7 Summary

Via the review of GIS data, relevant literature and anecdotal information it has been possible to develop a preliminary understanding of the potential locations of turbidity generation in the Upper Murrumbidgee catchment.

The aim of the ACWA plan is to develop a plan of works and other activities to improve water quality in the Murrumbidgee River via the mitigation of processes generating turbidity. In order to inform the development of the works and activities plan it is necessary to ground truth the particular issues identified via the prioritisation process.

The list of locations (sites, river reaches and sub-catchments) that have been identified via the preliminary prioritisation process is extensive. The next step in the development of the ACWA Plan will be to review this list and use it as the basis of the field assessment program. When this is completed, detailed plans for priority catchments can occur.

8 Attachment A- GIS Data analysis

8.1 Actions for Clean Water (ACWA) Plan

A consortium of natural resource management organisations in the Upper Murrumbidgee River catchment have come together to prepare an action plan (Actions for Clean Water - ACWA) to enhance surface water quality and reduce turbidity in the Upper Murrumbidgee River catchment across NSW and the ACT.

The project is a partnership between the Murrumbidgee CMA, ACTEW, ActewAGL, ACT WaterWatch, the ACT Natural Resource Management Council and the Upper Murrumbidgee Catchment Coordinating Committee (UMCCC).

The outcomes of the ACWA Plan process will be a plan which will provide direction to all stakeholders in the Upper Murrumbidgee River catchment in achieving improvements in water quality and reducing turbidity by identifying:

- prioritised on-ground actions (with business cases) over the short, medium and long term;
- other actions (community engagement, incentives or policy changes) which contribute directly to the goals of the project.

The ACWA Plan is being prepared using the State, Pressure, Impact and Response model.

Three distinct sources of information are being utilised to consolidate the overall understanding of the condition of the catchment. These are relevant spatial datasets, relevant literature and reports and information held by catchment stakeholders.

This document focuses on one of these three information sources that being a review of the relevant spatial datasets held by the numerous stakeholders throughout the upper Murrumbidgee Catchment.

8.2 Prioritisation Process

In order to identify locations in the catchment where sediment was being mobilised a three phased approach was utilised to collate the relevant information. This information will then be consolidated and utilised to develop a prioritised list of sub-catchments and/or waterway reaches for further investigation.

The three information sources used are:

1) A review of relevant published literature;
2) A review of anecdotal information provided by catchment stakeholders (the project Advisory Group); and
3) A review of relevant GIS based spatial information (this report).

This report summarises the approach used with regard to the review of the relevant spatial information.

8.3 Sources of GIS Data

Given that the ACWA project area is located both within New South Wales and the Australian Capital Territory there has been a requirement to source relevant data for multiple agencies across both jurisdictions.

Table summarises the spatial data collated and the custodian from which the data was sourced.

Table 8-1 GIS Data and Data Custodians

GIS Layer	Data Custodian
Erosion Areas	Murrumbidgee CMA
Erosion Gullies and Stream bank	Murrumbidgee CMA
Geology (NSW)	Murrumbidgee CMA
Geology	Murrumbidgee CMA
Landuse	Murrumbidgee CMA
Subcatchments	Murrumbidgee CMA
Watercourses	Murrumbidgee CMA
SPOT Imagery	NSW Office of Environment and Heritage
Digital Elevation Model	NSW Office of Environment and Heritage
Soil Landscape Mapping	NSW Office of Environment and Heritage
Aerial Photography	NSW Office of Environment and Heritage
ACT Land Use	ACT Conservation Planning and Research
ACT Vegetation Communities	ACT Conservation Planning and Research
ACT Digital Terrain Model	ACT Conservation Planning and Research
ACT Geology	ACT Conservation Planning and Research
ACT National Land	ACT Conservation Planning and Research
ACT Drainage	ACT Conservation Planning and Research
ACT Public Land	ACT Conservation Planning and Research
SedNet	CSIRO
ACT Unsealed Roads Condition	ActewAGL
Murrumbidgee River Styles Data	NSW Office of Water
Soil Regolith Stability Data	NSW Office of Environment and Heritage

Whilst some of the GIS datasets that were provided covered the entirety of the ACWA Project Area (both NSW and ACT) most of datasets were specific to either NSW or the ACT.

This presented problems when attempting to undertake spatial analysis on a whole of project area basis as there was a requirement to utilise different methodologies for the NSW and ACT portions of the ACWA plan area to allow for the differing data availability (see below).

8.4 GIS Analysis

The intent of the GIS analysis was to utilise existing relevant spatial information to identify subcatchments or waterway reaches in the ACWA plan area that had previously been identified as generating turbidity, i.e. being the sources of fine sediment.

Three specific datasets were identified as being the most relevant in this context. These were:

1) The SedNet model data which covered the entirety of the ACWA project area;
2) The NSW Erosion Areas and Erosion Gullies and Streambank datasets provided by the Murrumbidgee CMA; and
3) The Rivers Styles data recently completed by the NSW Office of Water.

Additional information regarding these data sets including key limitation of the data is provided in the following sections.

8.4.1 Relevant Data Sources

8.4.1.1 SedNet Model Data

The SedNet model was developed for the National Land and Water Resources Audit and is a physically-based process model that identifies the major sources, sinks and loads of sediment (Wilkinson, et al 2004). In the model, the river network is divided into a series of nodes which are the basic unit of calculation for the sediment budget.

In order to utilise the SedNet data for this assessment only data relating to turbidity (fine sediment) generation was utilised. Data related to coarse sediment generation and sediment deposition was excluded. Consequently three key datasets were extracted from the SedNet Model and then utilised for the GIS analysis:

- Gully suspended sediment input;
- Hillslope suspended sediment input; and
- Bank suspended sediment input.

These three data sets were then multiplied by the SedNet modelled fine sediment delivery ratio. This parameter is a ratio of current suspended sediment output and input for a particular node. Via its application it is possible to model the amount of sediment has been delivered to the node.

The outcome of this analysis is the provision of three values for modelled fine sediment delivery (gully, hillslope and bank) for each node throughout the ACWA Plan area.

8.4.1.2 NSW Erosion Data

Data was available for the NSW portion of the ACWA Plan area that noted the presence of three types of erosion and then noted the overall severity of the erosion types. This data was collated by

the former NSW Soil Conservation Service utilising a combination of aerial photograph interpretation and then ground truthing. This work was completed in approximately 2003.

The three erosion types noted were:

- Streambank erosion;
- Gully erosion; and
- Sheet erosion.

8.4.1.3 Murrumbidgee River Styles Data

A River Styles Assessment of the Murrumbidgee Catchment was completed by the NSW Office of Water in late 2011. The River Styles framework (Brierley and Fryirs, 2005) is a river characterisation process that allows interpretation of river form and behaviour from which appropriate management approaches can be formulated. Using the River Styles framework all of the waterways within the Murrumbidgee CMA region were classified into a particular river 'style' and then an assessment was made of the actual geomorphic condition of that waterway reach versus benchmark (natural and intact) conditions.

A key outcome of the River Styles process was the assessment of the Recovery Potential for each river reach. This metric is a measure of the stream reach's capacity to return to a good condition (GHD, 2011). The River Styles process identified seven categories of recovery potential and notes specific criteria to define each. Three of these categories are of direct relevance because one (or more) of the criteria in their respective definitions relates specifically to the generation of sediment.

Table 8-2 Criteria relevant to turbidity generation associated with River Styles Recovery Potential Categories

Recovery Potential	Relevant Criteria
Strategic	A headcut or bend cutoff present or imminent or; A site of recent bed material extraction, vegetation clearing or large woody debris removal or; A site of accelerated bank erosion or a gully that is supplying excess sediment to downstream reaches or
Moderate Recovery	Excess sediment supply in moderate slugs.
Low Recovery	Excess sediment supply large and continuous.

The River Styles data also considers any uncertainty in the attribution of River Styles via the inclusion of a confidence metric (High, Moderate or Low) for all reaches. This process recognised that in some circumstances there is still a degree of uncertainty present.

Information relating to river reaches noted as having either low or moderate recovery potential was included in the GIS analysis. Whilst information relating to sites with strategic recovery potential has not been included in the analysis but will be considered in the prioritisation process.

8.4.2 Data Suitability

The three data sets proposed to be used to assist the prioritisation process are more or less suitable for this purpose. Consideration has been made of the type of data (modelled versus observed) and the age of the data.

The SedNet data is modelled data from 2004, the NSW Erosion Data is field verified data from the period leading to 2003 whilst the River Styles data is modelled (and partially ground truthed) data from 2011. The River Styles data also considers any uncertainty in the data via the incorporation of a value for confidence.

Given the above, the method proposed for the analysis of the GIS data will place a greater emphasis on the River Styles data due to its currency than will be given to the two other data sets. The relative confidence of the River Styles data will also be considered to ensure that any uncertainty in that data set is carried forward into the analysis.

8.4.3 Data Coverage

Whilst the three relevant datasets were available for the NSW portion of the ACWA Plan area the NSW Erosion Data was not available for ACT.

On this basis two alternate GIS methodologies were used, one for the NSW portion of the ACWA plan area incorporating the three relevant data sets and a second for the ACT portion of the ACWA Plan area.

Further detail on these approaches is contained in the following sections.

8.5 Methodology

As noted above, alternate methodologies for the GIS analysis have been required for the NSW and ACT portions of the catchment in order to consider the differing data availability for the two jurisdictions.

The methodology utilised for each jurisdiction was undertaken in two stages to reflect the differing levels of suitability of the data being used. The following figure presents the steps undertaken in the analysis and further detail is contained in the following sections.

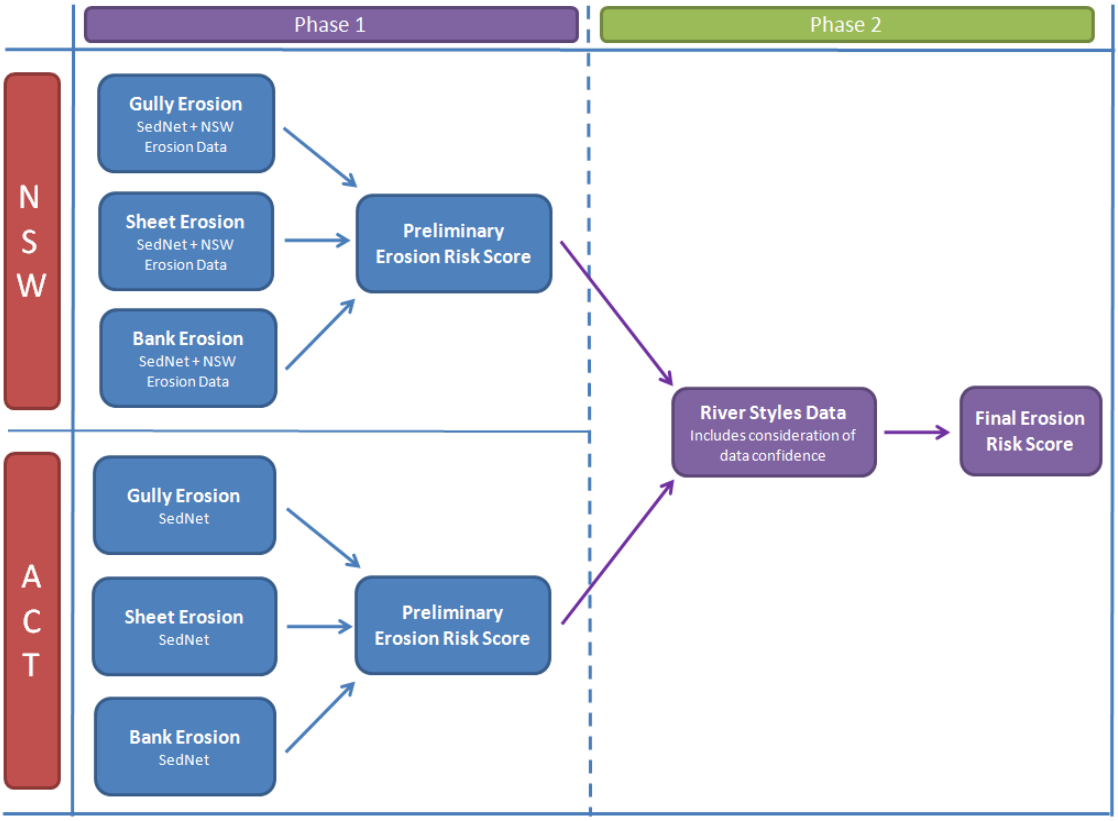


Figure 8-1 GIS Analysis Methodology

8.5.1 Phase 1 of Analysis

8.5.1.1 NSW Methodology

The initial phase of the GIS analysis for NSW considered the data derived from the SedNet model and the NSW Erosion Data. Given that these data sources consisted only of modelled data (SedNet) or older data (NSW Erosion Data) it was assumed that there is a degree of uncertainty relating to these datasets.

The initial phase of the GIS analysis involved the comparison of each of the three types of erosion information (gully, sheet and streambank) from the two nominated data sets. Individual comparisons for each erosion type were completed with the outcomes collated to produce a cumulative erosion risk score for each SedNet Model node (river reach).

The SedNet Model node (river reach) was utilised as the unit for the analysis as it represented the greatest level of detail at which the relevant data was able to be interrogated.

Gully Erosion

For the SedNet data, each river reach was given a ranking of high, moderate or low based on the modelled volume of Gully suspended sediment input (tonnes / year/ ha). For the NSW Erosion data each river reach was given a ranking of high, moderate or low based on the ratio of the area of extreme or severe gully erosion mapped in the catchment relative to the total area of the catchment.

The outcomes of the two rankings were then compared according to the following table with a score being generated for each river reach based on their respective ranking in terms of both the SedNet data and the NSW Erosion data. Scores were highest for reaches that were identified as being high in both data sets and scores were lowest for sites identified as low in both data sets.

Table 8-3 Phase 1 Gully Erosion Scores (NSW)

		NSW Erosion Data: Area of 'Extreme' and 'Severe Gully Erosion / area of subcatchment. Values then divided equally into following ranks:		
		HIGH	**MODERATE**	**LOW**
SedNet: Gully suspended sediment (tonnes / year / ha) *Values equally divided into rank	**HIGH**	4pts	3pts	2pts
	MODERATE	3pts	2pts	1pt
	LOW	2pts	1pt	-

Sheet Erosion

For the SedNet data, each river reach was given a ranking of high, moderate or low based on the modelled volume of Hillslope suspended sediment input (tonnes / year/ ha). For the NSW Erosion data each river reach was given a ranking of high, moderate or low based on the ratio of the area of extreme or severe sheet erosion mapped in the catchment relative to the total area of the catchment.

The outcomes of the two rankings were then compared according to the following table with a score being generated for each river reach based on their respective ranking in terms of both the SedNet data and the NSW Erosion data. Scores were highest for reaches that were identified as being high in both data sets and scores were lowest for sites identified as low in both data sets.

Table 8-4 Phase 1 Hillslope / Sheet Erosion Scores (NSW)

		NSW Erosion Data: Area of 'Extreme' and 'Severe Sheet Erosion / area of subcatchment. Values then divided equally into following ranks:		
		HIGH	**MODERATE**	**LOW**
SedNet: Hillslope suspended sediment (tonnes / year / ha) *Values equally divided into rank	**HIGH**	4pts	3pts	2pts
	MODERATE	3pts	2pts	1pt
	LOW	2pts	1pt	-

Streambank Erosion

For the SedNet data, each river reach was given a ranking of high, moderate or low based on the modelled volume of Bank suspended sediment input (tonnes / year/ ha). For the NSW Erosion data each river reach was given a ranking of high, moderate or low based on the ratio of the length of streambank erosion mapped in the catchment relative to the total area of the catchment.

The outcomes of the two rankings were then compared according to the following table with a score being generated for each river reach based on their respective ranking in terms of both the SedNet data and the NSW Erosion data. Scores were highest for reaches that were identified as being high in both data sets and scores were lowest for sites identified as low in both data sets.

Table 8-5 Phase 1 Streambank Erosion Scores (NSW)

		NSW Erosion Data: Length of Streambank erosion / area of subcatchment. Values then divided equally into following ranks:		
		HIGH	**MODERATE**	**LOW**
SedNet: Bank suspended sediment (tonnes / year / km) *Values equally divided into rank	**HIGH**	4pts	3pts	2pts
	MODERATE	3pts	2pts	1pt
	LOW	2pts	1pt	-

Collated Outcomes

The second step in the methodology was the calculation of a Preliminary Erosion Risk score for each SedNet Model node (river reach). The Preliminary Erosion Risk score was determined to be the sum of Gully Erosion Score, Sheet Erosion Score and Streambank Erosion Score with the Total Erosion Risk Ranking being defined according to the following table.

Table 8-6 Preliminary Erosion Risk Ranking - NSW

Preliminary Erosion Risk Ranking	Preliminary Erosion Risk Score
Very High	10-12pts
High	7-9pts
Moderate	4-6pts
Low	0-3pts

8.5.1.2 ACT Methodology

Given that only the SedNet data was available for the ACT portion of the ACWA Plan area the method for calculation of the Preliminary Erosion Risk Ranking for each of the SedNet Model nodes (river reaches) was less complex. The three Erosion Risk Scores were determined utilising the values contained within the SedNet data.

Gully Erosion

Each river reach was given a ranking of high, moderate or low based on the modelled volume of Gully suspended sediment input (tonnes / year/ ha).

Table 8-7 Phase 1 Gully Erosion Scores (ACT)

SedNet: Gully suspended sediment (tonnes / year / ha) *Values equally divided into rank	**HIGH**	4pts
	MODERATE	3pts
	LOW	2pts

Sheet Erosion

Each river reach was given a ranking of high, moderate or low based on the modelled volume of Hillslope suspended sediment input (tonnes / year/ ha).

Table 8-8 Phase 1 Sheet Erosion Scores (ACT)

SedNet: Hillslope suspended sediment (tonnes / year / ha) *Values equally divided into rank	**HIGH**	4pts
	MODERATE	3pts
	LOW	2pts

Streambank Erosion

Each river reach was given a ranking of high, moderate or low based on the modelled volume of Bank suspended sediment input (tonnes / year/ ha).

Table 8-9 Phase 1 Streambank Erosion Scores (ACT)

SedNet: Bank suspended sediment (tonnes / year / km) *Values equally divided into rank	**HIGH**	4pts
	MODERATE	3pts
	LOW	2pts

Collated Outcomes

The second step in the methodology was the calculation of a Preliminary Erosion Risk score for each SedNet Model node (river reach). The Preliminary Erosion Risk score was determined to be the sum of Gully Erosion Score, Sheet Erosion Score and Streambank Erosion Score with the Preliminary Erosion Risk Ranking being defined according to the following table.

Table 8-10 Preliminary Erosion Risk Ranking - ACT

Preliminary Erosion Risk Ranking	Preliminary Erosion Risk Score
Very High	11-12 pts
High	9-10 pts
Moderate	7-8 pts
Low	6 pts

8.5.2 Consistency between ACT and NSW

The difference in data coverage between NSW and the ACT has meant that a different analysis method has been required for the two areas. Consequently there is a requirement to standardise the outcomes of Phase one of the analysis. In order to do this the Preliminary Erosion Risk Scores were standardised as follows.

Table 8-11 Standardised Preliminary Erosion Risk Scores

Preliminary Erosion Risk Ranking	Preliminary Erosion Risk Score - NSW	Preliminary Erosion Risk Score - ACT	Standardised Preliminary Erosion Risk Score
Very High	10-12pts	11-12 pts	**4 pts**
High	7-9pts	9-10 pts	**3 pts**
Moderate	4-6pts	7-8 pts	**2 pts**
Low	0-3pts	6 pts	**1 pt**

8.5.3 Phase 2 of Analysis

Phase 2 of the GIS analysis involved the incorporation of data derived from the River Styles project. Specifically stream reaches were considered that had been identified as generating turbidity via their definition as having either low recovery potential ("*excess sediment supply large and continuous*") or moderate recovery potential ("*excess sediment supply in moderate slugs*").

The River Styles data also included a confidence value for each reach (high/medium/low).

Both of these attributes of the River Styles data were considered when utilising this data for the analysis with greater emphasis being placed on higher confidence data as per the following table.

Table 8-12 Weighting of River Styles Data based on Recovery Potential and Confidence

		River Styles Recover Potential	
		LOW	MODERATE
Confidence	HIGH	5	4
	MODERATE	4	3
	LOW	3	2

Using this approach the river reaches with lowest recovery potential (worst condition) and the highest confidence in that data are given the highest value while sites in better condition (moderate recovery potential) and/or less confidence in that information are given a lower value.

The next step in the analysis was then to consider the River Styles information for each river reach (SedNet node) in the ACWA area. For each river reach the following steps were taken:

1) The total length of waterway of each combination of Confidence and Recovery potential was identified from the River Styles data;

2) These lengths of waterway were then multiplied by the confidence/recovery potential weighting (as per Table);
3) The values created via step 2 were then added together for each river reach (SedNet Node);
4) The value created via step 3 was then divided by the total length of waterway in each River Reach (SedNet node) to provide a weighted ratio of waterway condition.

These ratios were then broken into quartiles with highest 25% of values being ranked as Very High through to the lowest 25% of values being ranked as Low. River Styles Erosion Risk Scores were then assigned to allow the River Styles data to be combined with the outcomes of Phase One of the analysis.

Where River Reaches did not contain any lengths of waterway mapped as either low recovery potential of moderate recovery potential they were also added to the Low Rank.

Table 8-13 River Styles Erosion Risk Score

River Styles Data Ranking	Weighted Ratio of Waterway Condition	River Styles Erosion Risk Score
Very High	1st Quartile of SedNet nodes (top 25%)	3 pts
High	2nd Quartile of SedNet nodes	1 pts
Moderate	3rd Quartile of SedNet nodes	0 pts
Low	4th Quartile of SedNet nodes (bottom 25%)	-1 pts

When assigning values to the River Styles Erosion Risk Score further consideration has been made of the relative quality of the differing data sets with more importance placed on the River Styles data primarily due to its currency.

The final step in Phase Two of the GIS Analysis is the incorporation of the River Styles Data to the outputs of Phase One of the Analysis (the SedNet and NSW Erosion data). The outcomes of this step are noted in the following table.

Table 8-14 Combined Erosion Risk Ranking (including River Styles data)

		River Styles Erosion Risk Score (River Styles Data) Length of all River Styles watercourses in subcatchment with 'Low' and 'Moderate' recovery potential / length of all River Styles watercourses in subcatchment. Values then divided equally into following ranks:			
		VERY HIGH (3)	HIGH (1)	MODERATE (0)	LOW (-1)
Preliminary Erosion Risk Score – Phase One (Combined SedNet & NSW Erosion risk ranking) *Values equally divided into rank	VERY HIGH (4)	7pts	5pts	4pts	3pts
	HIGH (3)	6pts	4pts	3pts	2pts
	MODERATE (2)	5pts	3pts	2pts	1pt
	LOW (1)	4pts	2pts	1pt	0pts

Table 8-15 Final Erosion Risk Scores and Rankings

Final Erosion Risk Ranking	Final Erosion Risk Score
Very High	6-7pts
High	4-5pts
Moderate	2-3pts
Low	0-1pts

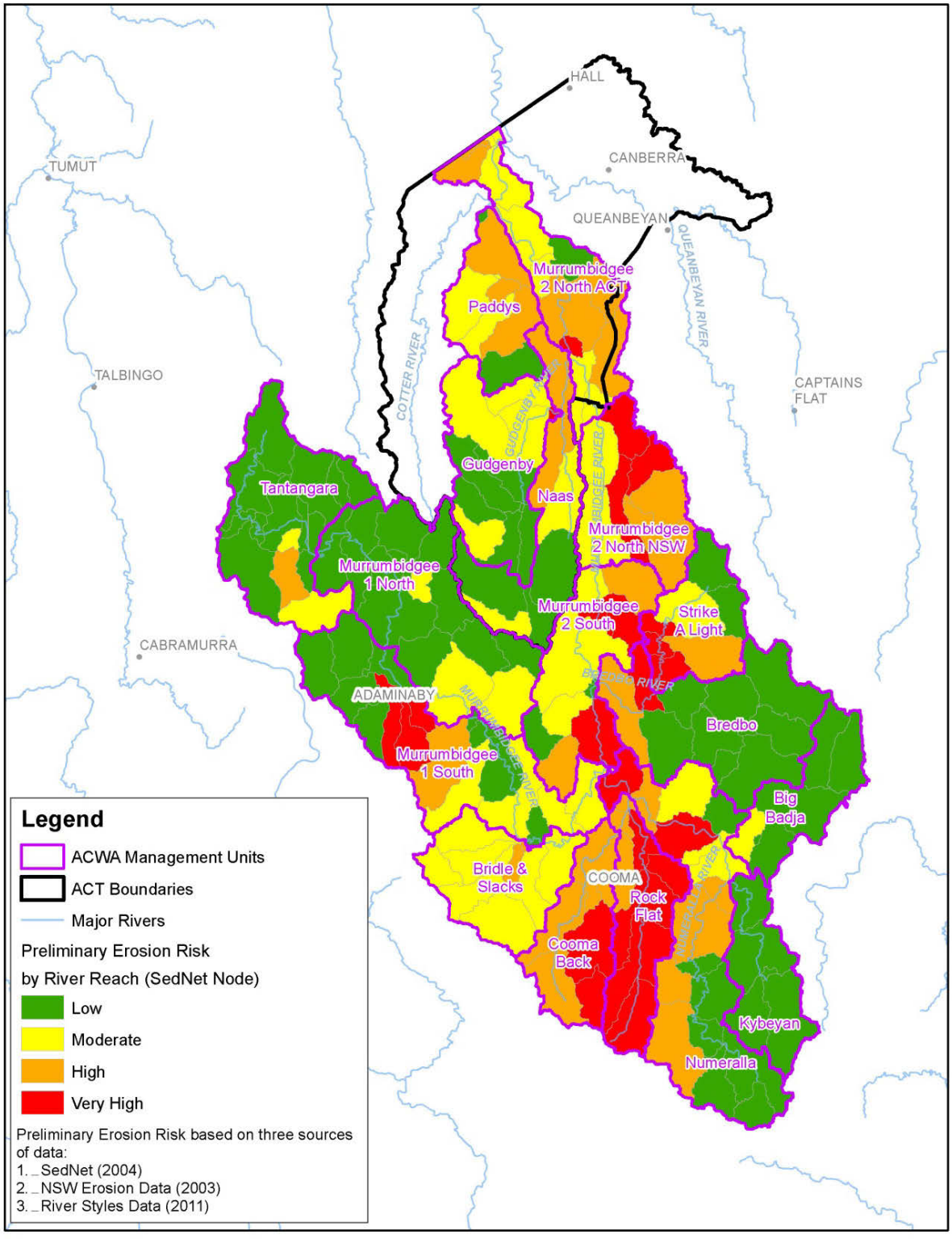
The River Styles data was given greater emphasis than the other two data sets given its contemporary nature (prepared in 2011) and the fact that it has included field verification rather than just being modelled data.

8.5.4 Outputs from GIS analysis

At the conclusion of the GIS analysis the Final Erosion Risk Ranking had been determined for all SedNet Model nodes (river reaches) within the ACWA Plan Area. This information is shown in Figure 8-2. In total there are in excess of 230 SedNet Model nodes (river reaches) displayed on this map.

It is intended that the outputs of this GIS analysis be utilised to assist in the prioritisation of sub-catchments within the ACWA Plan area for further assessment. In order for the Total Erosion Risk Ranking to be utilised for the prioritisation process it is necessary to aggregate the data to such a scale that the data is meaningful.

The final step in the GIS analysis was to divide the ACWA Plan area into a series of management units that are based on the watersheds within the Plan area. An average Total Erosion Risk Ranking was then calculated for each of ACWA management unit. This information is displayed in Figure 8-3.



Preliminary Erosion Risk by River Reach

0 5 10 20 Kilometres

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Figure 8-2 Final Erosion Risk Ranking by SedNet Node

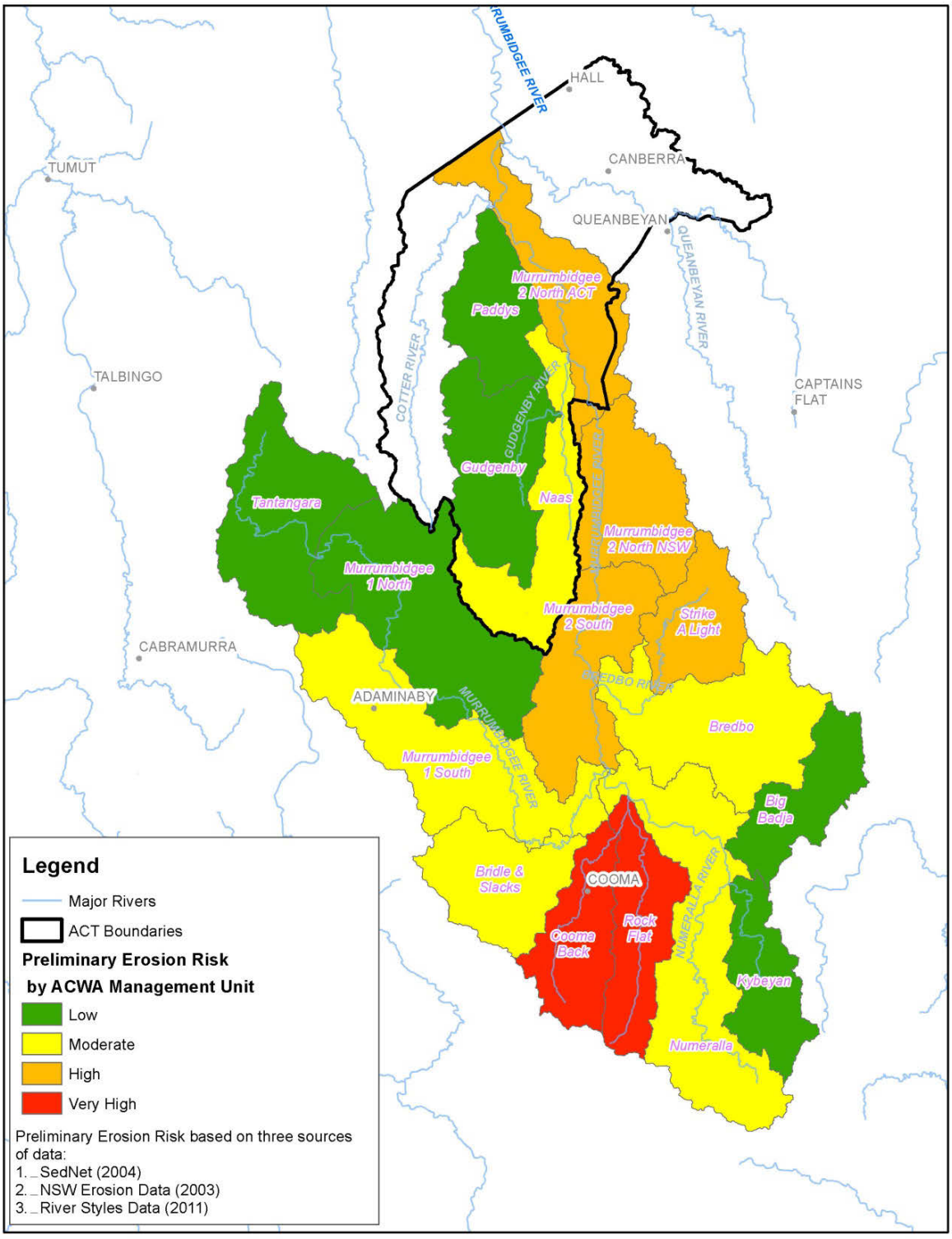

Figure 8-3 Total Erosion Risk Ranking by ACWA Management Units

8.6 References

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