5 Results

5.1 Management units

Through field interrogation, common likelihood and consequence ratings have been determined for specific waterways within each Management Unit. The Likelihood rating is essentially determined by looking at the proximity of sediment erosion issues to an extraction point and rating of sediment connectivity. For consequence ratings, specific erosion issues have been identified, and then a rating applied depending on the specific issue at hand. Table 14 outlines the results of field assessments.

Table 14 Likelihood and consequence ratings for each management unit based on field assessments

Management Unit	Likelihood	Consequences Gully erosion	Consequences Bank erosion	Consequences Sediment bars	Consequences Fine sediment	Consequence Bed deepening
Big Badja						
Stockyard Creek (Site 1)	3	4	3	-	4	5
Bredbo River						
River downstream of Buchan Creek (Site 2)	4	-	2	2	2	2
Buchan Creek and Tributaries (Site 3)	4	4	4	-	4	4
Bredbo Gullies (Sites 4, 5 and 7)	4	4	4	-	4	4
Bredbo River (Site 6)	4	-	4	4	4	4
Bredbo/Murrumbidgee River confluence (Site 8)	4	-	1	1	1	1
Cooma Back Creek						
Bunyan Gully (Sites 9 and 10)	2	3	3	-	3	3
Cooma Back Creek upstream of town (Site 11,)	2	2	2	2	2	2
Cooma Back Creek urban (Site 12)	2	-	2	2	2	2
Cooma Back Creek (Site 13)	2		3			
Cooma Back Creek (Site 14)	2		3			
Cooma Creek (Sites 15 and 16)	2	-	2	2	2	2
Cooma Creek (downstream of Cooma)(Site 17)	2	-	2	2	2	2
Lower Cooma Creek (Site 18)	4	-	4	2	4	2
Gudgenby River						
Gudgenby River (Sites 19, 21 and 22)	4	-	4	4	4	4
Spring Station Creek (Site 20)	4					
Honeysuckle Creek (Site 23)	4	-	5	5	5	5
Kybeyan River						
Kybeyan gully tributary (Site 24)	2	2	2	2	2	2
Kybeyan River (Site 25)	2	2	2	2	2	2
Murrumbidgee 1 South						
Goorudee Rivulet (Site 26)	2	-	3	3	3	3
Murrumbidgee River tributary gullies (Site 27)	2	3	3	3	3	3
Wambrook Creek (Site 28)	3	2	2	2	2	2

Management Unit	Likelihood	Consequences Gully erosion	Consequences Bank erosion	Consequences Sediment bars	Consequences Fine sediment	Consequence Bed deepening
Wambrook Creek (upstream of Snowy Mtns Hwy) (Site 29)	4					3
Wambrook Creek tributary (Site 30)	4		2			
Murrumbidgee 2 North NSW						
Ryries Creek (Site 31)	2	3	3	1	3	3
Murrumbidgee 2 North ACT						
Reedy Creek and tributary (Sites 32 and 33)	2	3	3	3	3	3
Lanyon Canyon (Site 34)	4		5			
Murrumbidgee 2 South						
Gungoandra Creek (Site 35)	4	4	3	2	4	4
Murrumbidgee River tributary gullies (Sites 36 and 39)	3	2	2	2	2	2
Murrumbidgee River Bumbalong (Site 37)	4	-	4	4	4	-
Murrumbidgee River Billilingra (Site 38)	4	-	4	4	4	-
Murrumbucca Creek (Site 40)	4	4	4	4	4	4
Naas						
Naas River (Sites 41, 43 and 45)	4	-	4	4	4	4
Naas River and gullies (Site 42)	4	4	4	4	4	4
Naas tributary (Site 44)	4	4	4	4	4	4
Numeralla						
Numeralla River Gully (Site 46)	2					
Carlaminda Road Gully (Site 47)	3	2				
Numeralla River (township and upstream) (Site 48)	4	-	2	2	2	-
Numeralla River Rose Valley district (Site 49)	4	-	2	2	2	-
Lower Numeralla River(Site 49)	4	-	2	2	2	-
Rose Valley Creek (Site 50)	3	3	3	3	3	3
Rose Valley gullies(Site 50)	3	2	2	2	2	2
Paddys						
Tidbinbilla Creek (Site 51)	4		5	5		
Punchbowl Creek (Site 52)	2	-	3	3	3	3
Paddys River (Site 53)	3	-	3	3	3	3
Rock Flat Creek						
Upper Rock Flat Creek (Site 54)	2	2	2	2	2	2
Lower Rock Flat Ck (Site 55)	3	3	3	3	3	3
Strike a Light Creek						
Strike a Light Creek (Site 56)	3	-	2	2	2	2
Wangrah Creek (Site 57)	4	4	4	4	4	4

5.2 Prioritisation outcomes

From the assessment process it is clear there are a number of erosion issues across the catchment. Fine sediment is the main risk to water quality.

The proximity of an issue to the extraction point, or worded another way, the likelihood an issue will impact on water quality downstream is another significant issue.

Finally for sites where there is the potential for ongoing erosion processes to generate large volume of sediment rapidly (i.e. high trajectory rating) the risk increases accordingly.

Using this process, the highest priority issues were identified, as outlined in Table 15.

Table 15 Priority Point Source Sites

Risk	Sites
Extreme (64-125)	Bank Erosion Lower Buchan Creek (Site 2) Gully, Bed & Bank Erosion Buchan Creek (Site 3) Channel Deepening Bredbo Gully (Site 4) Sediment Transfer Bredbo River Gully (Site 5) Bank Erosion Spring Station Creek (Site 20) Bank Erosion Lanyon Canyon (Site 34) Bank Erosion Murrumbucca Creek (Site 40) Bed & Bank Erosion Naas River (Site 41) Sediment Transport Naas River Tributary (Site 42) Bank Erosion Naas River (Site 43) Bank Erosion Naas River (Site 45) Bank Erosion Tidbinbilla Creek (Site 51)
Very High (43-63)	Gully Erosion Stockyard Creek (Site 1) Bank Erosion Lower Cooma Creek (Site 18) Bank Erosion Lower Gudgenby River (Site 19) Bank Erosion Gudgenby River (Site 21) Bank Erosion Honeysuckle Creek (Site 23) Bank Erosion Murrumbidgee River (Site 38) Sediment Transport Naas Tributary Gully (Site 44) Bank Erosion Lower Rose Valley (Site 50)

6 Site specific details

It was clear from the aerial and ground based assessments that major sediment sources are originating in the Numeralla, Bredbo and Naas catchments. Localised erosion issues were also identified. By using the risk assessment approach it has then been possible to look at the likely impact of specific issues based on their proximity to the water extraction points, and the likelihood that sediment from a specific catchment will cause an issue to consumptive water quality.

A summary of erosion issues identified across different ACWA Plan Management Units is provided in Table 16.

Table 16 Management Unit erosion summary

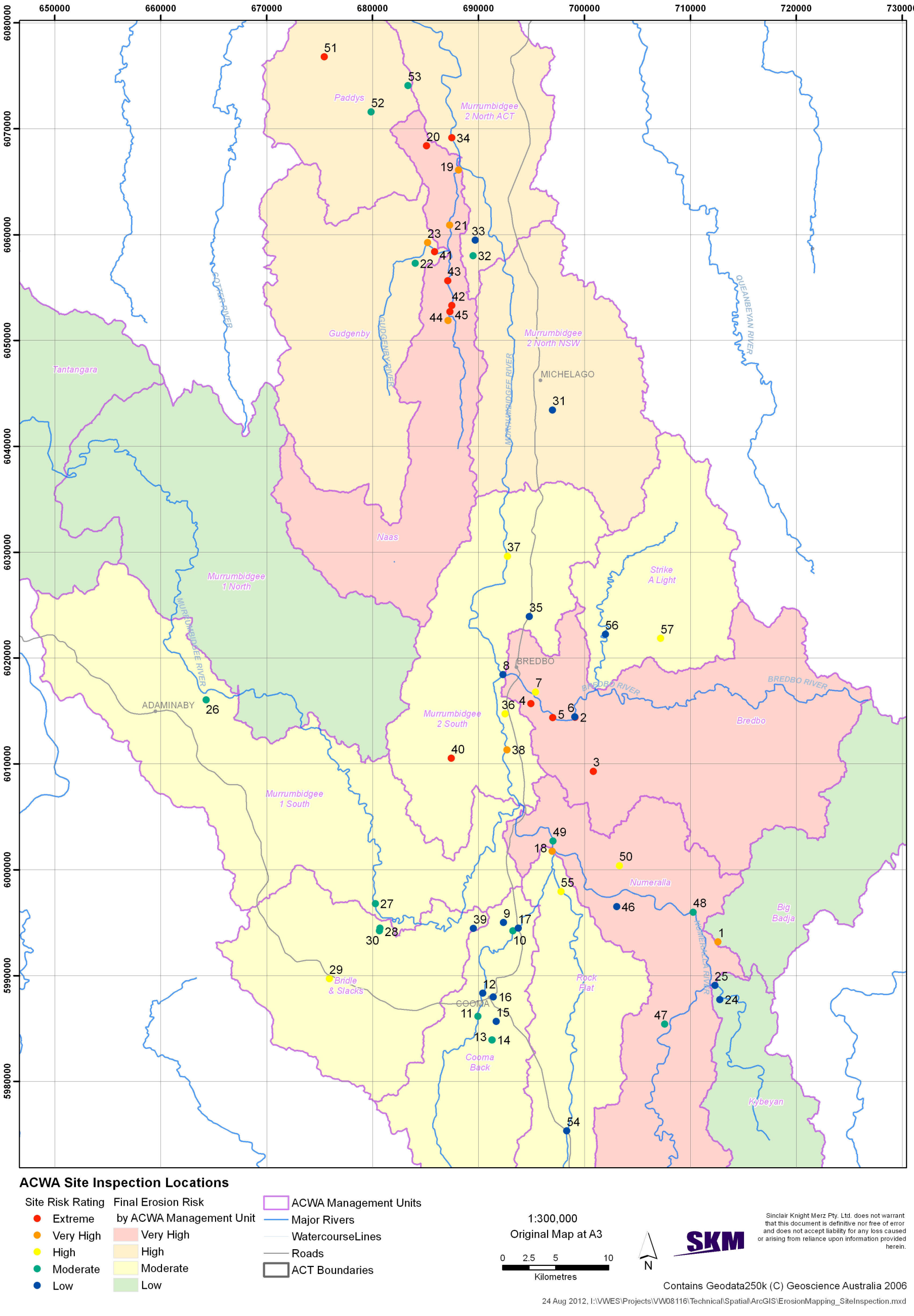
Management Units	Key findings
Cooma Back, Rock Flat, Bridle & Slacks and Murrumbidgee 1 South Management Units	Through the majority of these management units (much of the Cooma district and upstream into the Monaro plains and Adaminaby district) the predominant geology is Basalt plains, land and soil capability is typically higher than other parts of the ACWA Plan area and annual rainfall is also relatively high. Consequently most of the waterways in these Management Units are inherently more stable than the granitic catchments in the nearby Numeralla and Bredbo districts. There are however localised catchments with erosion issues in the Bunyan district and Dry Plains Road. This geographic area is a significant distance from extraction points downstream, however combined they have the potential to have a significant impact upon water quality. The lower reaches of Cooma Creek and Rock Flat Creek streams have significant bank erosion which would be generating significant silt loads in the Numeralla River.
Murrumbidgee 2 South Management Unit	A large proportion of this Management Unit has low relative rainfall and a large proportion of the soils of the eastern slope of the Clear Range are categorised as having extremely severe limitations on agricultural production. Within this Management Unit the Murrumbucca catchment is likely to be a major sediment source to the Murrumbidgee River. The creek is actively eroding its bed and banks. There are isolated occurrences of bank erosion on the Murrumbidgee River at Bumbalong and Billilingra which although limited in length would have a significant impact due to their direct connectivity to the river. A number of smaller catchments where gullies are directly linked to the Murrumbidgee River, such as Gungoandra and Billilingra have the potential to have a significant impact upon water quality.
Numeralla Management Unit	The upper portion of the Numeralla Management unit exhibits similar characteristics to the adjacent Rock Flat Management Unit. However the northerly portion of this Management Unit is dominated by soils categorised as

Management Units	Key findings
	having extremely severe limitations on agricultural production. The Numeralla River is a major tributary of the Murrumbidgee River. The Numeralla River itself has a number of significant tributaries which are impacting upon water quality. Specific issues are summarised below: ■ Lower Numeralla River: localised erosion of the bed and banks of the river mobilising coarse sediment downstream. ■ Rose Valley: major bank erosion in the reaches downstream of the homestead is increasing silt loads in the Numeralla River downstream. Sediments eroded from gullies dissecting the adjacent hillslopes do not appear to be transferred to Rose Valley Creek.
Big Badja Management Unit	The majority of the Big Badja Management Unit contains soils that are considered to have severe to very severe limitations on agricultural production. Rainfall in this Management unit is typically higher than the adjacent Numeralla and Bredbo Management Units. Erosion issues were noted on Stockyard Creek. Whilst this waterway is a significant distance from water extraction points, the site contains a very active gully with headward erosion.
Bredbo Management Unit	The Bredbo Management Unit contains a large proportion of soils that are considered to have extremely severe limitations on agricultural production. These areas of poor soils also correlate to areas of relatively low rainfall creating significant erosion potential. The Bredbo River is a highly degraded river and catchment, particularly the lower reaches. There are several sites of specific concern: ■ Sand mining practices upstream of Bredbo may have lead to significant incision of connecting tributary streams and gullies. ■ Gullies east of Bredbo are actively eroding and likely to be contributing to sediment loads. ■ Buchan Creek has major bank erosion which would appear difficult to manage. Gully erosion is also highly active in this catchment.
Strike A Light Management Unit	The majority of soils in the Strike A Light Management Unit are considered to have extremely severe limitations on agricultural production with rainfall in this Management Unit being typically higher than the adjacent Murrumbidgee 2 South Management Unit. Erosion issues were identified on Wangrah Creek which is actively eroding its bed and banks, contributing significant amounts of fine sediments.
Naas, Paddys and Gudgenby Management Units	These three Management Units are located in the north-west of the ACWA Plan area and generally have higher rainfall than those Management Units on the eastern side of the Tinderry range. The majority of soils in these Management Units are considered to have extremely severe limitations on agricultural

Management Units	Key findings
	production. The Naas, Paddys and Gudgenby Catchments have been affected by major floods in March 2012. The Naas River in particular is a significant source of fine sand and silt/clay sediments. These fine sediments are being eroded directly from the bed and banks of the channel. The connecting tributaries are also delivering significant volumes of sediment to the Naas River.
Murrumbidgee 2 North (ACT), Murrumbidgee 2 North (NSW), Kybeyan, Murrumbidgee 1 North and Tantangara Management Units	These five Management units are distributed throughout the ACWA Plan area and have a range of characteristics. Regardless of this variability the aerial and ground based assessments **did not identify any** major sediment sources originating in the Murrumbidgee 2 North (ACT), Murrumbidgee 2 North (NSW), Kybeyan, Murrumbidgee 1 North and Tantangara Management Units**.**

6.1 Condition assessments

The following figure presents the sites where condition assessments were undertaken and the risk rating calculated for each site.



ACWA Site Inspection Locations

Site Risk Rating
- Extreme
- Very High
- High
- Moderate
- Low

Final Erosion Risk by ACWA Management Unit
- Very High
- High
- Moderate
- Low

- ACWA Management Units
- Major Rivers
- WatercourseLines
- Roads
- ACT Boundaries

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Figure 17 Locations of sites where condition assessments were completed and risk ratings calculated

The following tables summarise the sites assessed through field interrogation.

6.2 Big Badja Management Unit

6.2.1 Site 1

Issue: Gully erosion	**Location:** E 0712601 N 5993162
Waterway: Stockyard Creek	**Management Unit:** Big Badja

Active headward erosion evident

Bed and bank erosion along Stockyard Creek

Vegetation apparent on gully floor

Further downstream along Stockyard Creek

Condition Assessment:

The gully at this location is 10m deep and 15-20m wide. It consists of fine red highly erodible silt/clay sediments. Sub-surface flows are important mechanism for continued erosion of the gully head and side walls. This gully flows into Big Badga River. This gully is assessed as having a high connectivity for fine sediments, however, there is a long transport distance to Murrumbidgee with opportunities for storage of sediments along channel margins and across floodplain storages.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
3	4	4	48

Risk Rating: Very high

Management Option: Undertake banks stabilisation via rock beaching and grade control to reduce ongoing instabilities. Fencing and revegetation of site in consultation with landholder.

6.3 Bredbo River Management Unit

6.3.1 Site 2

Issue: Bed and bank erosion	**Location:** E 0699115 N 6014373
Waterway: Buchan Creek	**Management Unit:** Bredbo

Confluence of Buchan and Bredbo River

Bank erosion along Buchan Creek

Condition Assessment:

This site is located at the confluence of Buchan Creek and the Bredbo River. It has been assessed as having a high connectivity for fine sediments. Fine sediments eroded from this creek are transferred to Bredbo River, which in turn has a high connectivity with the Murrumbidgee River.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4	64

Risk Rating: Extreme

Management Option: Stabilisation of eroding bank via construction of rock beaching. Fencing and revegetation of site in consultation with landholder.

6.3.2 Site 3

Issue: Sheet, rill, gully, bed and bank erosion	**Location:** E 0700882 N 6009269
Waterway: Buchan Creek and Tributaries	**Management Unit:** Bredbo

Sheet and rill erosion where land has been cleared of vegetation

Gullies forming, at bottom slope of cleared area

Gullies forming, at bottom slope of cleared area

Headward erosion at tributary confluence with Buchan Creek

Bank erosion Buchan Creek

Bank erosion Buchan Creek

Condition Assessment:

A steep cleared slope has been subjected to rill and gully erosion. This area has been historically cleared of vegetation, which has decreased the resistance of the ground surface to erosion. Attempts have been made to roughen rills with use of wooden control structures, with limited effect. A 2m headcut is evident at the confluence of the gully with Buchan Creek. It is likely that this headcut will extend headward and result

in further incision of the gully network. Downstream of the confluence of the gully with Buchan Creek, an 80m section of left bank, 4m in height, is evident. It is apparent that flows are actively undercutting banks.

Buchan Creek is assessed as having a high connectivity for fine sediments. Sediments eroded from gullied hillslopes and bed and banks of the creek are transported downstream along Buchan Creek. These sediments then pass directly into Bredbo River with high connectivity to the Murrumbidgee River.

It is possible that gravel/sand mining on Bredbo River has lowered the bed level of the river and incoming tributaries. The erosion problems documented along Buchan Creek may in part be due to the consequence associated with this downstream lowering of base level, which has then progressed up Buchan Creek leading to further incision of the drainage network.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4	64

Risk Rating: Extreme

Management Option: Undertake large woody debris stabilisation as alternative to rock beaching. Improve revegetation on site via mulching and revegetation.

6.3.3 Site 4

Issue: Channel deepening	**Location:** E 694940 N 6015660
Waterway: Bredbo Gully	**Management Unit:** Bredbo River

Erosion on secondary spillway

Main erosion head

Deepening downstream of dam

Primary erosion

Condition Assessment:

This site is located on a gully directly connected to the Bredbo River. The dam is spilling in two directions with both spillways actively eroding. Furthermore a headcut in the gully downstream of the dam is likely to cause further deepening in the longer term. It would appear most appropriate to construct a rock chute on the main gully, back fill the left hand spillway and widen and stabilise the right hand spillway.

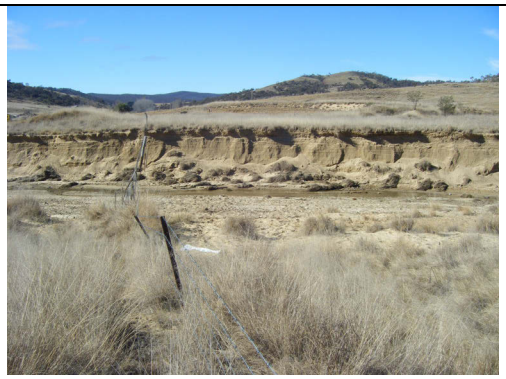
Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4	64

Risk Rating: Extreme

Management Option: Backfill left side spillway, rebuild right side spillway and redefine existing contour banks to manage erosion in the vicinity of the dam. Construct ne rock chute downstream of dam to manage issue of gully deepening. Fencing and revegetation of the site should be undertaken in consultation with landholder.

6.3.4 Site 5

Issue: Gravel/sand mining and impacts on channel stability	**Location:** E 0697013 N 6014335
Waterway: Bredbo River	**Management Unit:** Bredbo
	
Alluvial fan where a tributary intersects with Bredbo River. Large amounts of sediment have been mined from this area.	Lowered bed level of a Bredbo River tributary showing deep sand layer.

Condition Assessment:

This site concerns gravel/sand mining of the alluvial fans that intersect the Bredbo River and the channel and floodplain environment of the Bredbo River. It is possible that gravel/sand mining on Bredbo has lowered the bed level of the river and incoming tributaries, resulting in rejuvenation of the drainage network. Increased loadings of sediment can be expected from incoming tributaries which will impact on water quality in the Bredbo and Murrumbidgee Rivers.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4	64

Risk Rating: Extreme

Management Option: Review mining operations and investigate the impact that extraction is having on the stability of the Bredbo River and incoming tributaries. Construct rock chute upstream of existing extraction location to manage deepening of Bredbo River tributary. Fence and revegetate the site in consultation with landholder.

6.3.5 Site 6

Issue: Sediment transport	**Location:** E 0699080 N 6014418
Waterway: Bredbo River	**Management Unit:** Bredbo

Downstream of Bredbo River, at confluence with Buchan Creek

Upstream of Bredbo River, at confluence with Buchan Creek

Condition Assessment:

This site is well stabilised, with significant amount of grassy vegetation present along top of banks. The channel itself has a stable configuration. The site is assessed as having a high connectivity for fine sediments.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	2	1	8

Risk Rating: Low

Management Option: No structural works recommended. Fencing and revegetation of site recommended to further enhance sediment stabilisation

6.3.6 Site 7

Issue: Gully erosion and sediment transport	**Location:** E 0695377 N 6016763
Waterway: Bredbo River tributary gully	**Management Unit:** Bredbo

Un-named Bredbo tributary

Gully erosion upstream of un-named Bredbo tributary

Condition Assessment:

This gully carries runoff from a large subcatchment and is accommodating the transfer of sand and other fine sediments downstream. It has been assessed as having a high connectivity for fine sediments, given the apparent high mobility of sand. It is unsure how much fine sediment is being delivered from this catchment, however the historic gully erosion network upstream from this point indicates the potential for increased sediment loads.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	3	3	36

Risk Rating: High

Management Option: Construction of rock chute/sediment trap at confluence to manage bed deepening and to reduce sediment transport. Fencing and revegetation of site in consultation with landholder.

6.3.7 Site 8

Issue: Sediment transport	**Location:** E 0692309 N 6018393
Waterway: Bredbo/Murrumbidgee River confluence	**Management Unit:** Bredbo

Facing upstream of Bredbo River

Very coarse gravel deposited on bed

Facing downstream of confluence

Facing upstream of confluence

Condition Assessment:

This site is situated at the Bredbo and Murrumbidgee confluence. Cobble/gravel/sand bed load and stable banks are present at this site. A high connectivity for fine sediments mobilisation has been assumed.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	1	2	8

Risk Rating: Low

Management Option: No structural works recommended. Fencing and revegetation of site recommended in consultation with landholder.