Impact of livestock on riparian zone	SC64	SC66	SC74	SC80	SC85
1 – Stock consistently accessing waterway, degraded banks, manure present	3	2		1	
2 – Many tracks, heavily grazed or no understory	1	3	1	3	1
3 – Few tracks, grazed groundcover	1	1	3		1
4 – No evidence			2		1
Sites per subcatchment	5	6	6	4	3

Riparian width

Riparian vegetation in the Nowendoc catchment was typically less than 10 metres in width with 14 out of 24 sites receiving 1 point for this variable (Table 22). Two sites in subcatchment 74 had wider bands of riparian vegetation (20-30 m, Table 22).

Table 21 Scores and descriptions for attribute 'riparian width at narrowest point' showing scores assigned to each site assessed in EES subcatchments in the Nowendoc River catchment.

Riparian Width	SC64	SC66	SC74	SC80	SC85
0 – No riparian vegetation	**1**	**1**			
1 – Up to 10m	**3**	**4**	**2**	**4**	**1**
2 – Between 10 – 20m	**1**	**1**	**1**		**2**
3 – Between 20 – 30 m			**2**		
4 – Continuous with bushland			**1**		
Sites per subcatchment	**5**	**6**	**6**	**4**	**3**

Learnings

The Rapid Site Assessment program presented in this report had two objectives. The first objective was to validate spatial layers developed for the Manning catchment which present pressure data (local and modelled) at a subcatchment scale (defined by third order streams). Spatial layers were used to assess the risk of catchment pressures (e.g. diffuse runoff) on the values of the Manning River Estuary (Swanson 2019). Coastal Councils in New South Wales are at different stages of preparing their Coastal Management Programs (CMPs). Detailed risk assessments are often identified as a knowledge gap in the Scoping Study Stage 1 and are recommended for Stage 2 of preparing the CMP. The learnings for this objective shown below may be useful to Councils undertaking detailed risk assessments and ground-truthing programs.

The second objective was to observe the catchment first-hand and present field data to provide a snapshot of condition and threats. This objective was met. The report provides useful information that can be interrogated at a range of scales, informing management decisions to protect the ecological and community values of the system.

With regard to validating spatial layers used in risk assessments, key learnings are as follows.

Program design/site selection

- The Rapid Site Assessments presented in this report were undertaken over a 5-week period by two teams of 2 staff. The sampling strategy was to assess a small number of sites in many subcatchments. Over 200 sites were assessed across the catchment of the Manning River Estuary however, it became obvious during the assessment and data analysis that not enough sites were assessed in each subcatchment to fully validate (ground-truth) spatial layers used in risk assessments (see RISK ASSESSMENT report for further details, Swanson 2019). This was primarily due to the high variability in the condition of sites within subcatchments.
- A greater investment of time is required for the ground-truthing program to allow sufficient number of sites in each subcatchment to be assessed, probably in the order of 10-15 sites per subcatchment, depending on its size.
- Sites in each major land use present in the subcatchment should be included, including forested/ remote areas. Access / navigation is more difficult in remote and forested areas so scheduling needs to account for this. Sites near intensive land use need to be included to capture areas of potentially high impact.
- Sites on Crown Land can be included in the program but sites on private property should also be included in the assessment through discussions with landowners. Engaging with landowners is a time-consuming exercise and future programs should factor this into their project timelines.

Rapid Site Assessments

- The Geomorphic Condition and Instream Condition assessment should be interpreted with caution as some of the variables assessed are strongly related to a site's elevation, position in the catchment hierarchy and/or stream order. In these assessments, the same scoring was used for all sites without consideration of the site's elevation, position in the catchment hierarchy or stream order. Future assessments including geomorphic condition and habitat characteristics for instream condition should stratify sites into groupings of stream order for sampling and analysis, in order to reach more informative conclusions from the assessment.

- Geomorphic Condition as defined in the River Styles Framework describes the extent to which the river / stream has been altered relative to reference condition (Brierley and Fryirs 2005). Thus, inclusion of Geomorphic Condition in site assessments requires appropriate reference sites be included to score sites against. This approach requires accurate assessments of all substrate categories through measurement rather than estimation, to give one example of the extra time required for this type of assessment. As such, inclusion of Geomorphic Condition in Rapid Site Assessments may not be desirable as it is difficult to do properly with a rapid method.
- If additional resources and/or expertise are available Geomorphic Condition could be included in the Rapid Site Assessment. Variables for the attribute Geomorphic Condition to be included in the survey should be reviewed. There a different versions of survey questions and choices available that describe the state or condition of the variable being assessed.
- If both estuarine and freshwater sites are being assessed in Rapid Site Assessments, survey questions and scoring should be reviewed for better alignment of the assessments in the different systems. For example, the same attributes should be assessed at both freshwater and estuarine site where possible and appropriate. Similar scoring should be applied to equivalent variables so that weightings of individual attribute scores in the Overall Condition score are similar.

Freshwater site assessments

- The River Styles Framework is a tool used to characterise geomorphology, which provides baseline information and understanding of river forms, processes, evolution, condition and trajectory. The spatial layer has 3 main primary layers, being River Style, Geomorphic Condition, and Recovery Potential. A further derivative layer is developed to reflect the fragility of each style (NSW Office of Water 2012). River Style examines the pattern and connectivity of reaches of different River Style within the context of catchment-scale controls. Geomorphic condition describes the extent to which the river has been altered relative to reference condition for the given style. Recovery Potential describes the timeframes and trajectories for recovery. Fragility describes the sensitivity to disturbance for each style.
- The primary reason for including geomorphology in the site assessments was to collect field data to ground-truth the fragility spatial layer that was included in the erosion risk assessment (Swanson 2019). The majority of the streams in the Manning River catchment were rated as moderate fragility in the River Styles assessment and over 90% of streams surveyed by Rapid Site Assessment were classed as moderate fragility. If fragility is included in erosion risk assessments in the future, site selection should take into account the fragility rating of the stream/site in the River Styles assessment and ensure a representative number of streams classed as low and high Fragility are included in the surveys.

Estuarine site assessments

- Geomorphic Condition was not included in the estuarine Rapid Site Assessment as the spatial layer of stream fragility that required ground-truthing with field data (fragility layer from River Styles assessment) only included freshwater streams not estuarine waterways. However, given that bank erosion is a significant pressure on water quality in the Manning Estuary, in retrospect, bank condition/structure should have been included. In future, the attribute Geomorphic Condition should be included in Rapid Site Assessments for estuarine sites.

- A small number of estuarine Rapid Site Assessments were done from the water and additional observations of estuarine subcatchments from the water proved to be a valuable exercise. Future ground-truthing programs should include Rapid Site Assessments in the catchment as well as surveys of the shoreline from the water, if possible and if relevant to the system being assessed.

Literature Cited

ANZECC & ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra

BMT WBM (2017) *NSW Marine Estate Statewide Threat and Risk Assessment*, Marine Estate Management Authority, NSW Government.

Brierley, G. and Fryirs, K. 2005. Geomorphology and River Management: Applications of the River Styles Framework. Blackwell Publishing, Melbourne.

Chittleborough, D.J. 1983. The nutrient load in surface waters as influenced by land use patterns. In: The effects of change in land use upon water resources. Ed. J.W. Holmes. Water research Foundation of Australia, Adelaide.

Dela-Cruz J., Kuo W., Floyd J., Littleboy M., Young J., Swanson R., Cowood A., Dawson G. 2019. NSW Estuary Health Risk Dataset. A first pass risk assessment to assist with the prioritisation of catchment management actions. Office of Environment and Heritage, NSW Government, Sydney

ELA 2019. Mapping of wetland communities in the MidCoast LGA.

Glamore, W.C., Ruprecht, J. E. and Rayner, D.S. 2016. Lower Manning River Drainage Remediation Action Plan [Report], WRL Technical Report 2016/01, August 2016, UNSW.

Jansen A., Robertson A., Thompson L. and Wilson, A. 2005. Rapid Appraisal of Riparian Condition Version 2, a River and Riparian Land Management Technical Guideline 4A, published by Land and Water, Canberra.

MEMA 2018. *NSW Marine Estate Management Strategy 2018–2028*, NSW Government.

McDowell R.W. and Wilcock R.J. 2007. Sources of sediment and phosphorous in stream flow of a highly productive dairy farmed catchment, Journal of Environmental Quality. 36: 540-548

MidCoast Council (MCC) 2018. Scoping study: Manning River Estuary - Coastal Management Program December 2018.

MidCoast Council (MCC) 2019. Manning River Catchment and Estuary Management Program. Stage 2: Ground-truthing – Rapid site assessments. March 2019.

Nennich T.D, Harrison J.H., Meyer D., Heinrichs A.J., Weiss W.P., St-Pierre N.R., Kincaid R.L., Davidson D.L. and Block E. 2005. Prediction of manure and nutrient excretion from dairy cattle, Journal of Dairy Science. 88: 3721-3733.

NSW Government 2016. *Coastal Management Act* 2016.

NSW Office of Water 2012. River Styles Spatial Layer for New South Wales. Bioregional Assessment Source Dataset (https://data.bioregionalassessments.gov.au/datastore/dataset/06fb694b-d2f1-4338-ab65-a707c02f11d7)

OEH 2015. Warringah Council Creek Monitoring, Evaluation and Reporting Project - spring 2014 and autumn 2015. Office of Environment and Heritage, Sydney.

OEH 2016a. MidCoast Catchment Monitoring, Evaluation and Reporting Program. Report by Jan Miller, Office of Environment and Heritage. NSW Government, Sydney.

OEH 2016b. Assessing estuary ecosystem health: Sampling, data analysis and reporting protocols, NSW Natural Resources Monitoring, Evaluation and Reporting Program, Office of Environment and Heritage, NSW Government, Sydney.

Schindler DW 2006, Recent advances in the understanding and management of eutrophication, Limnology and Oceanography. 51: 356–363.

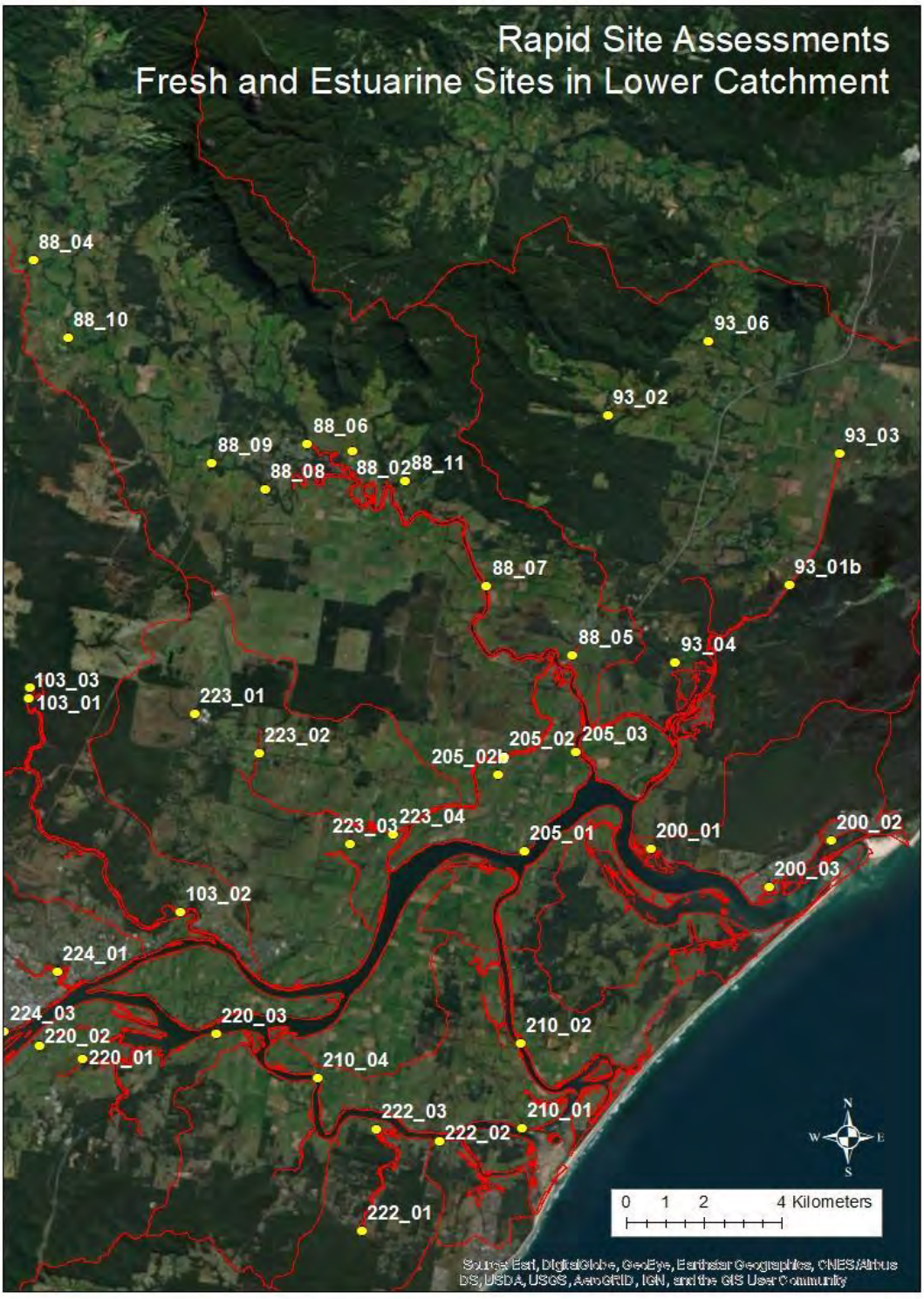
Southeast Engineering and Environmental 2016. Tuross Estuary Water Quality Improvement Plan. Report prepared for Eurobodalla Shire Council.

Swanson 2019 Manning River Estuary and catchment RISK ASSESSMENT – An assessment of risk of catchment pressures on ecological and community values of the estuary. Environment, Energy and Science. NSW Government, Sydney.

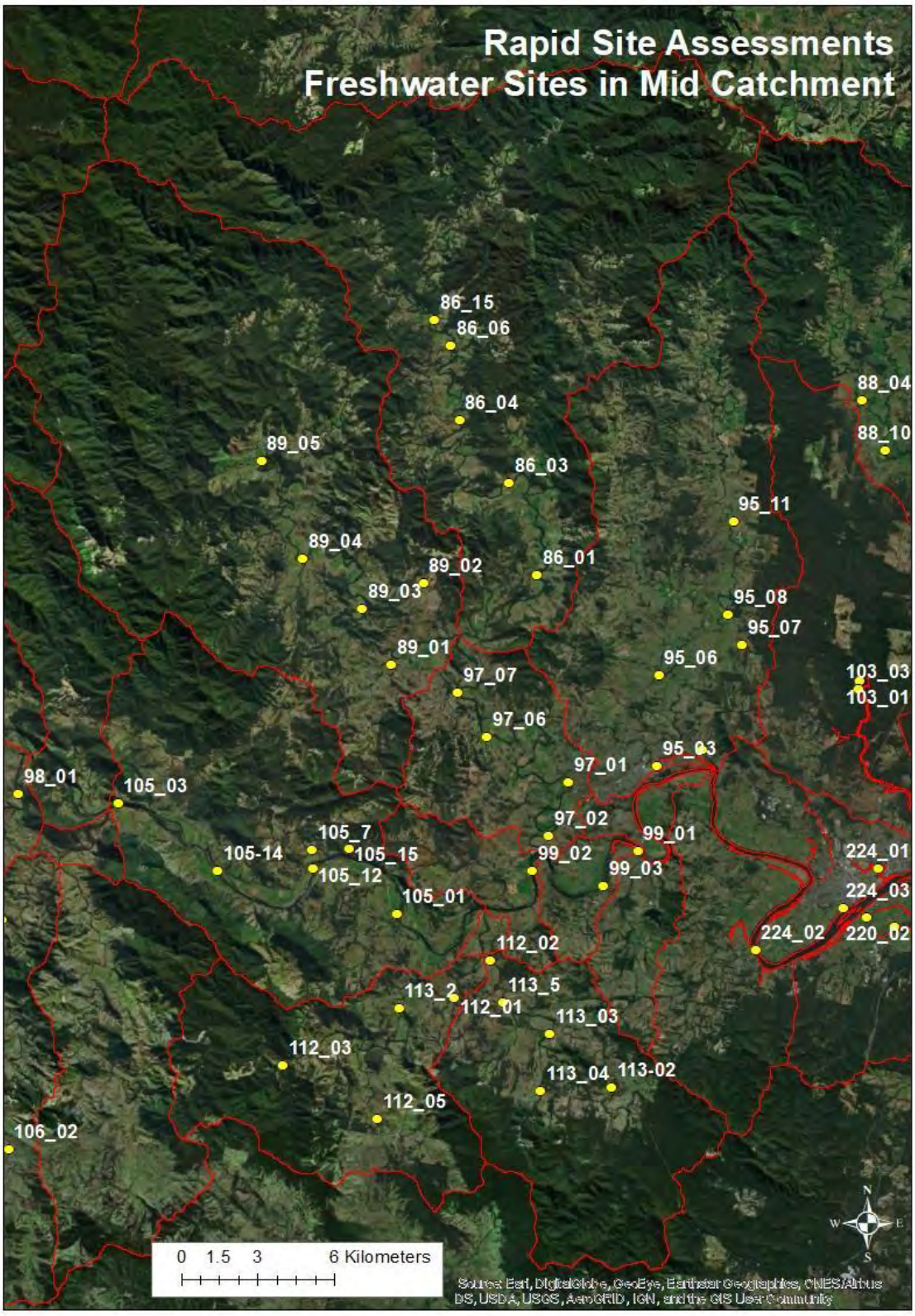
Turak, E., Waddell, N. and Johnstone, G. 2004. *NSW Australian River Assessment System Sampling and Processing Manual 2004,* for Natural Heritage Trust.

WaterNSW 2019 https://realtimedata.waternsw.com.au/water.stm?ppbm=208_MANNING&rs&2&rsvm_org

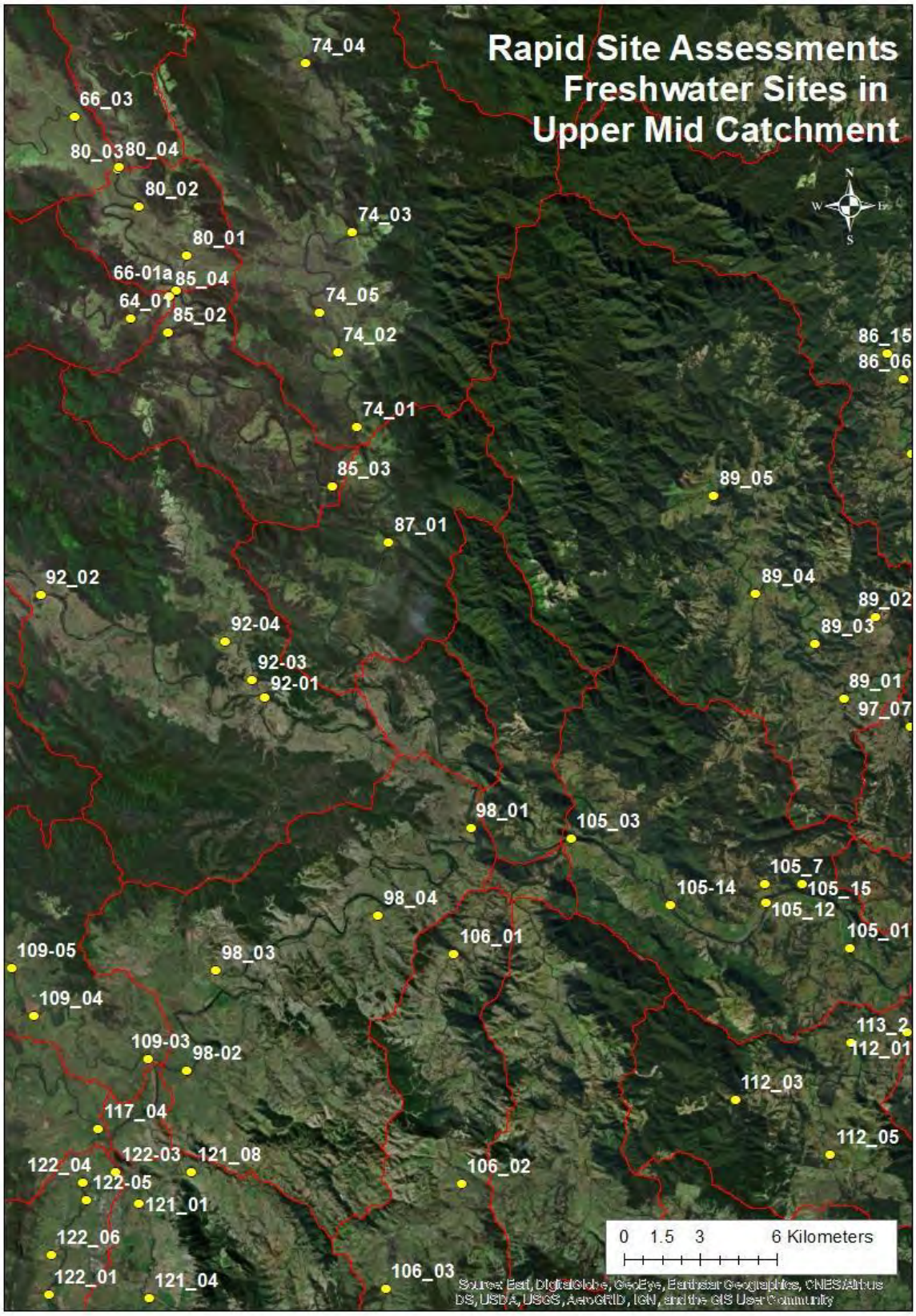
APPENDIX 1 Location maps for all sites



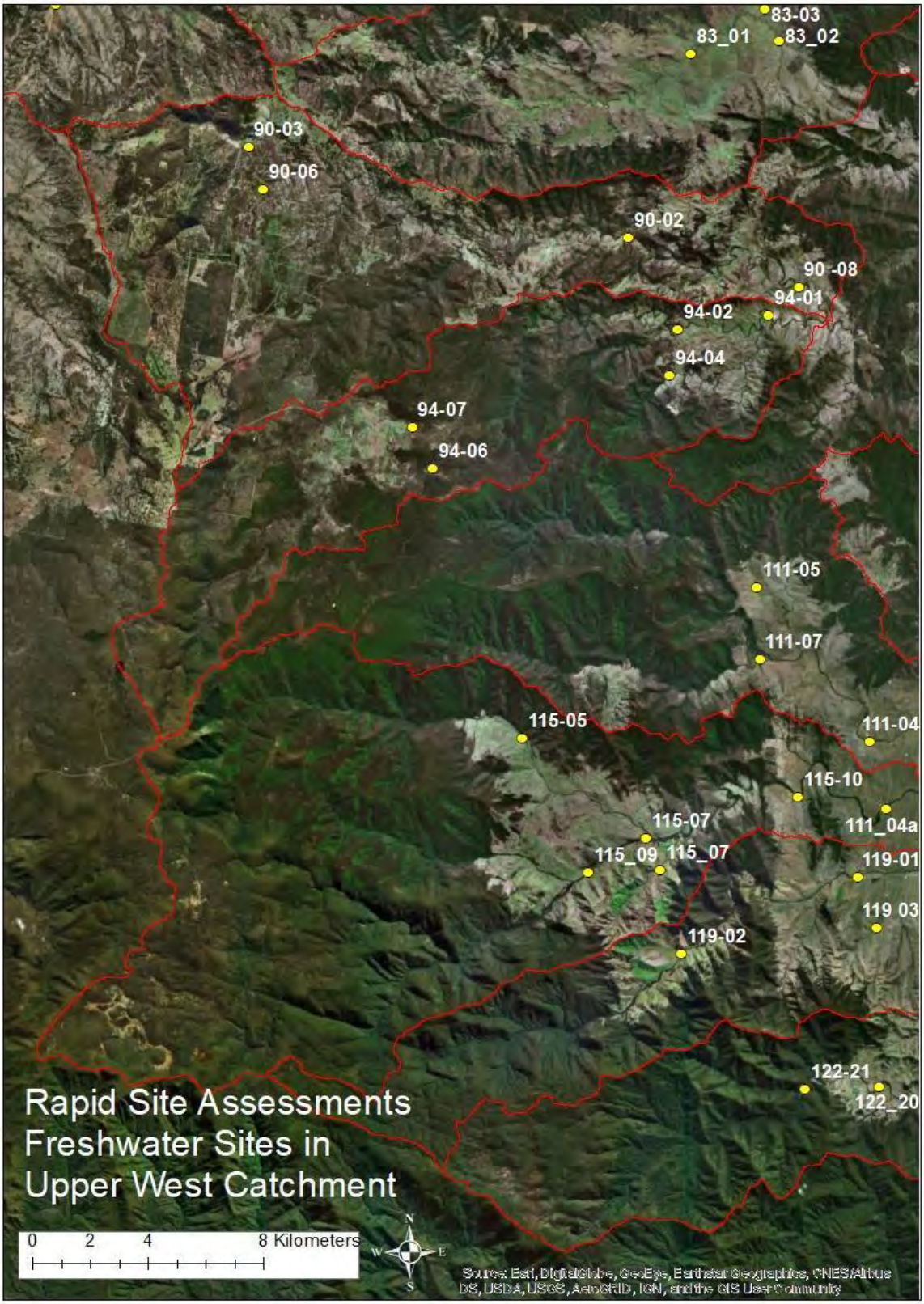
Map A1-1 **Location and site-codes of Rapid Site Assessments in Lansdowne River (subcatchments 88, 223), Cattai Creek (subcatchment 93), Dawson River (subcatchment 103) and Manning River Estuary (all other subcatchments)**



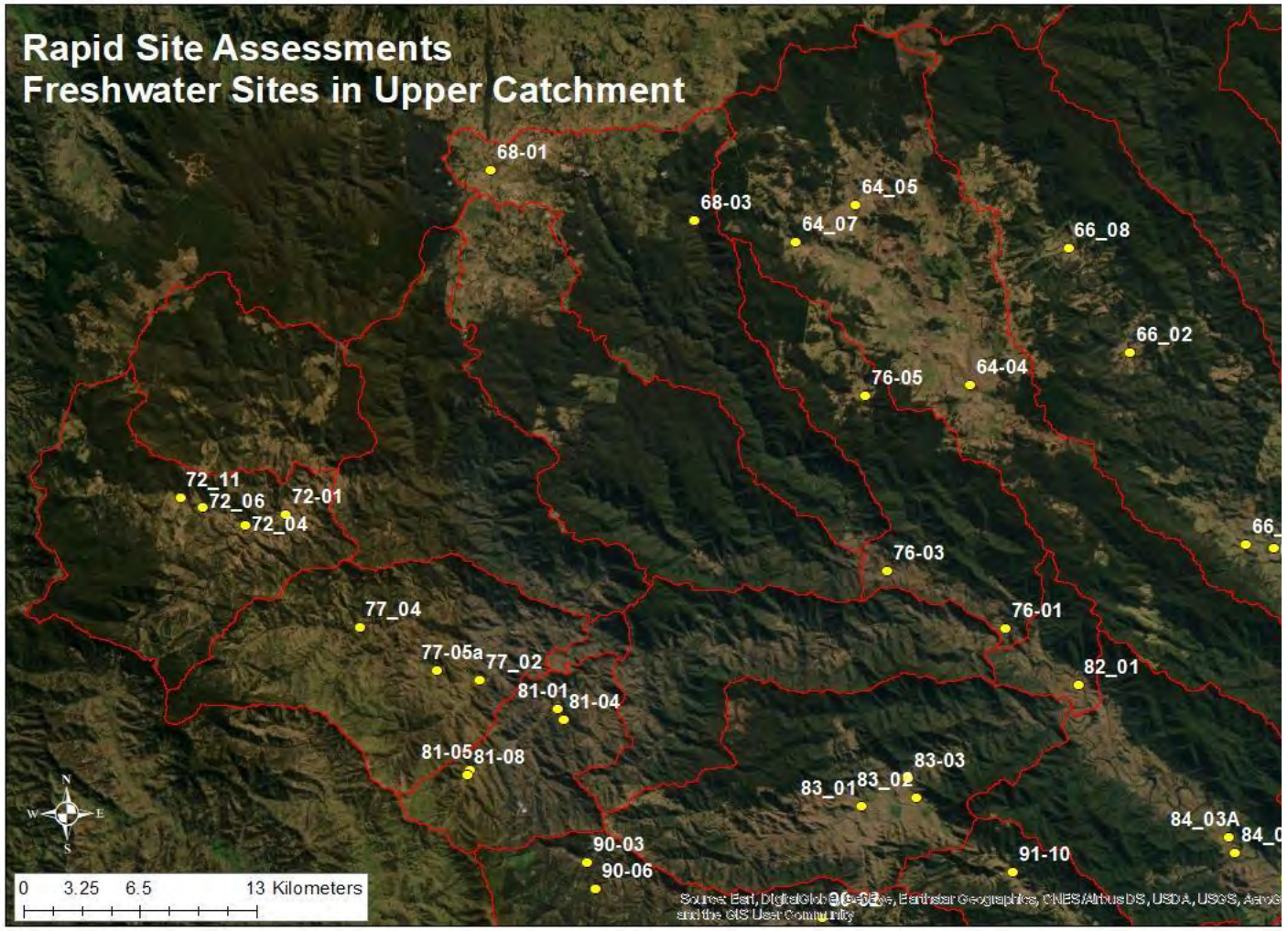
Map A1-2 **Location and site-codes of Rapid Site Assessments in Dingo Creek (subcatchments 86, 89, 97), Cedar Party Creek (subcatchment 95), Burrell Creek (subcatchments 112, 113), Dawson River (subcatchment 103) and Manning River (subcatchments 99, 105)**



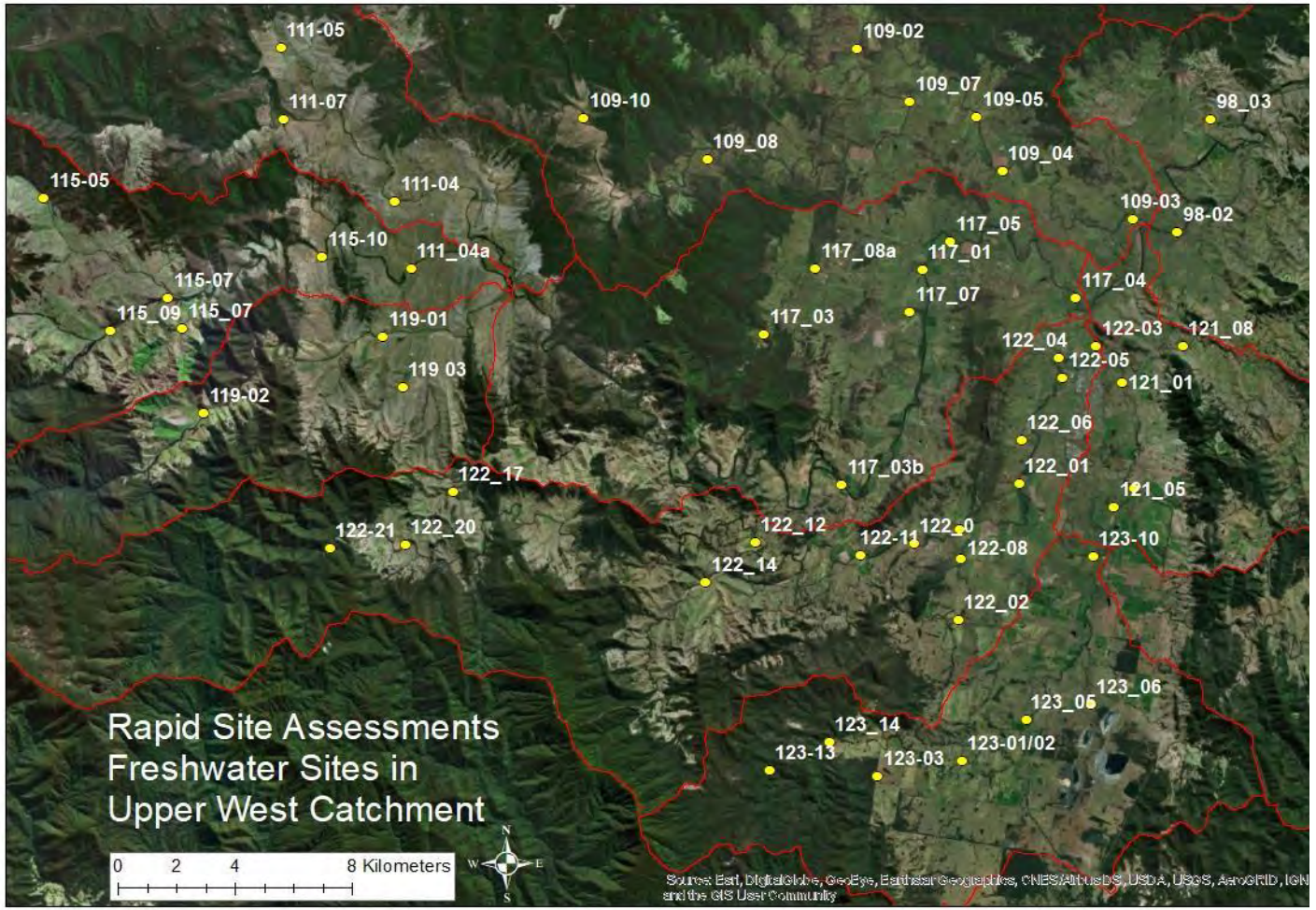
Map A1-3 Location and site-codes of Rapid Site Assessments in lower reaches of Nowendoc River (subcatchments 66, 80, 85, 87) and Upper Manning River (subcatchment 92) and upper reaches of Manning River (subcatchments105, 106)



Map A1-4 **Location and site-codes of Rapid Site Assessments in upper west catchment including Upper Manning River (subcatchments 90, 94), Barrington River (subcatchments 111, 115, 119) and Gloucester River (Subcatchment 122).**



Map A1-5 **Location and site-codes of Rapid Site Assessments in upper north-west catchment including Nowendoc River (subcatchments 64, 66), Myall Creek (subcatchments 68, 76) and Barnard River (subcatchments 72, 77, 81, 82, 83, 84)**



Map A1-6 Location and site-codes of Rapid Site Assessments in upper south-west catchment including Barrington River (subcatchments 111, 115, 119) Gloucester River (122, 98), Bowman River (subcatchment 109) and Avon River (121, 123)

Appendix 2 variables assessed for each attribute, function and how they were measured

Table A2-1 The full list of variables assessed for each attribute, variable function and how they were measured are shown below. The questionnaire used for Rapid Site Assessment is in Appendix 3. Scores assigned to variable descriptions reflecting the level of impact are in Appendix 4.

Attribute variables included in Rapid Site Assessments		
Land Use Pressure (All)	**Effect of pressure**	**What we assessed / measured**
Land use	Modified land use (agricultural, urban, industrial) results in increased peak flows and pollutant exports to receiving waters compared to pristine /unmodified land	Dominant land use in surrounding area
Stock access	In rural areas livestock access to waterways and riparian zones can increase erosion, sedimentation and water pollution	Extent of stock impact assessed based on fencing, pugging, grazing, animal waste evident in riparian zone
Fertiliser use	Increased levels of inorganic nutrients (phosphates, ammonium, nitrates) in waterways can lead to excessive algal and plant growth = eutrophication	Present or absent in surrounding area
Irrigation	Irrigation of pastures, crops can increase export of nutrients and sediment to waterways leading to poor water quality and eutrophication	Present or absent in surrounding area
Geomorphic Condition (Freshwater only)	Function of variable	What we assessed / measured
Bank erosion	Erosion of banks adds sediment to the stream, undercuts the riparian zone and reduces in-stream habitat.	Bank structure, bank undercutting and extent of erosion on both banks
Geomorphology	River-bed substrates, and riffles, runs and pools, provide a variety of habitat for in-stream fauna.	Dominant substrate type/ % cover and presence/type of riffle/run/pool sequences
Sedimentation	An increased sediment load removes in-channel habitat and can increase flooding.	Accumulation of loose sediment / gravel-sand-silt bars in channel
Instream Condition (Freshwater)	Function of variable	What we assessed / measured
Channel habitat	A variety of in-channel habitats will increase aquatic biota. These include tree roots in the water, boulders, undercut banks, riffles and deep pools.	Number of habitat types present
Macrophytes	Macrophytes provide important habitat and food for in-stream fauna.	Macrophytes present and type of macrophyte/s (submerged, floating, emergent) present (% of reach with macrophytes). Note, not all streams will be suitable for macrophytes
Filamentous green algae	Algae are food for many aquatic biota but then can become a problem when blooms occur or filamentous algae growth is dense.	Presence of filamentous green algae (% of reach with filamentous algae)
Large woody debris (LWD)	LWD provides important habitat for in-stream fauna.	Present or absent % of reach with LWD
Leaf litter	A large number of aquatic fauna utilise leaf litter for feeding or refuge.	Present or absent
Instream	Function of variable	What we assessed /

Condition (Estuary)		measured
Macroalgae	Macroalgae provide habitat and food for aquatic biota	% distribution/type
Seagrass	Seagrass beds are important nursery grounds, provide habitat and food for aquatic biota and stabilise sediments	Distribution including wrack (dead leaves)
Instream Condition - Water Quality (All)	Function of variable	What we assessed/ measured
Turbidity	A large amount of sediment in the water affects fish and invertebrate feeding and breathing, and blocks light to macrophytes.	NTU units using a multi-meter
Electrical conductivity	High EC will reduce the habitat availability for many aquatic fauna.	mS/cm using a multi-meter
Dissolved oxygen	Most aquatic biota require oxygen in the water, and habitat availability is reduced when there is low DO.	mg/L and % saturation using a multi-meter
Temperature	High water temperatures affect aquatic biota ability to breathe and feed. Many aquatic macroinvertebrates do not survive in warm water.	Degrees C using a multi-meter
pH	Aquatic biota survive in a range of pH but cannot tolerate very high or low pH or sudden changes in pH.	pH using a multi-meter
Chlorophyll-*a*	Chlorophyll-*a* can be used to measure phytoplankton biomass, which indicates high light and/or nutrient levels.	µg/L by fluorometry using a multi-meter see page 135 for discussion of limitations
fDOM (dissolved organic matter)	Indicates level of dissolved organic matter	By fluorometry using a multi-meter
Rubbish	The presence of rubbish in a channel indicates disturbance, and the potential for water pollution to be present.	How much? Low to High.
Odours	Odour coming from the water indicates pollution, or decomposing organic matter in anoxic conditions	Present or absent
Grease and oil	Indicates pollution from stormwater runoff or industry	Present or absent
Riparian Condition (Freshwater)	Function of variable	What we assessed / measured
Disturbance	Tracks and roads can create direct connection to the stream, allowing sediment incursion. Clearing can increase weed growth.	% of riparian zone disturbed (tracks, erosion, cleared, trampled)
Continuity	Breaks in the riparian zone allow sediment incursion, increased sunlight, loss of food resource and habitat, loss of corridor connectivity.	Percentage of continuous vegetation in reach
Width	A wide riparian zone will work more effectively to reduce sediment and pollutant incursion into the stream and will provide better habitat for fauna.	Width of zone at thinnest point
Canopy layer	Provides shading, allochthonous input, habitat corridor for native fauna, habitat in-stream where roots extend into water, reduces bank erosion.	% cover (shading) of stream
Canopy nativeness/diversity	Native trees in the canopy provide natural food resource for in-stream and terrestrial fauna.	% native or exotic # native species
Shrub layer	Provides habitat, shading, allochthonous food	% cover

	resource, reduces bank erosion.	
Shrub nativeness/diversity	Native shrubs provide natural food resource and habitat for terrestrial fauna.	% native or exotic # native species
Ground cover	Reduces erosion and sedimentation of stream, reduces nutrients entering the stream, provides habitat for terrestrial fauna.	Present or absent % cleared
Ground nativeness/diversity	Native ground cover provides better habitat for native fauna.	% native or exotic # native species
Hollow logs	Provide habitat for native flora/fauna	Present or absent
Tree hollows	Provide habitat for native flora/fauna	Present or absent
Leaf litter	Provides habitat for fauna and invertebrates, reduces erosion, reduces pollutants entering the stream.	Present or absent
Rubbish	The presence of rubbish in a riparian zone indicates disturbance, and the likely presence of pollutants.	Present or absent
Invasive weeds	Reduces habitat for native flora/fauna	Present or absent
Natural regeneration of native species	Indicates viable seeds/seedlings of native species present and capacity for regeneration	Present or absent
Riparian Condition (Estuarine)	Function of variable	What we assessed / measured
Native trees/shrubs	Provides shading, allochthonous input, habitat corridor for native fauna, reduces bank erosion.	% distribution, width of continuous band
Native groundcover/grasses/sedges	Reduces erosion and sedimentation of stream, reduces nutrients entering the stream, provides habitat for terrestrial fauna.	% distribution, width of continuous band
Exotic vegetation	Reduces habitat for native flora/fauna	% distribution
Mangroves	Mangroves provide food and habitat, stabilise banks and reduce erosion	% distribution, width of continuous band
Saltmarsh	Saltmarsh provide habitat and food for aquatic biota and waders. Act as a buffer between land and estuary, filtering nutrients and capturing sediment from stormwater	% distribution

Appendix 3 Rapid Site Assessment Field Form

Manning River Catchment and Estuary Management Program

Stage 2: Ground truthing – Rapid site assessments

July 2019

Field Assessment and ODK Collect Form Information

Question	Answer(s)
*Name of field team staff member-1	
*Name of field team staff member-2	
*Date of survey	
Take 5 Safety Check! Please consider the following potential safety issues:	Weather Site Access conditions and permissions Communication PPE Waterway Condition Site Specific Hazards Dangerous Fauna Fire Dangers
Any site-specific hazards identified in the Take 5?	
*Have you considered/identified potential hazards and are ready to proceed safety?	Yes No

(*indicates required fields)

Site Location Information	
Name of the sampling/monitoring program	MidCoast-Manning River ECMP-Stage 2
*Name of the catchment that the site is within	
***SiteID** (site number or code, should be a unique identifier)	
*Waterway and site location name	
GPS Coordinates (Geopoint)	
Manual input of latitude	
Manual input of longitude	
Reason for manual input of coordinates	
Site Location comments Note any aspects of site location not covered above	
Site Photos	**Try to capture the site features from a broad perspective and a good representation of the bankfull width looking across stream.**
Take a photo looking upstream	
Take a photo looking downstream	
Take a photo across the stream	
Comments on photos. Important to note which bank the across stream photo was taken. Left and right is considered when facing downstream.	

Land Use in the adjacent and surrounding land	
Dominant land use (select one) What is the dominant land use in the adjacent and surrounding lands including both banks? This should include land use observed when accessing site.	Conservation area/National Park/minimal use Residual native cover Production from native forests Forestry plantations Rural-residential or hobby farms Cattle grazing Dairy sheds and yards Grazing other than cattle Poultry sheds and yards Cropping Mining Industrial Urban, houses, low and high density Commercial Other
Assessment of the impact of livestock (select one) If dominant land use is grazing of any type, including dairying, what is the extent of impact of stock in the riparian zone?	No evidence Few tracks/ grazed ground cover Many tracks, heavily grazed or no understory Stock consistently accessing waterway, degraded banks, manure obvious
Is the land clearly irrigated? (select one)	Yes No
Is there evidence of fertiliser use?	Yes No
If the land use is 'Grazing other' please specify type	Horses, Sheep, deer, goats, alpaca, other
If the land use is 'Other' provide more detail here	
Other land use activities, other than the dominant land use, at the site or surrounds (select multiple)	Conservation area/National Park/minimal use Residual native cover Production from native forests Forestry plantations Rural-residential or hobby farms Cattle grazing Dairy sheds and yards Grazing other than cattle Poultry sheds and yards Cropping Mining Industrial Urban, houses, low and high density Commercial

	Other
Is there any evidence of recent fires (not bushfires but farmer-initiated fires)? (select one)	Evidence of recent fire possibly within past 2 years Evidence of fire between 2 to 10 years ago No evidence of fire
Additional Land Use Comments Add any comments that may provide additional information of the land use within and surrounding the site. Note if there is a type of farming that is not covered in the land use descriptions	

Flow and stream dimensions	
Water Level (select one) This is to determine if flow in the waterway at time of sampling is comparable to base flow. Any evidence to suggest that a recent flood has passed through the site should be recorded in the Comments section.	No Flow - isolated pools Low - below expected baseflow Moderate - baseflow High - above normal baseflow Flood - overbank flow
Any comments on the water/flow level at time of survey?	
Minimum stream width (m)	
Maximum stream width (m)	
Mean stream width (m)	
How was the stream width measured? (select one) This is used to assess the accuracy of stream and channel form measures	Estimate Tape measure Range Finder

Water quality *in situ* measures	
Time water quality was measured	
Sample depth (m) Approximately 0.3 m is optimal	
Water Temperature (°C)	
Salinity (ppt)	
Conductivity (µS/cm)	
pH (Units)	
Dissolved Oxygen (mg/L)	
Dissolved Oxygen (% saturation)	
Turbidity (NTU)	
Chlorophyll-a (µg/L)	
fDOM (QSU)	
Water quality comments	
Estuarine or Freshwater?	

Is it an estuarine or freshwater site? (select one)	Estuarine (go to ‘Estuarine Sites’) Freshwater (go to ‘Freshwater Sites’)

Estuarine Sites	
Macroalgae Distribution and Abundance	
What is the distribution of macroalgae at the site? (select one)	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
(What is the colour and structure of the macroalgae at the site (if present)? (select multiple)	Green Green Mat Floating Green Filamentous Green Brown Brown Mat Floating Brown Filamentous Brown
Select the types of macroalgal species observed at the site? (select multiple)	Charophyte, Chaetomorpha, Caulerpa, Cladophora Codium sp., Delisea, Dictyota, Ecklonia, Enteromorpha, Hormosira, Najas, Phyllospora, Sargassum, Ulva, Other/Unknown
Other macroalgal species name (if known)	
Seagrass Distribution and Abundance	
Is seagrass or wrack present? (select one)	No evidence of seagrass or wrack Localised/patchy/sparse seagrass or wrack Widespread
Extent and Type of Saltmarsh Habitat (if present)	
% of the shoreline consisting of saltmarsh? (select one)	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
Width of saltmarsh vegetation from shoreline (m)	
Select the types of saltmarsh species observed at the site	
Other saltmarsh species name (if known) (select multiple)	Atriplex, Bacopa, Chenopodium, Crinum, Juncus, Leptinella, Mimulus, Samolus, Sarcocornia, Selliera Sesuvium, Sporobolus, Suaeda, Tecticornia, Tetragonia, Triglochin, Zoysia, Other/Unknown
Extent of mangrove on shoreline	
% of the shoreline consisting of mangroves? (select one)	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %)

	High (51-75 %) Very High (> 75 %)
(If Present) Width of continuous mangrove cover from shore line (m)	

Estuarine Sites (cont.)	
Extent and Type of Native Trees and Shrubs	
% of the shoreline consisting of native trees and shrubs? (select one)	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
(If present) Width of continuous tree and/or shrub cover (m)	
(If present) Select the types of native trees and shrubs observed at the site (select multiple)	Casuarina, Eucalyptus, Melaleuca, Mangroves, Banksia, Leptospermum, Acacia, Angophora, Xanthorrhoea, Other/Unknown
Other native tree species name (if known)	
Extent and type of Native Grasses (if known)	
% of the shoreline consisting of native grasses? (select one)	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
(If present) Width of continuous native grass from shoreline (m)	
(If present) Select the types of native grasses observed at the site (select multiple)	Phragmites, Juncus, Lomandra, Schoenoplectus, Gahnia, Baumea, Ficinia, Paspalum, Bolboschoenus, Cyperus, Fimbristylis, Typha, Other/Unknown
Other native grass species name (if known)	
Extent and Type of Introduced Vegetation	
% of the shoreline consisting of introduced vegetation? (select one)	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
(If present) Select the types of introduced vegetation observed at the site (select multiple)	Pasture Grass, Bitou, Lantana, Residential Grass, Senna, Balloon Vine, Ground Asparagus, Radiata Pine, Willow, Coastal Morning Glory, Other/Unknown
Other introduced vegetation species name (if known)	
Estuarine instream assessment	

Is there rubbish, litter etc. at the site? (select one)	None Low Medium High
Were plastics among the rubbish? (select one)	Yes No
Comments on rubbish (type, amount, likely source)	
Odours (select one)	Present or Absent
If odours present, describe type and likely source e.g. Oils, petroleum, manure, sulphur (rotten eggs) from decaying organic matter or acid sulphate soils.	
Grease and oil (select one) Indicates pollution from stormwater runoff or industry. Presence or absence (visual assessment only).	Present or Absent
If grease/oils visible, describe type, extent, likely source	

Freshwater Sites	
Geomorphic Condition Channel form, bank structure and erosion potential	
Topography (select one) This is recorded to provide a general idea of the shape of the river valley around the site. Choose the category that best describes the site.	Floodplain (freshwater) Broad Valley Steep Valley Gorge
Bankfull channel width (m) Bankfull channel is the width of the top of the banks. Leave blank if the site is an estuary or lowland floodplain with no defined bankfull channel.	
Channel pattern (select one) Channel pattern is the 'birds-eye view' of the form of the waterway.	Straight Meandering Anastomosing (anabranching) Braided (more than one channel)
Dominant substrate type(s) of the stream bed (dominant substrate is >15% cover but more likely to be >30%)	Bedrock Boulder (>200 mm) Cobble (60-200 mm) Pebble (20-60 mm) Gravel (2-20 mm) Sand (0.02-2 mm) Clay/Silt (<0.02 mm)
Approximate cover of the dominant substrate type	15-30% 30-45% 45-60% 60-75% >75%
Other substrate types within the stream bed (>15% cover, can select multiple)	Bedrock Boulder (>200 mm) Cobble (60-200 mm) Pebble (20-60 mm) Gravel (2-20 mm) Sand (0.02-2 mm) Clay/Silt (<0.02 mm)
Riffle/pool sequences within reach (select one)	Frequent alternation of riffles and pools Long pools with infrequent short riffles Natural channel without riffle / pool sequence Artificial channel; no riffle / pool sequence
Channel sediment accumulation (select one)	Little or no accumulation of loose sediments Some gravel bars but little sand or silt Bars of sand and silt common

	Braiding by loose sediment
Channel and bank substrates and condition	
General assessment of bank structure across site (select one)	Banks fully stabilised by trees, shrubs etc. Banks firm but held mainly by grass and herbs Banks loose, partly held by sparse grass etc. Banks unstable, mainly loose sand or soil
Bank undercutting assessed for whole site (select one) Erosion of banks adds sediment to the stream, undercuts the riparian zone and reduces in-stream habitat.	None, or restricted by tree roots Only on curves and at constrictions Frequent along all parts of stream Severe, bank collapses common
Mean slope of left bank (select one)	No discernible bank slope Slight: 0-10° Moderate: 10-45° Steep: 46-65° Very Steep: >65°
Extent of erosion visible on left bank (select one)	Banks with slumping and undercutting Banks vertical with some undercutting Banks not vertical but erosion evident Banks with minor erosion evident No erosion evident, or vertical bedrock constrained banks
Mean slope of right bank (select one)	No discernible bank slope Slight: 0-10° Moderate: 10-45° Steep: 46-65° Very Steep: >65°
Extent of erosion visible on right bank (select one)	Banks with slumping and undercutting Banks vertical with some undercutting Banks not vertical but erosion evident Banks with minor erosion evident No erosion evident, or vertical bedrock constrained banks
Are there any attributes of the geomorphology not yet captured or comments?	
Instream Condition Assessment	
In-channel habitat (select one) A variety of in-channel habitats will support a variety of aquatic/semi-aquatic biota. Habitats can include tree roots in the water, over-hanging vegetation (shrubs and/or trees) LWD, undercut banks, runs, riffles and shallow and/or deep pools.	Uniform straight sediment channel One habitat type present (usually pool but may be run) 2 to 3 habitat types present 3 to 4 habitat types present More than 4 habitat types present
Large woody debris (select one)	None

LWD provides important habitat for in-stream fauna.	Low 1 to 10% Moderate 11 to 20% High 21 to 30% Very high >30%
Leaf litter (select one) Many aquatic fauna utilise leaf litter for feeding or refuge.	None Low 1 to 10% Moderate 11 to 20% High 21 to 30% Very high >30%
Filamentous green algae (select one) Algae provides a food resource for many aquatic biota but can become a problem when blooms occur, or filamentous algae growth is dense.	None Low 1 to 10% Moderate 11 to 20% High 21 to 30% Very high >30%
Macrophytes (select one) Macrophytes provide important habitat for in-stream fauna. Presence or absence (note, not all streams will be suitable for macrophytes).	None Low 1 to 10% Moderate 11 to 20% High 21 to 30% Very high >30%
Rubbish in the channel	None Low Medium High
Odour from channel substrate/water Odour coming from the water indicates pollution, or decomposing organic matter in anoxic conditions	Present or absent
If odours present, describe type. e.g. Oils, petroleum, manure, sulphur (rotten eggs) from decaying organic matter	
Grease and oil (select one) Indicates pollution from stormwater runoff or industry. Presence or absence (visual assessment only).	Present or absent
Types and extent of macrophytes in the reach (if present)	
Submerged Macrophytes in Habitat	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
Emergent Macrophytes in Habitat	None (0 %)

	Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)
Floating Macrophytes in Habitat	None (0 %) Low (1 - 25 %) Moderate (26 - 50 %) High (51-75 %) Very High (> 75 %)

Riparian Condition Assessment	
Riparian Condition Assessment Assessment of riparian vegetation condition and extent. The following questions should consider only the area within the riparian zone vegetation, not within the channel.	
Longitudinal continuity of riparian vegetation (select one)	No riparian vegetation Up to 25% continuous 25 to 50% continuous 50 to 75% continuous More than 75% continuous
Width of riparian vegetation (at thinnest point) (select one)	No riparian vegetation Up to 10m Between 10 and 20m Between 20 and 30m Continuous with bushland
Disturbance, % disturbed (tracks, erosion, cleared, trampled) (select one)	100% disturbed, tracks, erosion, trees and shrubs cleared More than 75% disturbed 50 to 75% disturbed 25 to 50% disturbed Less than 25% disturbed
Canopy % cover (% shading) (select one) (not applicable to grasslands and heathlands)	No canopy - cleared Canopy sparse, <25% cover Canopy disturbed, 25 to 50% cover Canopy slightly disturbed, 50 to 75% cover Canopy greater than 75% cover
Native tree diversity (select one)	No native species Dominated by 1 or 2 native species Supports 3 - 4 native species Supports 5 - 10 native species Very diverse, more than 10 native species
Canopy nativeness - percent of canopy species that are native (select one)	Cover 100% exotic Cover up to 75% exotic Cover 50 to 75% exotic Cover 25 to 50% exotic Cover more than 75% native
Shrub layer % cover (select one) (not applicable to grasslands or closed forest)	No shrub layer - cleared No shrub layer due to dense natural canopy Less than 25% of shrub layer remaining 25 to 50% of shrub layer intact 50 to 75% of shrub layer intact

	More than 75% of shrub layer intact
Shrub layer nativeness	Cover 100% exotic Cover up to 75% exotic Cover 50 to 75% exotic Cover 25 to 50% exotic Cover more than 75% native
Native shrub layer diversity	No native species Dominated by 1 or 2 native species Supports 3 - 4 native species Supports 5 - 10 native species Very diverse, more than 10 native species
Ground % cover	Ground cover absent Ground cover sparse due to dense canopy of native species Ground cover less than 25% Ground cover between 25 and 50% Ground cover between 50 and 75% Ground cover >75%
Ground cover nativeness	Cover 100% exotic Cover up to 75% exotic Cover 50 to 75% exotic Cover 25 to 50% exotic Cover more than 75% native
Native ground cover diversity	No native species Dominated by 1 or 2 native species Supports 3 - 4 native species Supports 5 - 10 native species Very diverse, more than 10 native species
Other characteristics of the riparian zone	
Tree hollows (select one)	Present or Absent
Mature trees with hollows	Present or Absent
Hollow logs (select one)	Present or Absent
Hollow logs in riparian zone	Present or Absent
Leaf litter in riparian zone	Present or Absent
Rubbish in riparian zone	None Low Medium

	High
Invasive weeds in riparian zone	Present or Absent
Natural regeneration of native species in riparian zone	Present or Absent

Appendix 4 Scoring of Rapid Site Assessments

Manning ECMP Stage 2 - Scoring of Rapid Site Assessments (only questions which were scored are shown). ***Note higher scores = less land use pressure and better condition***

Question	Choices	Score
Land Use (estuarine and freshwater sites) - max score 11		
Dominant land use What is the dominant land use in the adjacent and surrounding lands including both banks?	Conservation Area	5
	Native Forest	5
	Forestry-native	4
	Forestry-plantation	2
	Rural-residential	3
	Grazing	2
	Dairy	1
	Grazing Other	2
	Poultry	1
	Cropping	1
	Mining	1
	Industrial	2
	Urban	2
	Commercial	2
Assessment of the impact of livestock (if dominant land use is grazing or dairy) what is the extent of impact of stock in the riparian zone?	No evidence	4
	Few tracks/ grazed ground cover	3
	Many tracks, heavily grazed or no understory	2
	Stock consistently accessing waterway, degraded banks, manure obvious	1
Is the land clearly irrigated?	Yes	0
	No	1
Is there evidence of fertiliser use?	Yes	0
	No	1

Estuarine sites - max score = 69		
Instream Condition Assessment - max score = 23		
Water Quality		
Chlorophyll	< 1ug/L	4
	<2.7 ug/L	3
	2.7 - 4 ug/L	2
	>4 ug/L	1
Turbidity	<1 NTU	4
	<3 NTU	3
	3-5 NTU	2
	>5 NTU	1
pH	7-8.5	4
	6.5-7	3
	<6	1
Macroalgae Distribution and Abundance		
What is the distribution of macroalgae at the site?	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Seagrass Distribution and Abundance		
Is seagrass or wrack present?	No evidence of seagrass or wrack	0
	Localised/patchy/sparse seagrass or wrack	1
	Widespread	2
Pollutants		
Is there rubbish, litter etc. at the site?	None	4
	Low	3

	Medium	2
	High	1
Grease and oil	Present	0
	Absent	1
Riparian condition assessment (max score = 35)		
Extent and Type of Saltmarsh Habitat (if present)		
% of the shoreline consisting of saltmarsh?	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Extent of mangrove on shoreline		
% of the shoreline consisting of mangroves?	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Width of continuous mangrove cover from shore line (m)	<= 2m	1
	3-5m	2
	6-10m	3
	11-20m	4
	>20m	5
Extent and Type of Native Trees and Shrubs		
% of the shoreline consisting of native trees and shrubs?	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3

	Very High (> 75 %)	4
Width of continuous tree and/or shrub cover (m)	<= 2m	1
	3-5m	2
	6-10m	3
	11-20m	4
	>20m	5
Extent and type of Native Grasses (if known)		
% of the shoreline consisting of native grasses?	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Width of continuous native grasses from shoreline (m)	<= 2m	1
	3-5m	2
	6-10m	3
	11-20m	4
	>20m	5
% of the shoreline consisting of introduced vegetation?	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Freshwater Sites - max score = 125		
Geomorphology assessment - max score = 29		
Dominant substrate % cover	15-30%	1
	30-45%	2
	45-60%	3
	60-75%	4

	>75%	5
Riffle/pool sequences within reach	Frequent alternation of riffles and pools	4
	Long pools with infrequent short riffles	3
	Natural channel without riffle / pool sequence	2
	Artificial channel; no riffle / pool sequence	1
Channel sediment accumulation	Little or no accumulation of loose sediments	4
	Some gravel bars but little sand or silt	3
	Bars of sand and silt common	2
	Braiding by loose sediment	1
Channel and bank substrate condition		
General assessment of bank structure across site	Banks fully stabilised by trees, shrubs etc.	4
	Banks firm but held mainly by grass and herbs	3
	Banks loose, partly held by sparse grass etc.	2
	Banks unstable, mainly loose sand or soil	1
Bank undercutting assessed for whole site	None, or restricted by tree roots	4
	Only on curves and at constrictions	3
	Frequent along all parts of stream	2
	Severe, bank collapses common	1
Extent of erosion of left/right bank	Banks with slumping and undercutting	0
	Banks vertical with some undercutting	1
	Banks not vertical but erosion evident	2
	Banks with minor erosion evident	3
	No erosion evident, or vertical bedrock constrained banks	4
Instream Condition Assessment - max score = 37		
In-channel habitat	Uniform straight sediment channel	0
	One habitat type present (usually pool but may be run)	1
	2 to 3 habitat types present	2
	3 to 4 habitat types present	3

	More than 4 habitat types present	4
Large woody debris	None	0
	Low 1 to 10%	1
	Moderate 11 to 20%	2
	High 21 to 30%	3
	Very high >30%	4
Leaf litter	None	0
	Low 1 to 10%	1
	Moderate 11 to 20%	2
	High 21 to 30%	3
	Very high >30%	4
Filamentous green algae	None	4
	Low 1 to 10%	3
	Moderate 11 to 20%	2
	High 21 to 30%	1
	Very high >30%	0
Macrophytes	None	0
	Low 1 to 10%	1
	Moderate 11 to 20%	2
	High 21 to 30%	3
	Very high >30%	4
Rubbish	None	4
	Low	3
	Medium	2
	High	1
Odour	Present	1
	Absent	0

Grease/Oil	Present	1
	Absent	0
Submerged Macrophytes in Habitat	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Emergent Macrophytes in Habitat	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Floating Macrophytes in Habitat	None (0 %)	0
	Low (1 - 25 %)	1
	Moderate (26 - 50 %)	2
	High (51-75 %)	3
	Very High (> 75 %)	4
Riparian Condition Assessment - max score 56		
Longitudinal continuity of riparian vegetation	No riparian vegetation	0
	Up to 25% continuous	1
	25 to 50% continuous	2
	50 to 75% continuous	3
	More than 75% continuous	4
Width of riparian vegetation (at thinnest point)	No riparian vegetation	0
	Up to 10m	1
	Between 10 and 20m	2
	Between 20 and 30m	3

	Continuous with bushland	4
Disturbance, % disturbed (tracks, erosion, cleared, trampled)	100% disturbed, tracks, erosion, trees and shrubs cleared	0
	More than 75% disturbed	1
	50 to 75% disturbed	2
	25 to 50% disturbed	3
	Less than 25% disturbed	4
Canopy % cover	No canopy - cleared	0
	Canopy sparse, <25% cover	1
	Canopy disturbed, 25 to 50% cover	2
	Canopy slightly disturbed, 50 to 75% cover	3
	Canopy greater than 75% cover	4
Native tree diversity	No native species	0
	Dominated by 1 or 2 native species	1
	Supports 3 - 4 native species	2
	Supports 5 - 10 native species	3
	Very diverse, more than 10 native species	4
Canopy nativeness - percent of canopy species that are native	Cover 100% exotic	0
	Cover up to 75% exotic	1
	Cover 50 to 75% exotic	2
	Cover 25 to 50% exotic	3
	Cover more than 75% native	4
Shrub layer % cover	No shrub layer - cleared	0
	No shrub layer due to dense natural canopy	4
	Less than 25% of shrub layer remaining	1
	25 to 50% of shrub layer intact	2
	50 to 75% of shrub layer intact	3
	More than 75% of shrub layer intact	4

Shrub layer nativeness	Cover 100% exotic	0
	Cover up to 75% exotic	1
	Cover 50 to 75% exotic	2
	Cover 25 to 50% exotic	3
	Cover more than 75% native	4
Native shrub layer diversity	No native species	0
	Dominated by 1 or 2 native species	1
	Supports 3 - 4 native species	2
	Supports 5 - 10 native species	3
	Very diverse, more than 10 native species	4
Ground cover % cover	Ground cover absent	0
	Ground cover sparse due to dense canopy of native species	4
	Ground cover less than 25%	1
	Ground cover between 25 and 50%	2
	Ground cover between 50 and 75%	3
	Ground cover >75%	4
Ground cover nativeness	Cover 100% exotic	0
	Cover up to 75% exotic	1
	Cover 50 to 75% exotic	2
	Cover 25 to 50% exotic	3
	Cover more than 75% native	4
Native ground cover diversity	No native species	0
	Dominated by 1 or 2 native species	1
	Supports 3 - 4 native species	2
	Supports 5 - 10 native species	3
	Very diverse, more than 10 native species	4
Other characteristics of the riparian zone		

Tree hollows	Present Absent	1 0
Mature trees with hollows	Present Absent	1 0
Hollow logs	Present Absent	1 0
Leaf litter in riparian zone	Present Absent	1 0
Rubbish in riparian zone	None Low Medium High	4 3 2 1
Invasive weeds in riparian zone	Present Absent	1 0
Natural regeneration of native species in riparian zone	Present Absent	1 0

Appendix 5 Freshwater Catchment Site Scores

Rapid Site Assessment methodology assigns a grade to scores in each category (Overall Condition, Land Use, Geomorphic Condition, Instream Condition and Riparian Condition) for each site (Table A3-2) using the grading scale shown in Table A3-1.

Table A5 - 1 Grading scale applied to scoring of attributes in Rapid Site Assessments in the freshwater catchment.

Grade	% of total possible score	Overall Condition score (max 125)	Land Use Pressure score (max 11)	Geomorphic Condition score (max 29)	Instream Condition score (max 37)	Riparian Condition Score (max 56)
Excellent	>80%	≥100	≥9	≥23	≥30	≥38
Good	>60%	≥76	≥7	≥18	≥23	≥29
Fair	>40%	≥51	≥5	≥12	≥15	≥20
Poor	>20%	≥26	≥2	≥6	≥8	≥10
Very Poor	<20%	<26	<2	<6	<8	<10

Table A5 - 2 A summary of all scores from Rapid Site Assessments at freshwater sites (Grade – Excellent = dark green =, Good = light green, Fair = yellow, Poor = orange, Very Poor = red). Overall Condition, Land Use Pressure, Geomorphic, Instream and Riparian Condition scores are shown in Maps A3-1 to A3-10.

SiteID	Major River catchment	Overall Condition score (max 125)	Land Use Pressure score (max 11)	Geomorph Condition score (max 29)	Instream Condition score (max 37)	Riparian Condition score (max 56)
121_01	Avon River	71	6	17	24	24
121_04	Avon River	65	5	19	17	24
121_05	Avon River	73	7	24	18	24
121_08	Avon River	81	7	25	20	29
123_05	Avon River	54	4	15	12	23
123_06	Avon River	41	5	17	13	6
123_14	Avon River	103	11	27	13	52
123-01/02	Avon River	72	6	19	18	29
123-03	Avon River	66	8	25	12	21
123-10	Avon River	68	5	23	13	27
123-13	Avon River	104	11	27	15	51
72_04	Barnard River	60	7	17	14	22
72_06	Barnard River	69	6	21	17	25
72_11	Barnard River	75	7	20	14	34
72-01	Barnard River	66	5	17	17	27
77_02	Barnard River	66	6	25	20	15
77_04	Barnard River	68	7	23	11	27
77-05a	Barnard River	56	6	22	10	18
81-01	Barnard River	57	6	22	13	16
81-04	Barnard River	53	6	22	13	12
81-05	Barnard River	57	6	24	12	15
81-08	Barnard River	47	5	22	11	9
82_01	Barnard River	62	4	21	12	25
83_01	Barnard River	52	5	20	12	15
83_02	Barnard River	45	5	18	12	10
83-03	Barnard River	56	6	20	13	17
84_03	Barnard River	76	5	24	19	28

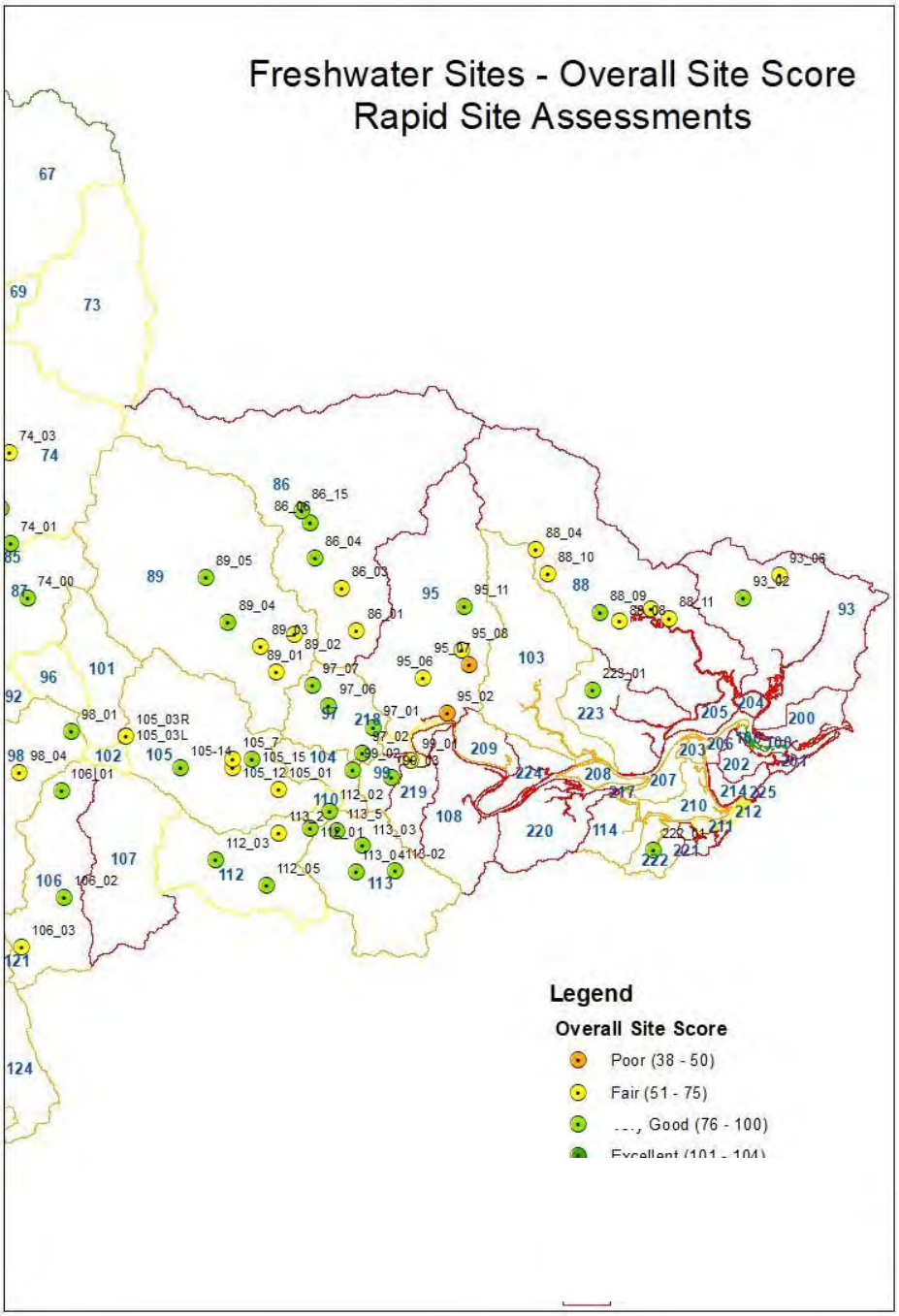
84_03A	Barnard River	81	5	26	19	31
84_04	Barnard River	69	5	21	11	32
84_05	Barnard River	74	5	22	18	29
111 04A	Barrington River	73	7	24	14	28
111-04	Barrington River	66	6	23	16	21
111-05	Barrington River	43	5	15	15	8
111-07N	Barrington River	74	6	26	15	27
115 07	Barrington River	55	5	17	13	20
115 09	Barrington River	74	7	27	12	28
115-05	Barrington River	84	6	27	15	36
115-07	Barrington River	80	7	26	13	34
115-10	Barrington River	76	4	25	14	33
117_01	Barrington River	69	5	17	13	34
117_03	Barrington River	59	5	16	9	29
117_03B	Barrington River	83	6	23	14	40
117_04	Barrington River	65	4	21	14	26
117_05	Barrington River	58	3	17	10	28
117_07	Barrington River	41	4	11	11	15
117_08a	Barrington River	43	5	13	8	17
119 03	Barrington River	38	5	14	11	8
119-01	Barrington River	61	7	23	13	18
119-02	Barrington River	70	6	23	15	26
109 04	Bowman River	65	5	22	12	26
109 07	Bowman River	81	7	24	17	33
109 08	Bowman River	78	8	25	14	31
109-02	Bowman River	71	6	26	14	25
109-03	Bowman River	59	5	18	15	21
109-05	Bowman River	56	5	19	13	19
109-10	Bowman River	86	7	29	13	37
112_01	Burrrell Creek	94	8	27	18	41
112_02	Burrrell Creek	100	10	25	18	47
112_03	Burrrell Creek	95	9	27	18	41
112_05	Burrrell Creek	94	7	27	19	41

113_03	Burrrell Creek	90	7	22	18	43
113_04	Burrrell Creek	92	7	27	15	43
113_2	Burrrell Creek	71	6	17	14	34
113_5	Burrrell Creek	78	9	19	18	32
113-02	Burrrell Creek	86	7	20	15	44
93_02	Cattai Creek	86	7	27	20	32
93_06	Cattai Creek	67	4	23	16	24
95_02	Cedar Party Creek	43	5	16	13	9
95_06	Cedar Party Creek	68	6	24	15	23
95_07	Cedar Party Creek	43	4	16	11	12
95_08	Cedar Party Creek	75	7	19	19	30
95_11	Cedar Party Creek	76	8	19	16	33
86_01	Dingo Creek	71	7	14	18	32
86_03	Dingo Creek	75	7	21	13	34
86_04	Dingo Creek	78	8	17	16	37
86_06	Dingo Creek	82	8	22	15	37
86_15	Dingo Creek	91	11	20	14	46
89_01	Dingo Creek	65	7	20	14	24
89_02	Dingo Creek	73	7	14	12	40
89_03	Dingo Creek	74	6	16	18	34
89_04	Dingo Creek	79	7	23	17	32
89_05	Dingo Creek	80	7	19	16	38
97_01	Dingo Creek	84	6	23	18	37
97_02	Dingo Creek	82	5	25	18	34
97_06	Dingo Creek	77	5	24	14	34
97_07	Dingo Creek	92	6	24	19	43
122_N	Gloucester River	77	6	23	17	31
122_01	Gloucester River	65	6	21	11	27
122_02	Gloucester River	47	4	10	11	22
122_04	Gloucester River	58	9	12	12	25
122_06	Gloucester River	47	4	20	10	13
122_12	Gloucester River	80	6	21	15	38
122_14	Gloucester River	61	4	22	11	24

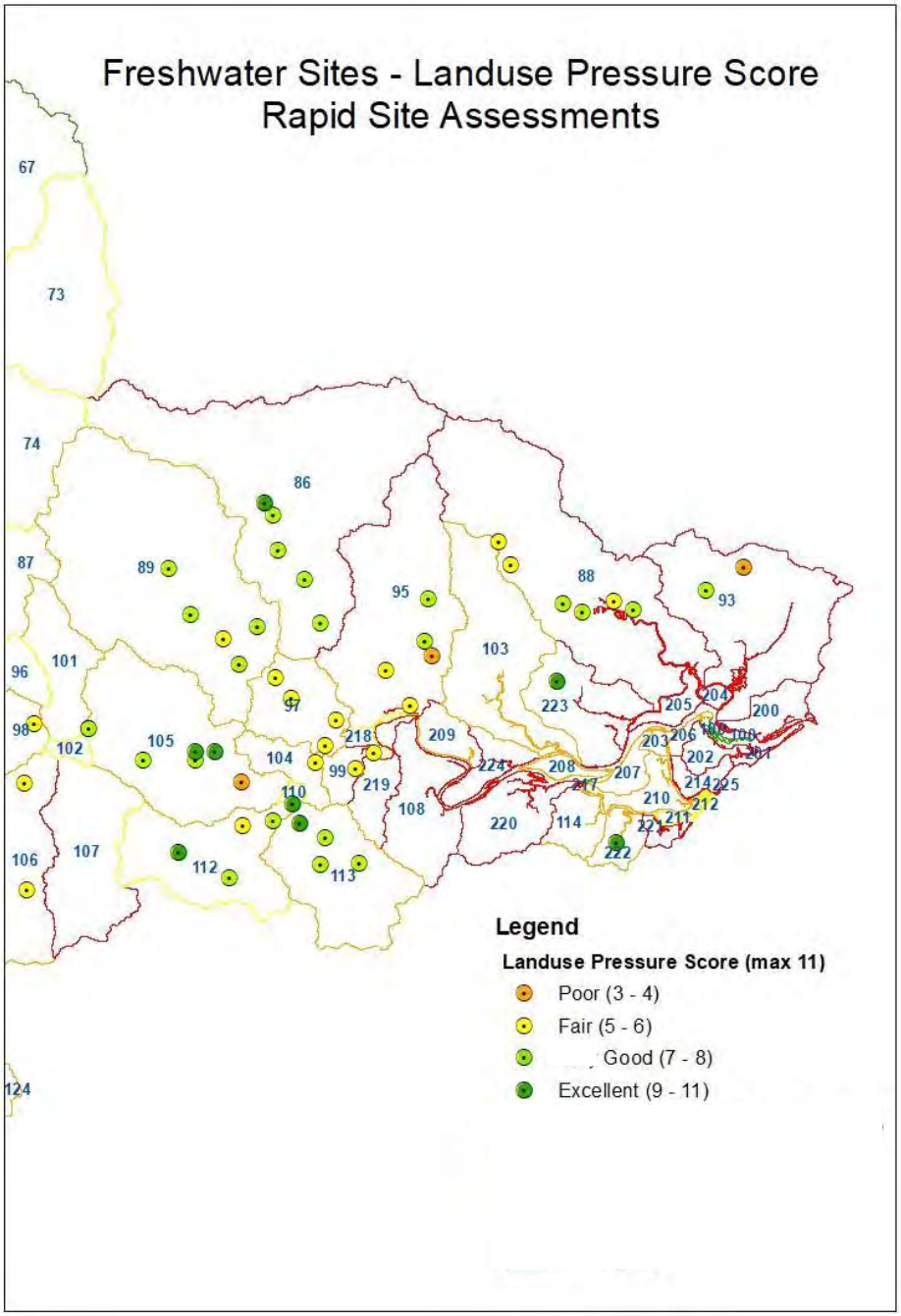
122_17	Gloucester River	71	6	22	16	27
122_20	Gloucester River	74	5	22	13	34
122-01	Gloucester River	69	5	24	12	28
122-03	Gloucester River	50	5	11	11	23
122-05	Gloucester River	71	11	21	16	23
122-06	Gloucester River	72	10	27	15	20
122-07	Gloucester River	47	6	23	10	8
122-08	Gloucester River	69	7	22	12	28
122-11	Gloucester River	76	5	26	14	31
122-12	Gloucester River	71	7	21	13	30
122-14	Gloucester River	64	6	26	13	19
122-17	Gloucester River	87	7	26	18	36
122-20	Gloucester River	73	6	24	14	29
122-21	Gloucester River	102	11	27	13	51
98 03	Gloucester River	74	5	22	24	23
98_01	Gloucester River	95	5	26	17	47
98_04	Gloucester River	51	5	25	9	12
98-02	Gloucester River	75	3	16	26	30
88_02	Lansdowne River	58	6	26	8	18
88_04	Lansdowne River	62	6	16	15	25
88_08	Lansdowne River	71	8	27	10	26
88_09	Lansdowne River	88	8	25	16	39
88_10	Lansdowne River	66	5	16	14	31
88_11	Lansdowne River	74	7	21	17	29
105_01	Manning River	74	3	19	20	32
105_03L	Manning River	68	7	20	16	25
105_03R	Manning River	65	7	20	16	22
105_12	Manning River	69	8	27	14	20
105_15	Manning River	93	11	29	18	35
105_7	Manning River	74	11	22	16	25
105-14	Manning River	78	7	22	18	31
106_01	Manning River	76	6	22	18	30
106_02	Manning River	77	6	26	20	25

106_03	Manning River	72	6	21	20	25
222_01	Manning River	82	11	28	11	32
223_01	Lansdowne River	93	11	19	17	46
99_01	Manning River	70	5	19	18	28
99_02	Manning River	83	6	21	17	39
99_03	Manning River	88	6	24	22	36
68-01	Myall Creek	49	6	26	8	9
68-03	Myall Creek	101	11	29	15	46
76-01	Myall Creek	82	6	23	18	35
76-03	Myall Creek	63	4	19	13	27
76-05	Myall Creek	74	6	25	13	30
64_01	Nowendoc River	77	5	21	18	33
64_01A	Nowendoc River	90	7	27	14	42
64_05	Nowendoc River	46	5	15	13	13
64_07	Nowendoc River	87	6	28	17	36
64-04	Nowendoc River	53	5	23	11	14
66_02	Nowendoc River	83	6	25	15	37
66_03	Nowendoc River	74	6	25	17	26
66_04	Nowendoc River	75	5	23	19	28
66_05	Nowendoc River	47	5	19	15	8
66_08	Nowendoc River	88	7	26	15	40
66-01a	Nowendoc River	72	6	22	12	32
87_01	Nowendoc River	89	11	24	16	38
74_01	Nowendoc River	87	9	24	12	42
74_02	Nowendoc River	76	7	23	15	31
74_03	Nowendoc River	57	6	16	13	22
74_04	Nowendoc River	87	7	26	14	40
74_05	Nowendoc River	85	7	23	14	41
80_01	Nowendoc River	55	6	19	11	19
80_02	Nowendoc River	64	6	18	11	29
80_03	Nowendoc River	67	5	19	13	30
80_04	Nowendoc River	78	6	25	15	32
85_02	Nowendoc River	78	6	24	16	32

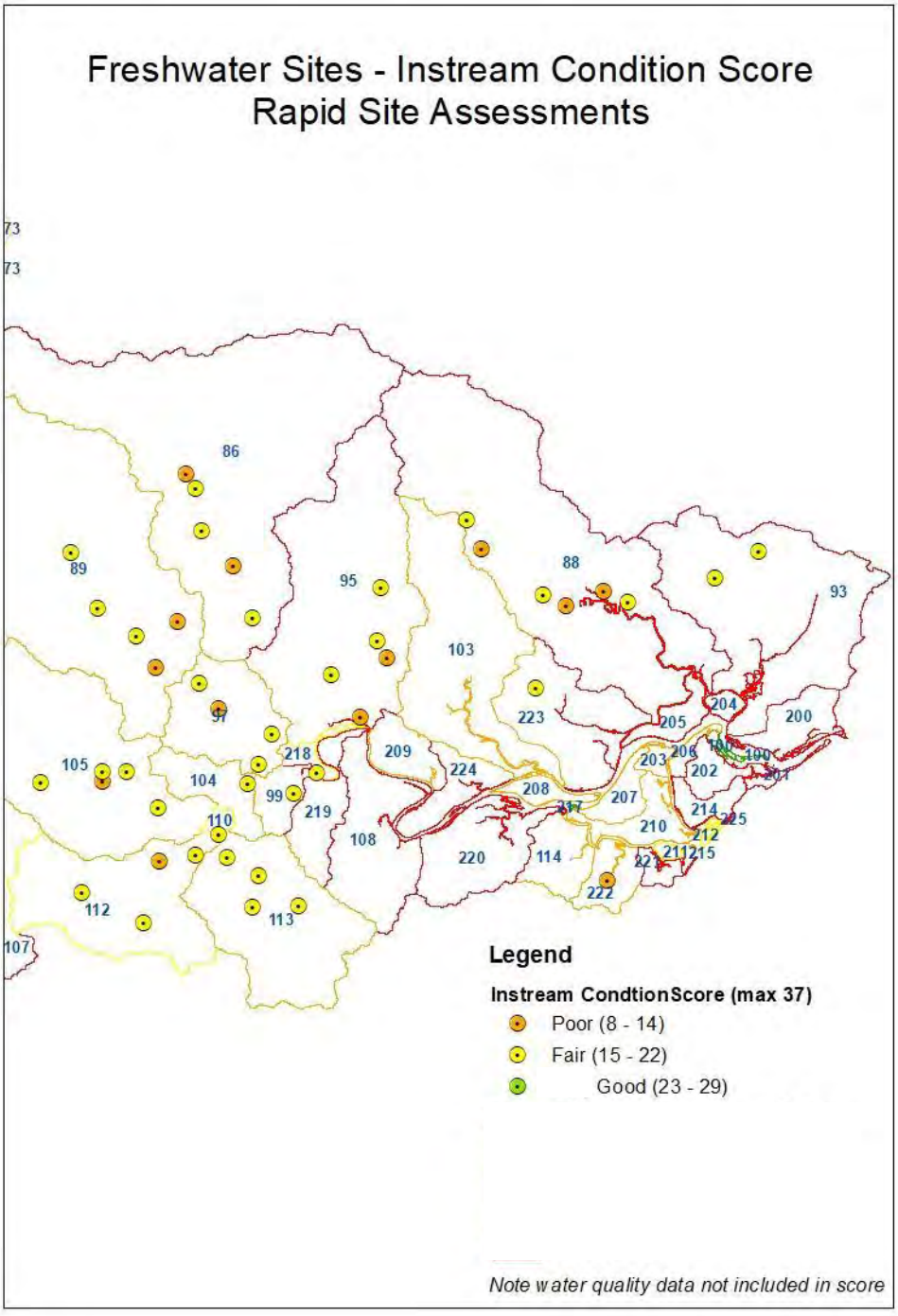
85_03	Nowendoc River	97	11	28	16	42
85_04	Nowendoc River	93	7	28	13	45
90 -08	Upper Manning River	55	5	18	13	19
90-02	Upper Manning River	71	6	19	18	28
90-03	Upper Manning River	83	7	26	20	30
90-06	Upper Manning River	83	6	22	15	40
91_02	Upper Manning River	90	11	28	13	38
91_04	Upper Manning River	97	7	26	21	43
91-06	Upper Manning River	68	6	19	14	29
91-07	Upper Manning River	82	7	24	20	31
91-10	Upper Manning River	83	5	23	13	42
91-14	Upper Manning River	76	6	26	16	28
92_02	Upper Manning River	71	5	21	17	28
92-01	Upper Manning River	75	6	20	21	28
92-03	Upper Manning River	55	5	20	10	20
92-04	Upper Manning River	69	6	23	15	25
92-05	Upper Manning River	78	6	24	18	30
94-01	Upper Manning River	69	6	24	13	26
94-02	Upper Manning River	78	6	25	14	33
94-04	Upper Manning River	56	5	23	12	16
94-06	Upper Manning River	100	8	27	15	50
94-07	Upper Manning River	90	8	25	14	43



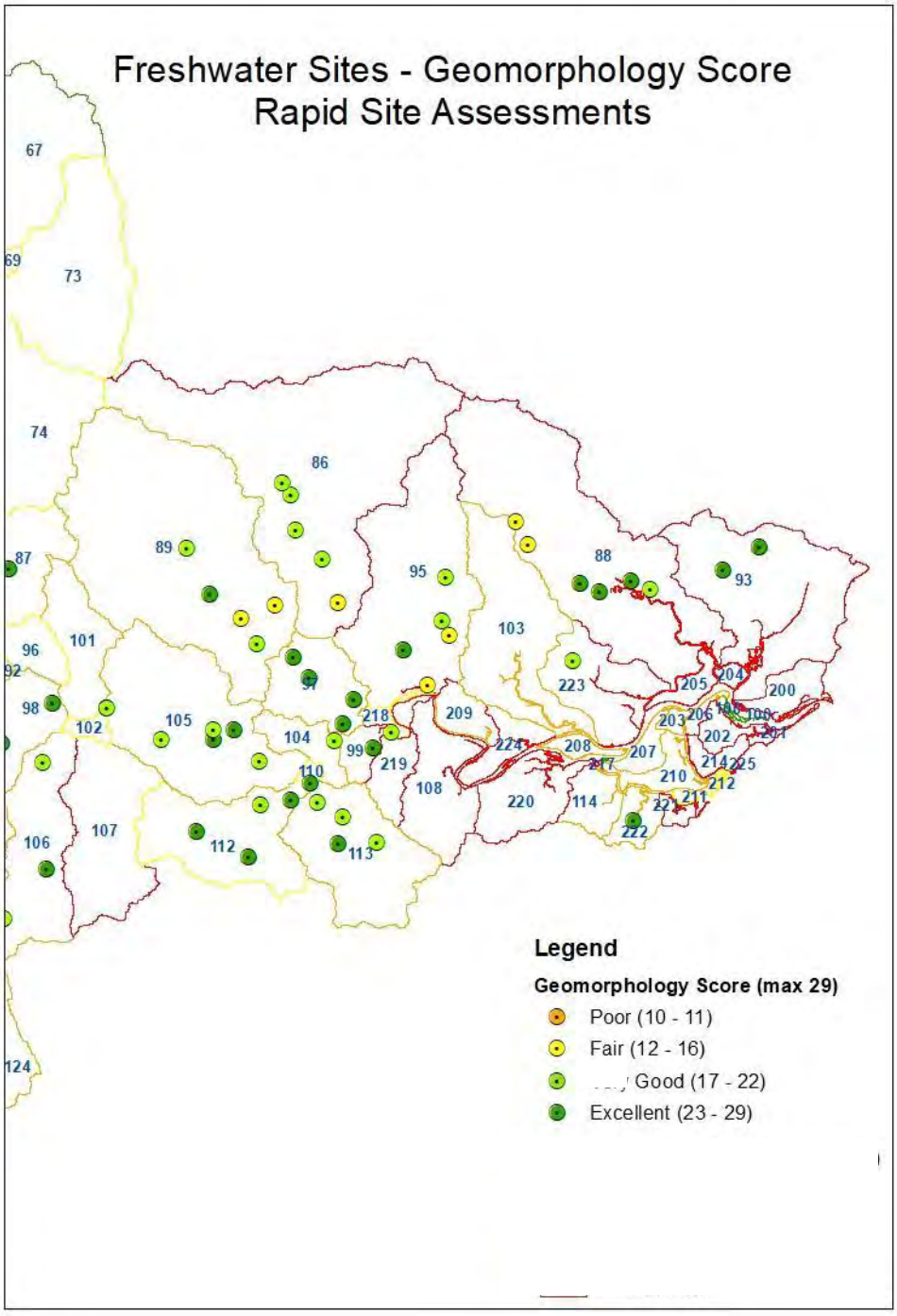
Map A5 - 1 Overall Condition scores from the Rapid Site Assessments at freshwater sites in lower catchment (sum of Land Use, Geomorphic Condition, Instream Condition and Riparian Condition scores). Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



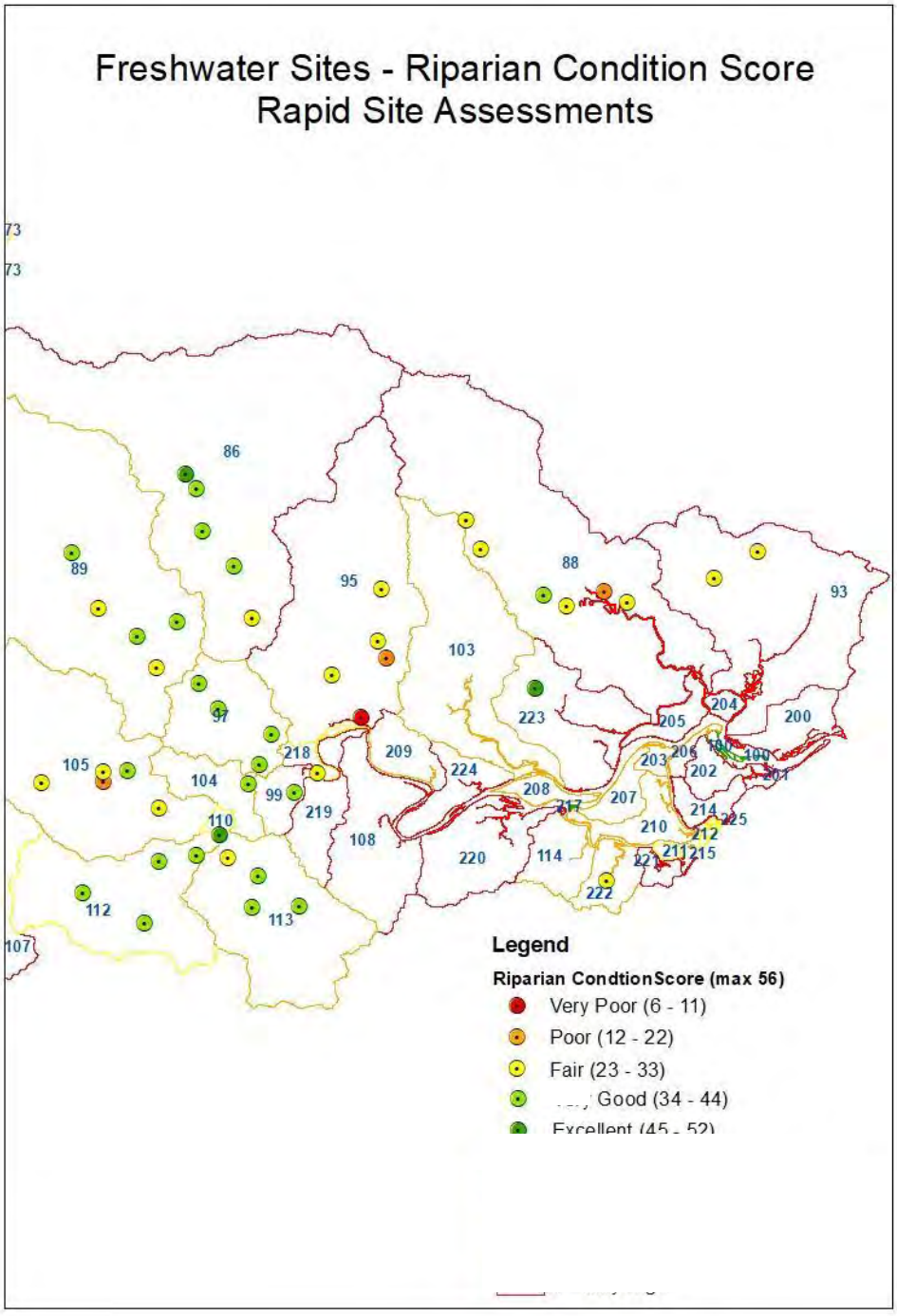
Map A5 - 2 **Land Use pressure scores from Rapid Site Assessments at freshwater sites in lower catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)**



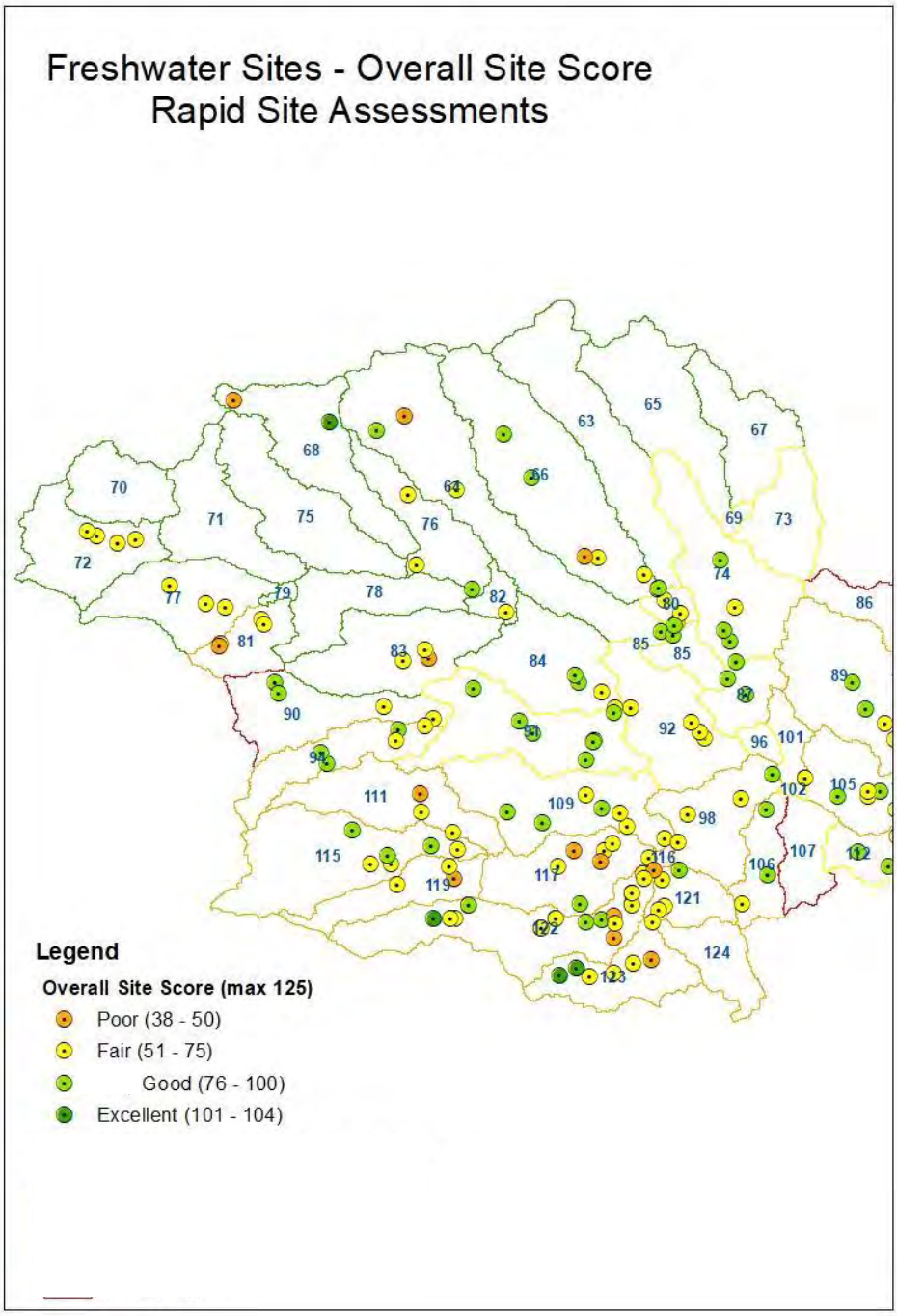
Map A5 - 3 **Instream Condition scores from Rapid Site Assessments at freshwater sites in lower catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)**



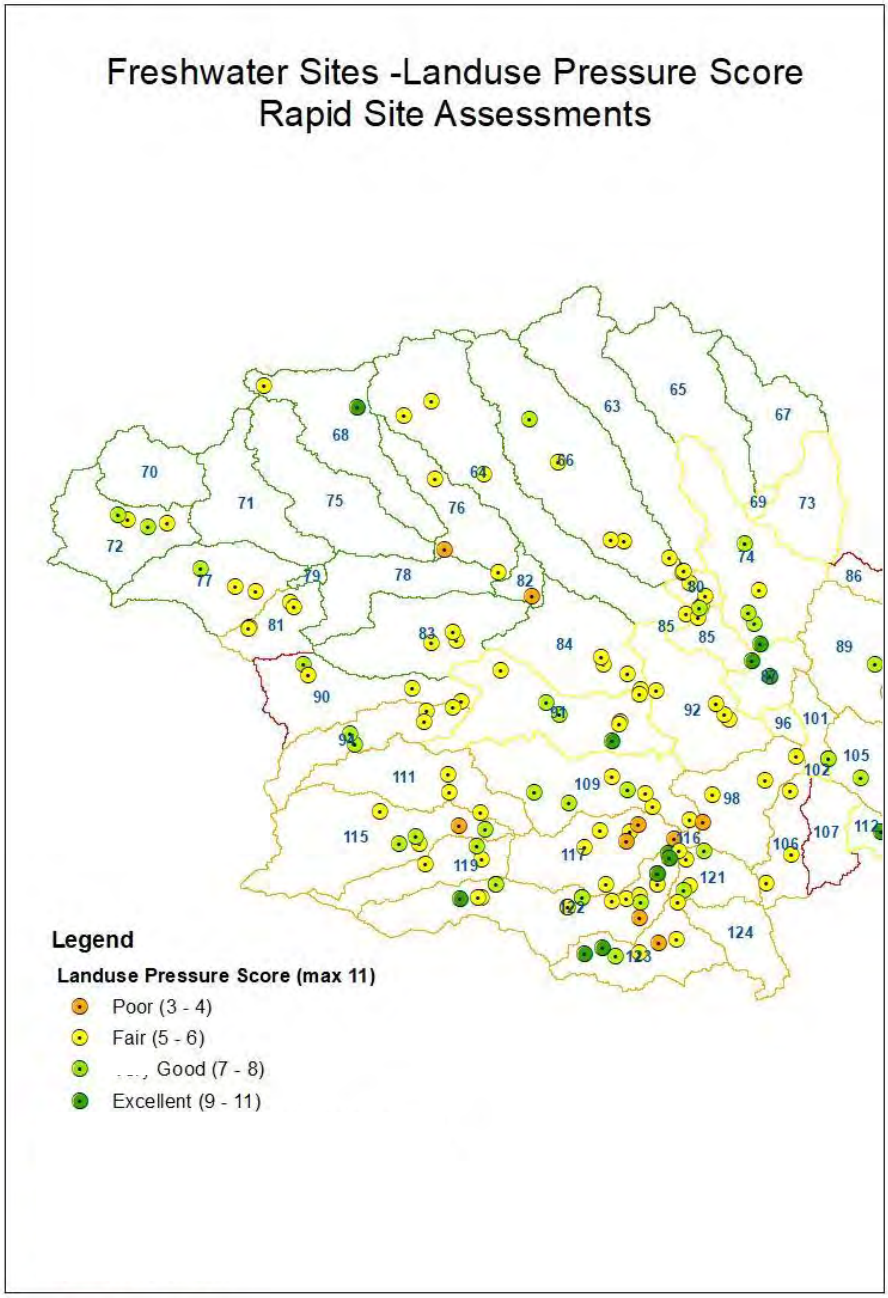
Map A5 - 4 Geomorphic Condition scores from Rapid Site Assessments at freshwater sites in lower catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



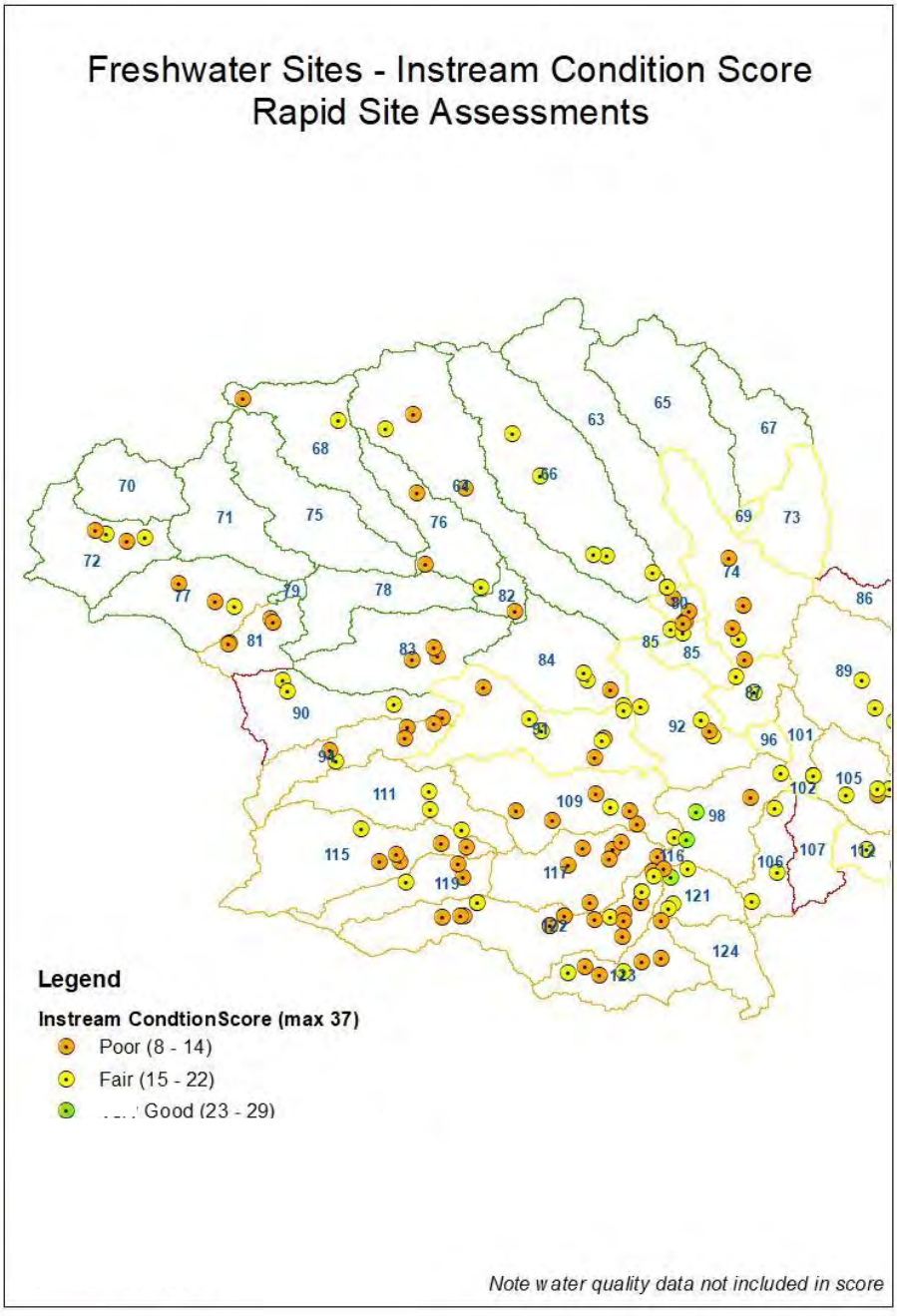
Map A5 - 5 Riparian Condition scores from Rapid Site Assessments at freshwater sites in lower catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



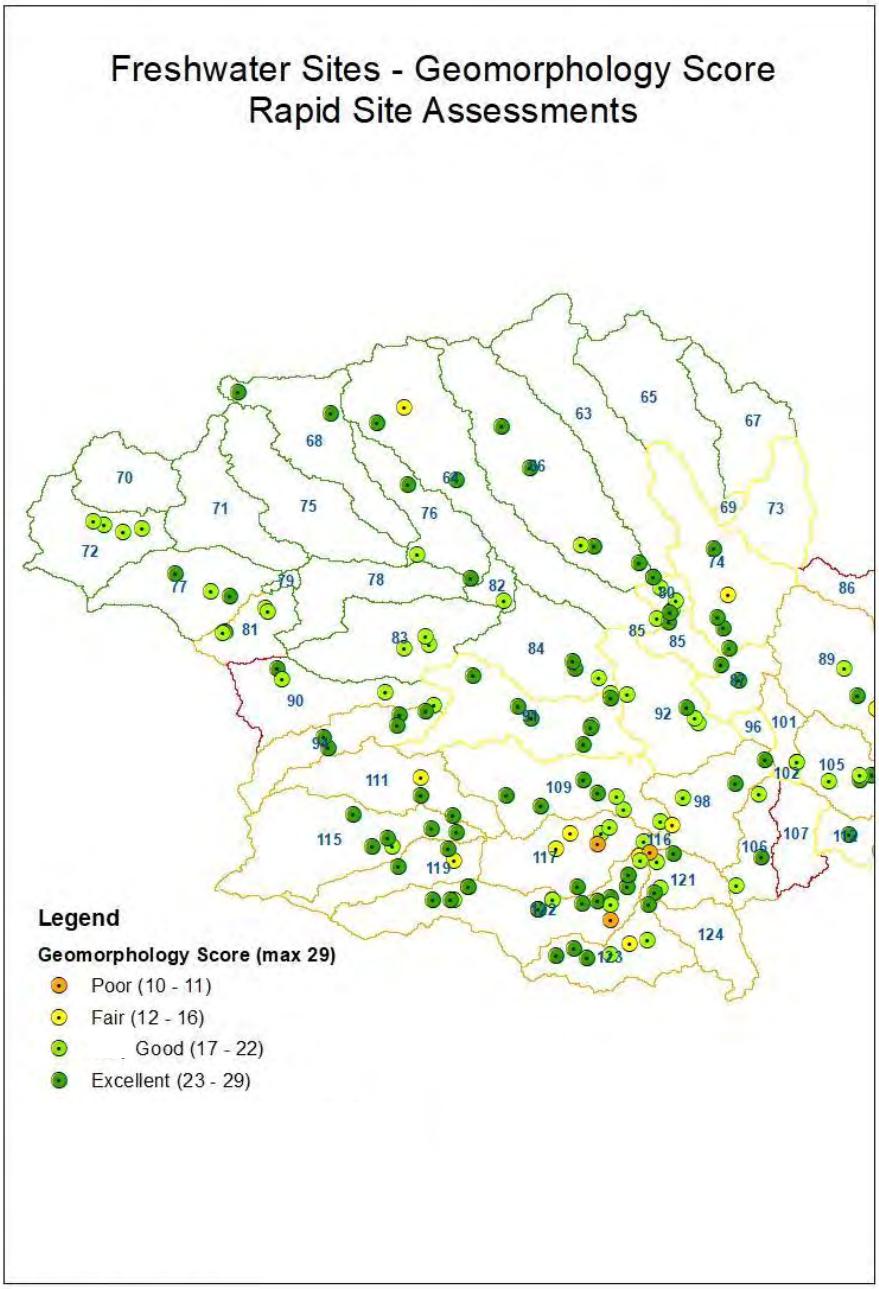
Map A5 - 6 Overall Condition scores from the Rapid Site Assessments for the freshwater sites in upper catchment (sum of Land Use, Geomorphic Condition, Instream Condition and Riparian Condition scores). Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



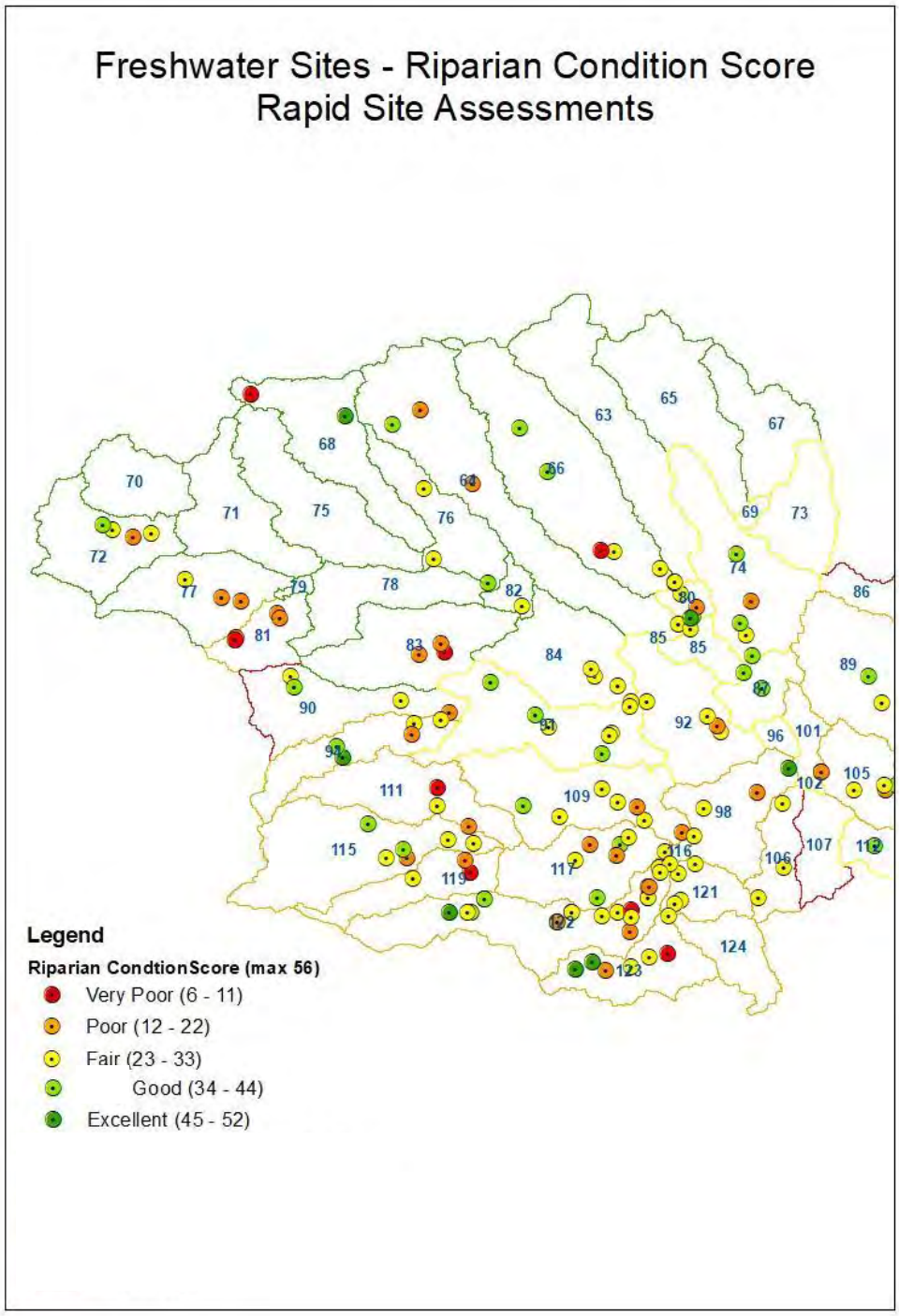
Map A5 - 7 **Land Use pressure scores from Rapid Site Assessments at freshwater sites in upper catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)**



Map A5 - 8 Instream Condition scores from Rapid Site Assessments at freshwater sites in upper catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



Map A5 - 9 Geomorphic Condition scores from Rapid Site Assessments at freshwater sites in upper catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



Map A5 - 10 **Riparian Condition scores from Rapid Site Assessments at freshwater sites in upper catchment. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)**

Appendix 6 Estuarine Catchment Site Scores

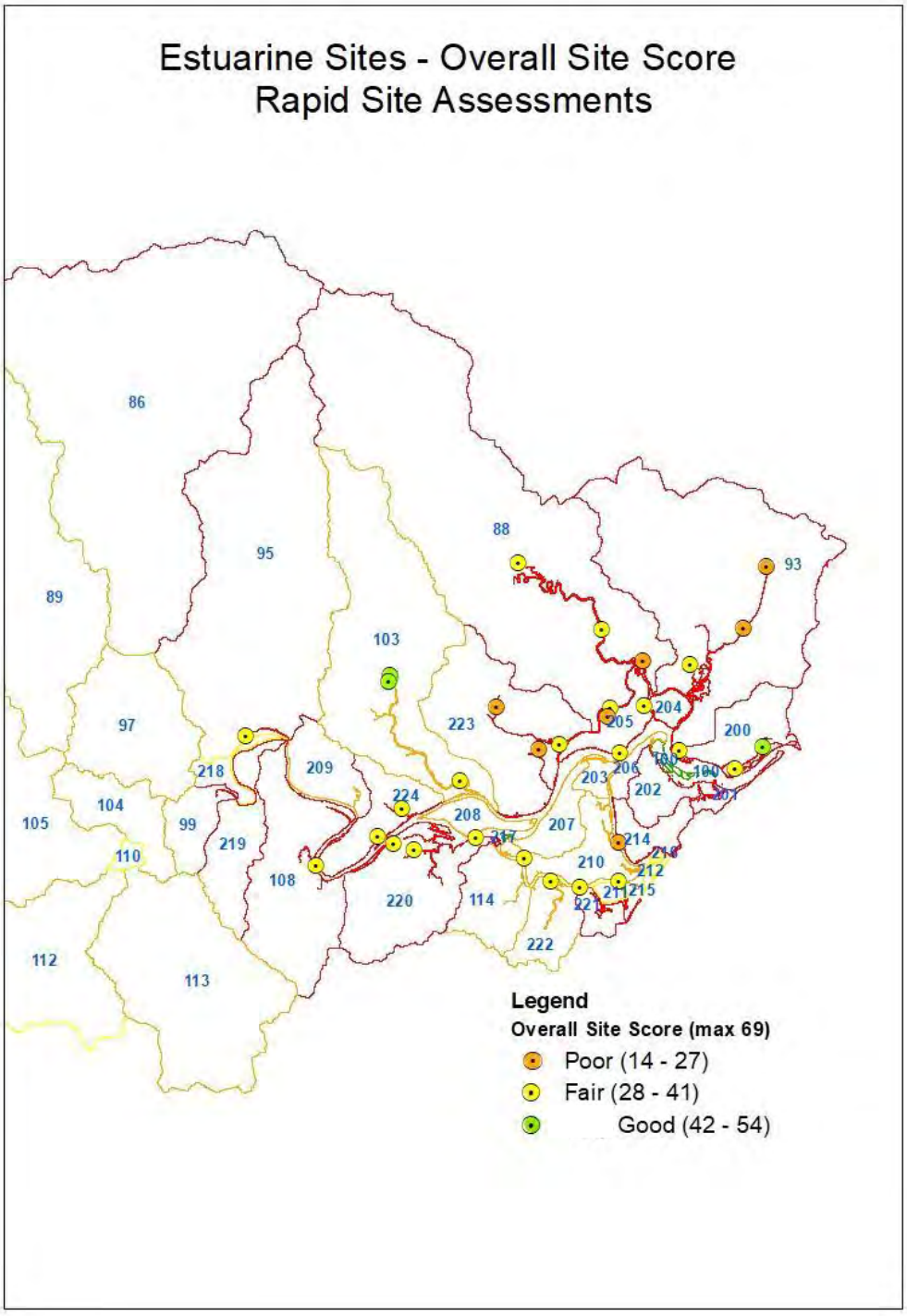
Rapid Site Assessment methodology assigns a grade to scores in each category (Overall Condition, land use pressure, instream condition and riparian condition) for each site (Table A4-2) using the grading scale shown in Table A4-1.

Table A6 - 1 Grading scale applied to scoring of attributes in Rapid Site Assessments in the estuarine catchment

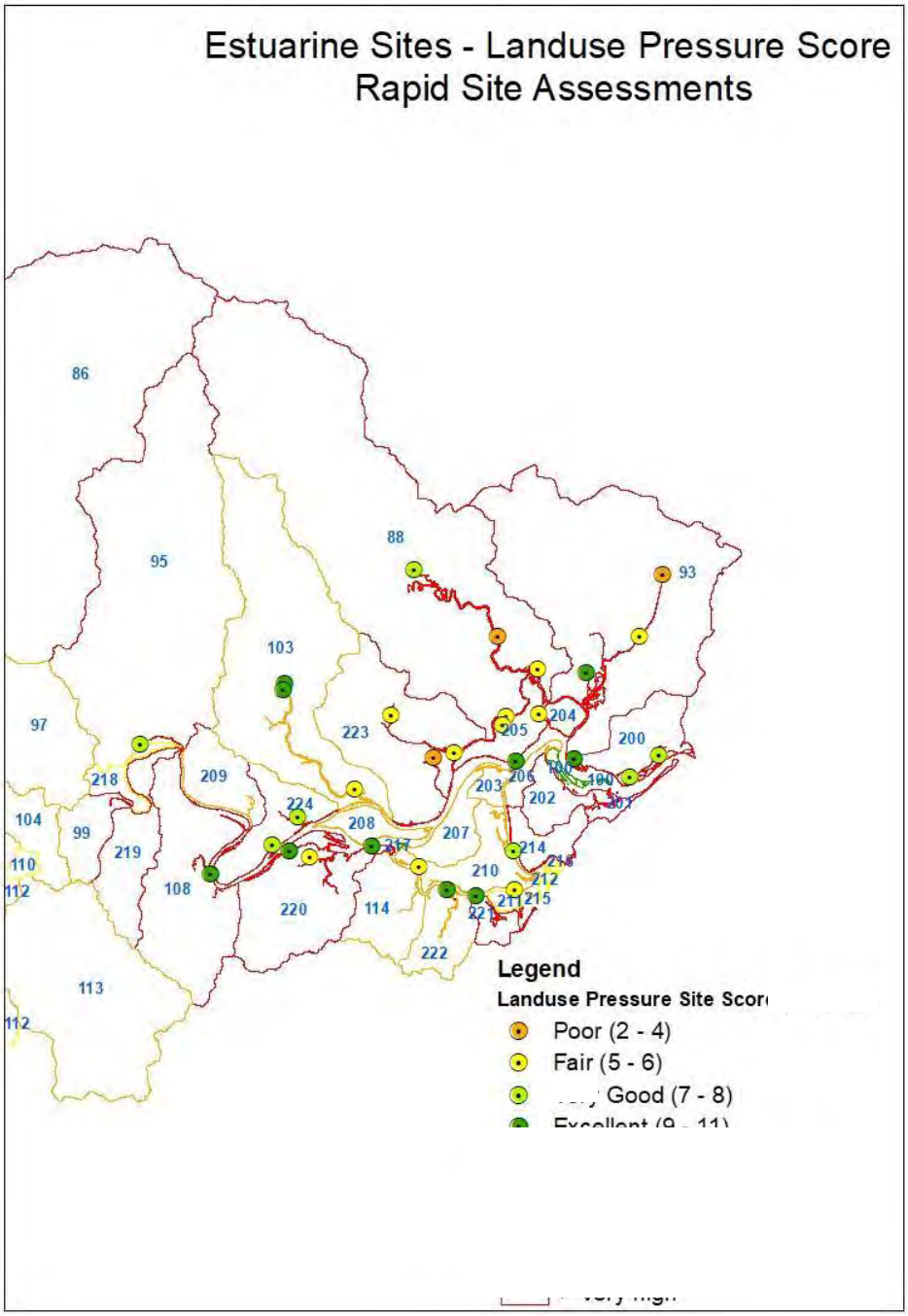
Grade	% of total possible score	Overall Condition score (max 69)	Land Use Pressure score (max 11)	Instream Condition score (max 23)	Riparian Condition score (max 35)
Excellent	>80%	≥55	≥9	≥18	≥28
Good	>60%	≥42	≥7	≥14	≥21
Fair	>40%	≥28	≥5	≥9	≥14
Poor	>20%	≥14	≥2	≥5	≥7
Very Poor	<20%	<14	<2	<5	<7

Table A6 - 2 **A summary of all scores and grades for estuarine sites (Grade – Excellent = dark green =, Good = light green, Fair = yellow, Poor = orange, Very Poor = red). Overall Condition scores, Land Use Pressure score, Instream Condition score and Riparian Condition scores are shown in Maps A4-1 to A4-4.**

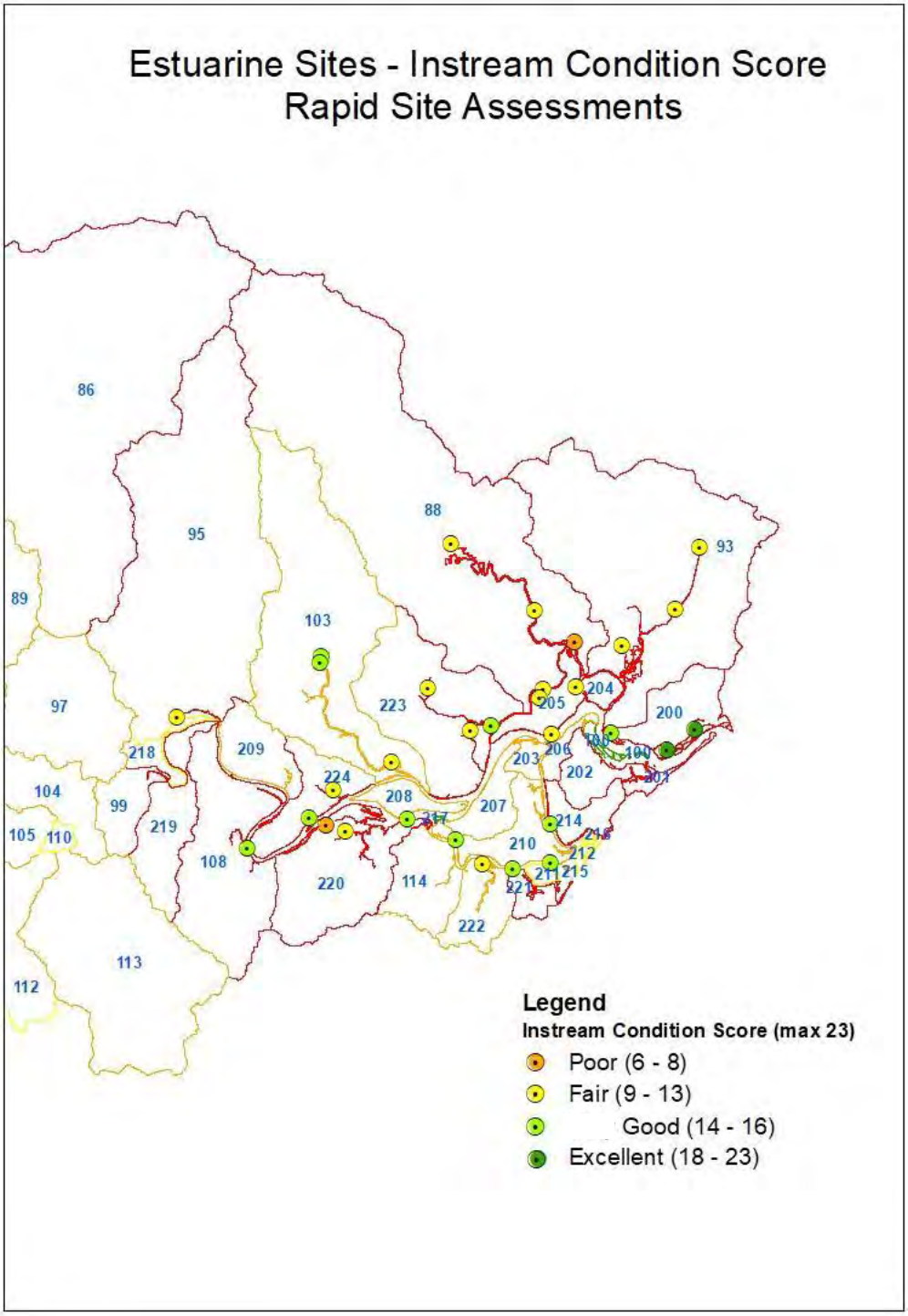
Catchment	SiteID	Overall Condition score (max 69)	Land Use Pressure score (max 11)	Instream Condition score (max 23)	Riparian Condition score (max 35)
Dawson River	103_01	42	11	16	15
	103_02	32	6	13	13
	103_03	43	11	14	18
Manning River	200_01	37	9	14	14
	200_02	42	8	19	15
	200_03	29	8	17	4
	205_01	39	9	11	19
	205_02	36	6	13	17
	205_02b	23	5	9	9
	205_03	29	5	9	15
	210_01	29	5	14	10
	210_02	26	7	14	5
	210_04	37	5	16	16
	220_01	31	6	13	12
	220_02	*30*	9	*8*	13
	220_03	37	9	15	13
	222_02	37	9	14	14
	222_03	34	9	13	12
	224_01	34	8	11	15
	224_02	40	9	14	17
	224_03	34	8	15	11
Lansdowne River	223_02	24	5	13	6
	223_03	*19*	4	*10*	5
	223_04	37	5	15	17
	88_05	27	6	6	15
	88_06	30	7	11	12
	88_07	34	4	13	17
Cattai Creek	93_01b	23	6	10	7
	93_03	22	4	10	8
	93_04	36	11	10	15
Cedar Party	95_03	28	8	13	7



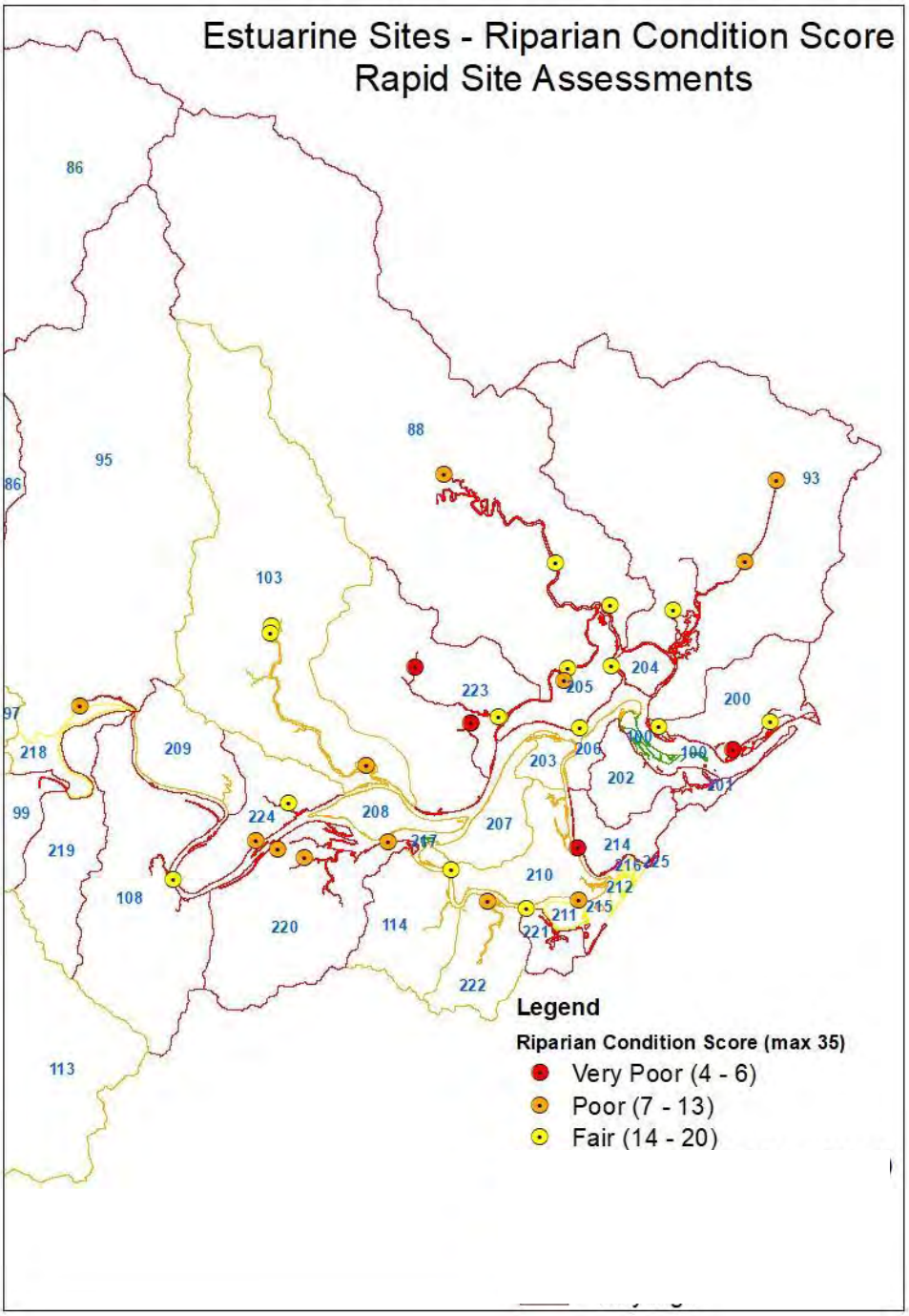
Map A6 - 1 Overall Condition scores from Rapid Site Assessments at 31 estuarine sites (sum of Land Use, Instream Condition and Riparian Condition score). Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



Map A6 - 2 Land Use pressure scores from Rapid Site Assessments at 31 estuarine sites. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



Map A6 - 3 Instream Condition scores from Rapid Site Assessments at 31 estuarine sites. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)



Map A6 - 4 Riparian Condition scores from Rapid Site Assessments at 31 estuarine sites. Borders of subcatchments are colour coded to Likelihood scores for generation rates (TN, TP, TSS - kg/ha/y) from catchment model of preliminary Estuary Health Risk Map (Likelihood; Green-Very Low, Yellow-Low, Orange-Moderate, Red-High)