

Memo

Subject Upper Murrumbidgee ACWA Site Review
Date 14 March 2019
Distribution Brent Johnson (Icon Water)
Project Googong Dam catchment Actions for Clean Water Plan

1 Introduction

Actions for Clean Water (ACWA) Plan are used to identify and prioritise erosion hotspots in terms of risk to water quality. The ranking in the report provides guidance to prioritising investment in stabilisation or remediation. ACWA plans assist government and natural resource management organisations to link future investment to science-based models they are familiar with and are consistently applied by various departments and agencies.

An ACWA Plan was developed for the Upper Murrumbidgee catchment in 2012¹.

Alluvium Consulting Australia (Alluvium) is currently engaged by Icon Water to develop an Actions for Clean Water (ACWA) Plan to establish a baseline understanding of the sources and quantum of the sediment loads entering the Queanbeyan River and Burra Creek upstream of the Googong Reservoir. As part of this project, it was requested that Alluvium also review the 'extreme' rated sites from the Upper Murrumbidgee ACWA Plan. This was a small task with minimal resources allocated, including two days of field work and one day for writing up the findings.

Site inspections were undertaken by Alluvium staff on the 24 – 25 September 2018. Landholders were originally contacted by the ACT Government or Snowy Monaro Regional Council to request access to their properties to undertake the site inspections.

This memo provides the site assessments including information from the 2012 Upper Murrumbidgee ACWA Plan and revised risk ratings from the October 2018 inspections and where relevant, recommended management options.

Assessment approach

The risk assessment approach estimates risk based on five criteria:

$$\text{Risk} = \text{Value} \times \text{Threat} \times \text{Consequence} \times \text{Likelihood} \times \text{Trajectory}$$

Definitions of the criteria are provided in the text box below, which is taken from the Upper Murrumbidgee ACWA Plan.

The risk assessment ratings for likelihood, consequence and trajectory are provided in Table 1. The consequence rating refers to the amount of fine sediment that could potentially be mobilised such that the different erosion processes can be compared between sites. The assessment considers likelihood, consequence and trajectory based on the desktop and field erosion assessment.

¹ Upper Murrumbidgee Actions for Clean Water Plan 2012, prepared by SKM for the Murrumbidgee Catchment management authority. http://umccc.org.au/files/acwa_plan_part_a.pdf

Extract from the Upper Murrumbidgee ACWA Plan

Value = Water Quality for human consumptive use. This is the same value for every risk assessment, therefore it is attributed a multiplier of “1”.

Threat = Threat posed by turbidity on water quality. This is the same value for every risk assessment, therefore it is attributed a multiplier of “1”.

Consequence = This rating relates to the consequence of a specific erosion issue on water quality. It considers the size fraction of sediment eroded and volume that is being exported from an eroding area. For example, fine silts mobilised are going to have a higher consequence on turbidity than coarse sediment.

Likelihood = This rating relates to the proximity of a specific erosion issue to the water extraction point or the likelihood that a specific stream has the ability to deliver sediment to the water extraction point. Implicit within this is an assessment of sediment connectivity from the area of erosion to the water extraction point.

Trajectory = This rating refers to the level of erosion activity identified at a site and its stage of development. For example, is there evidence that a site is in the early stages of erosion as evident by incision and presence of active head cuts, has it proceeded to the next stage where it is now eroding its

Table 1. Risk assessment ratings (adopted from Upper Murrumbidgee ACWA Plan)

Component	Score	Rating	Definition
Likelihood	5	Almost certain	High connectivity, close proximity to extraction point
	4	Likely	High connectivity, direct input into major waterway
	3	Moderate	Moderate connectivity
	2	Unlikely	Low sediment connectivity, high potential for sediment storage
	1	Rare	Disconnected from tributary and major waterway
Consequence	5	Catastrophic	Fine sediment, large volume, erosion over several 100 m or kilometres
	4	Major	Fine sediment, large volume, localised erosion
	3	Moderate	Fine sediment, moderate volume, localised erosion
	2	Minor	Fine sediment/small volume or coarse sediment
	1	Insignificant	Coarse sediment
Trajectory	5	Early degradation phase	Stream incising bed, active head cuts
	4	Degradation and widening	Bed still incising and banks also eroding (vertical or undercut)
	3	Widening and aggradation	Bed aggrading, erosion of banks (vertical or undercut)
	2	Partially stabilised	Toe of banks and bed partially stabilised with vegetation
	1	Stabilised	Stable channel configuration

The overall risk score is calculated by multiplying Likelihood, Consequence and Trajectory scores. The higher the risk score, the higher the priority of a specific site or issue. The overall risk rating can then be defined using the following classifications (Table 2).

Table 2. Relative risk ratings (adopted from Upper Murrumbidgee ACWA Plan)

Risk rating	<i>Extreme</i>	<i>Very High</i>	<i>High</i>	<i>Moderate</i>	<i>Low</i>
Risk score	64 - 125	43 - 63	34 - 42	15 - 30	<15

2 Summary of assessment findings

There were 12 sites identified as *Extreme* risk in the Upper Murrumbidgee ACWA Plan. A summary of the site review is provided in Table 3 and an overview map of the site locations is provided in Figure 1.

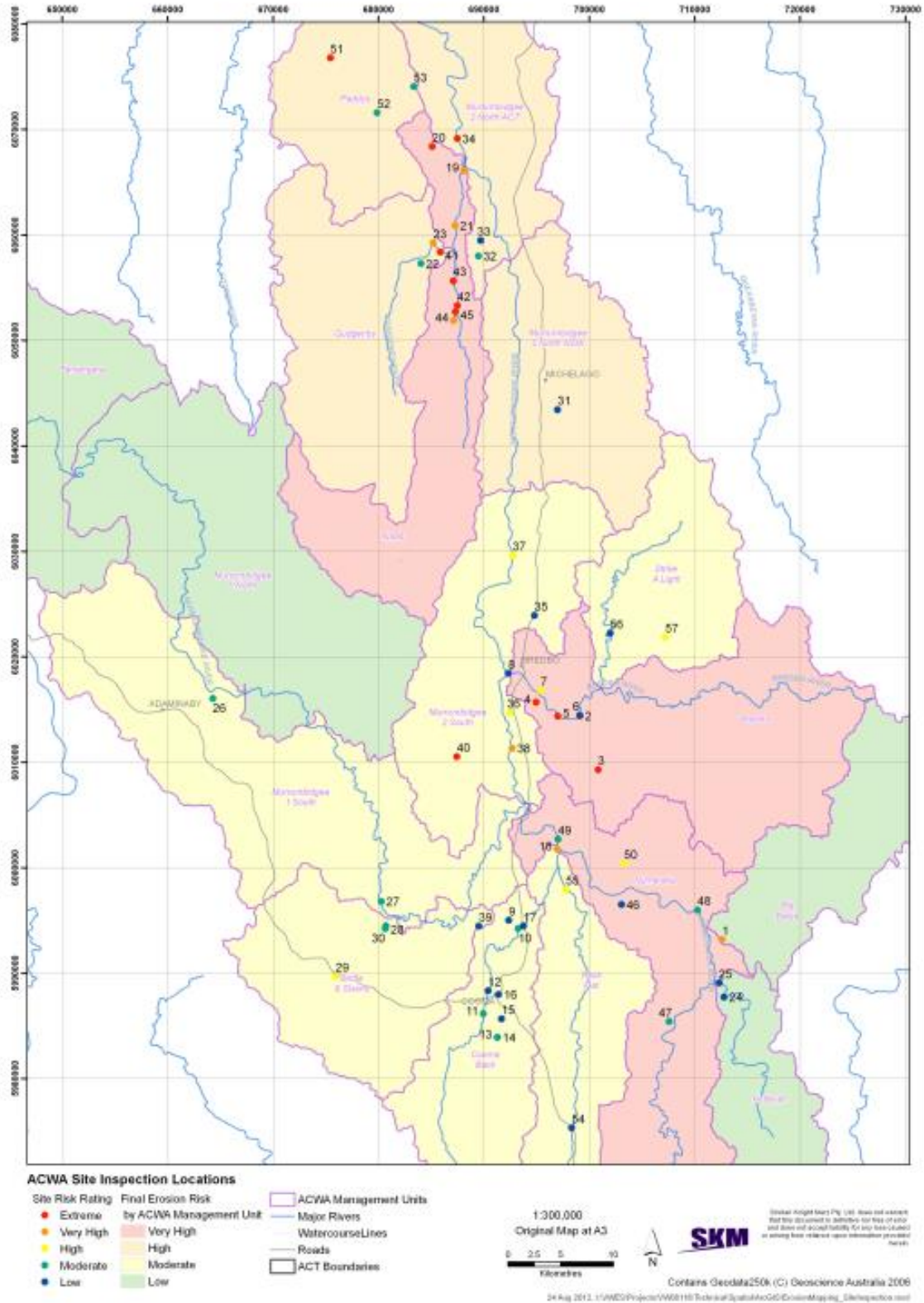


Figure 1. Overview of site locations from the upper Murrumbidgee AWA Plan

Six sites were assessed as having a reduced risk rating (sites 2, 3, 5, 34, 40, 41) while the risk rating of Extreme was maintained for the other six sites (sites 4, 20, 42, 43, 45, 51).

Management options are provided for all sites with a revised risk rating of *High, Very High* or *Extreme*.

Table 3. Summary of assessment findings

Site	2012 risk rating	Revised risk rating (2018)
2	Extreme	High
3	Extreme	High
4	Extreme	Extreme
5	Extreme	High
20	Extreme	Extreme
34	Extreme	Low risk
40	Extreme	Very high
41	Extreme	Low risk
42	Extreme	Extreme
43	Extreme	Extreme
45	Extreme	Extreme
51	Extreme	Extreme



3 Site assessments

Site 2 2012 assessment

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.

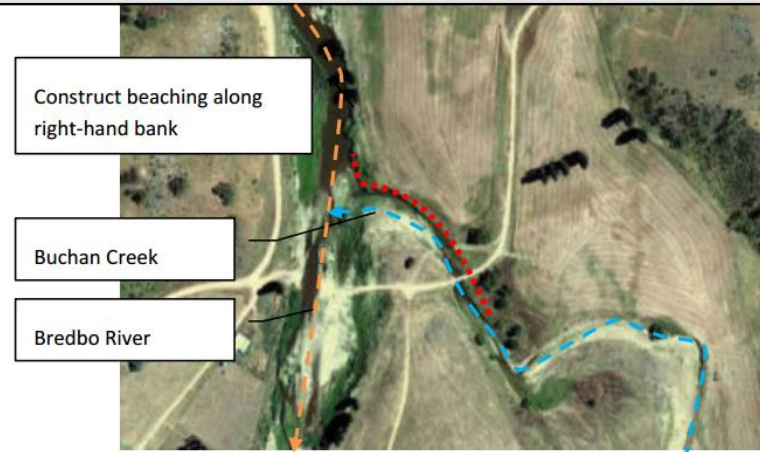
Risk Assessment:

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.

Concept Design:



Site 2 revised assessment

Site 2				
Condition assessment				
Vertical banks were observed along the right bank of the Buchan Creek for a section immediately upstream of its confluence with the Bredbo River and the road that crosses Buchan Creek. The Bredbo River has a high connectivity with the Murrumbidgee River, therefore fine sediments eroded from this site are highly connected with the Bredbo and Murrumbidgee Rivers.				
Site photos				
				
Bank erosion along Buchan Creek upstream of its confluence with the Bredbo River		Bank erosion along Buchan Creek upstream of the road crossing		
Risk assessment				
<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>	
4	3	3	36 / High risk	
Management options				
Previous management option suggested works from the confluence between Buchan Creek and the Bredbo River to upstream of the road crossing of Buchan Creek. However, works are only required where vertical banks were present, as seen in the figure below. Recommended works are laying back and revegetating the banks, with rock placed at the toe of the banks as needed (more detailed hydraulic analysis is required to design these works).				

Site 2



Composite aerial image of vertical banks present along Buchan Creek where bank stabilisation works are required

Site 3 2012 assessment

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.

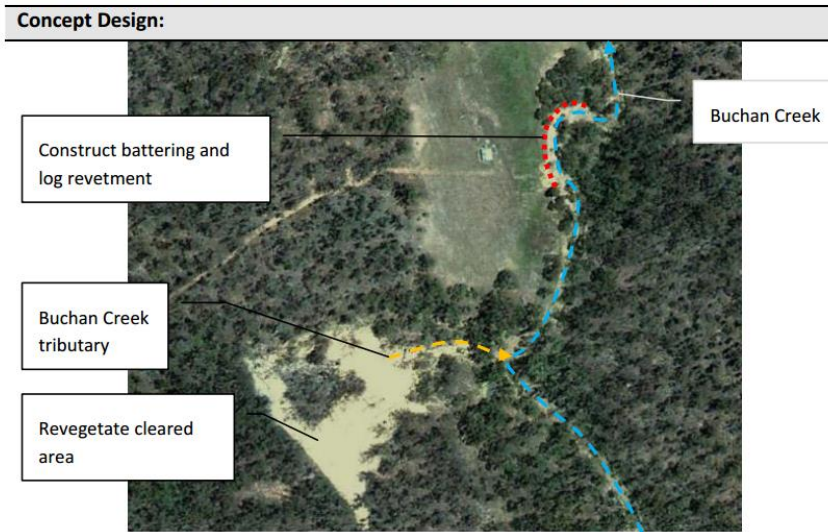
It is possible that gravel/sand mining on Bredbo River has lowered the bed level of the river and incoming tributaries. The erosion problems documented along Buchan Creek may in part be due to the consequence associated with this downstream lowering of base level, which has then progressed up Buchan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

7.1.2 Gully, Bed & Bank Erosion Buchan Creek (Site 3)



Site 3 revised assessment

Site 3

Condition assessment

A steep slope which has historically been cleared of vegetation has been subjected to rill and gully erosion. In 2009 the gullies were filled in and the cleared area was revegetated. Small levees (referred to as 'push up banks') were constructed at the top of the cleared slope and half way down the slope. Coir logs were also placed just downstream of push up banks. The push up banks and revegetation in the cleared area at the top of the slope has been successful however further downstream the gully network has re-established, as unconsolidated fill material has been washed out. This is causing sediment to build up behind the second push up bank. While the second strip of coir logs have remained intact, they are being undercut by small rills, and the gully network has returned to its pre-works state. The gully network appears relatively stable, largely as result of flows being successfully diverted away down more resistant channels by the push up banks.

Downstream of the confluence of the gully and Buchan Creek, the banks of Buchan Creek are vertical and approximately five metres high for approximately 80 m of the left bank. There does not appear to have been significant erosion since the last assessment, and the banks are relatively stable due to the cohesive nature of the bank material, and the absence of ongoing bed incision in this reach of the Buchan Creek. A meander cut off is occurring at the end of this section. No works have been undertaken here.

Site photos



Revegetation of cleared land



Coir logs on slope washed away with small gullies forming

Site 3



Relatively stable re-formed gullies



Bank erosion Buchan Creek

Risk assessment

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	3	3	36 / High risk

Management options

Continue revegetation of cleared area with Eucalyptus spp. Monitor sediment load at the downstream 'push up bank'.
 Install large wood at the toe of sheer banks along Buchan Creek to reduce velocities at the toe of the bank to promote sediment deposition, reduce force on the bank toe and increase the rate of vegetation establishment.

Site 4 2012 assessment

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.

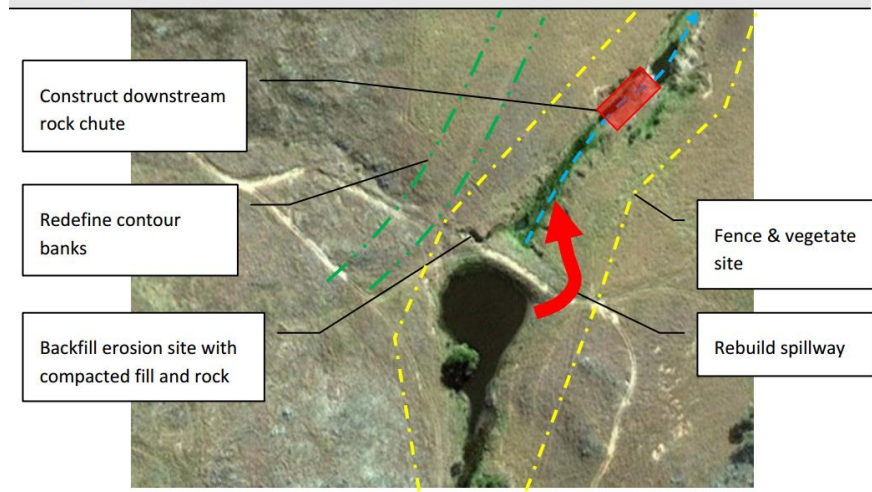
Risk Assessment:

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.

Concept Design:



Site 4 revised assessment

Site 4

Condition assessment

An existing farm dam located on a tributary of the Bredbo River is a risk of imminent failure due to recent overtopping of dam embankment. A lack of a dedicated spillway and overland flow path to control overtopping of the dam when full has led to a low point on the western side of the dam embankment directing overflow over the embankment and scouring away the embankment toe. This process has effectively set off a new head cut migrating back through the embankment. At the time of the site inspection the head cut was approximately 1 m away from initiating complete failure of the dam.

Without intervention imminent failure of the dam embankment is likely which would release both water and sediment stored within the base of the dam and set off a new phase of incision 1 to 2m deep in the tributary. This process would release a significant volume of sediment directly downstream to the nearby Bredbo River (500m downstream of the site).

The downstream gully appears to be relatively stable with no signs of ongoing incision or significant bank migration.

Site photos



Aerial imagery of the site from September 2018



Failing dam embankment looking east

Site 4



Failing dam embankment looking west



Head cut migrating through the embankment



Risk assessment

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	4	5	80 / Extreme

Management options

Rebuild the failed dam embankment with clay core and incorporate dedicated spillway on eastern side set at least 500 mm below embankment crest. Rock armour spillway.

Site 5 2012 assessment

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.

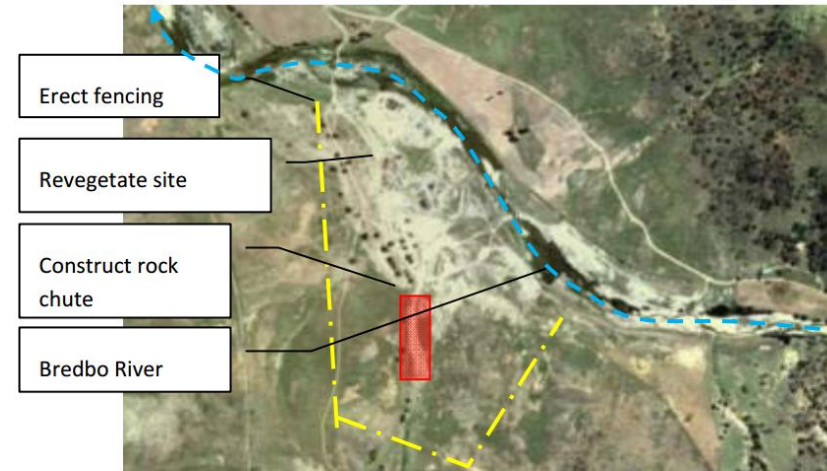
Risk Assessment:

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.

Concept Design:



Site 5 revised assessment

Site 5

Condition assessment

Large amounts of gravel/sand have been mined from the floodplain at this site. The site consists of an over-widened channel immediately upstream of its confluence with the Bredbo River. Banks of the over-widened channel are vertical, but relatively are stable, with isolated slumping. A new low-flow channel has formed through a new phase of incision that progressing upstream at a relatively slow rate. It is unlikely to impact on the banks of the over-widened channel as the low-flow channel is narrow and in the middle of the over-widened channel. No works have been undertaken.

Site photos



New low flow channel slowly moving its way upstream



Banks with isolated slumping

Risk assessment

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	3	3	36 / High risk

Management options

No major works recommended. New phase of incision should be monitored (once every two-three years). Possible to improve site with fencing and revegetation in consultation with the landholder.

Site 20 2012 assessment

Issue: Bed and Bank erosion	Location: E 685098 N 6068353
Waterway: Spring Station Creek	Management Unit: Gudgenby River



Bank erosion at the confluence



Overview of deepening up the gully line

Condition Assessment:

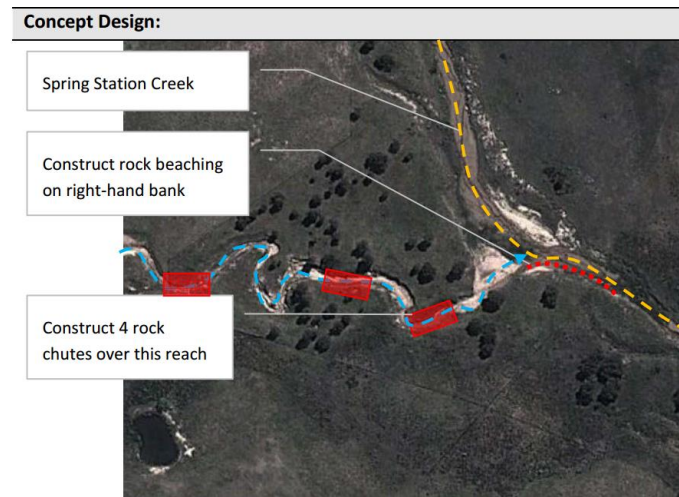
This site consists of active bank erosion on Spring Station Creek at a location where a secondary gully enters the creek. The creek was previously unchannelised, however following flooding in 2012, the gully has now channelized and is actively deepening and delivering sediment downstream. To stabilise the confluence of the gully and Spring Station Creek, bank stabilisation is required to prevent further erosion. To manage deepening in the gully survey should be undertaken, and then strategic grade control constructed to manage deepening.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4	64

Risk Rating: Extreme

Management Option: Construct rock beaching to stabilise bank at confluence of gully and Sheep Station Creek., Construct rock chutes in gully to control bed deepening. Fencing and revegetation of the site in consultation with the landholder.



Site 20 revised assessment

Site 20

Condition assessment

The site concerns active bank erosion where a secondary gully enters Spring Station Creek. The gully has reached bedrock therefore further incision is halted. The gully will continue to adjust via widening.

Site photos



Bank erosion just upstream of the gully's confluence with Spring Station Creek



Bank erosion along Spring Station Creek

Site 20



2017 aerial of the gully upstream of the confluence with Spring Station Creek



2017 aerial of bank erosion in Spring Station Creek upstream of the confluence with the gully



2017 aerial of bank erosion at confluence of Spring Station Creek and the gully



2017 aerial of bank erosion in Spring Station Creek downstream of the confluence with the gully

Site 20



2017 aerial image of erosion of gully and Spring Station Creek upstream from the site

Risk assessment





Risk assessment unchanged from previous assessment of this site, as reproduced below

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	4	4	64 / Extreme

Management options

Management options include rock beaching and revegetation to control channel widening at the site. Revegetation of the riparian corridor should include a fully structured suite of native vegetation (groundcover, shrubs and trees) in consultation with the landholder.

Site 34 2012 assessment

Issue: Bank erosion	Location: E 687483 N 6069117
Waterway: Lanyon Canyon	Management Unit: Murrumbidgee North
	
Erosion head at dam	Spillway to the north
	
Looking downstream over erosion	Looking past fence to Murrumbidgee River

Condition Assessment:

This site is known locally as the Lanyon Canyon. It consists of an erosion head approximately 5m high, which drops approximately 10m into the Murrumbidgee River. It would appear burrowing by Wombats has encouraged tunnel erosion which has set off a major gullying episode in close proximity to the Murrumbidgee River. To stabilise the site, check banks should be constructed to encourage flow to spill to the north into a more stable flowpath.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	5	4	80

Risk Rating: Extreme

Management Option: Back fill existing scour hole with a clay bank. Face with rock beaching. Define northern spillway to improve overflow stability from the dam. Fencing and revegetation of site in consultation with landholder.





Concept Design:



Site 34 revised assessment

Site 34			
Condition assessment			
<p>Past overflow from a dam located adjacent to the Murrumbidgee River resulted in scouring of the bank as it traverses the cleared floodplain and dropped into the Murrumbidgee River channel. Without intervention this had potential to continue to scour resulting in ultimate dam failure and moderate volume of sediment entering the river system. However, recent works have been undertaken to stabilise the dam overflow and re-entry point into the Murrumbidgee. As such the threat of erosion and sediment liberation is no longer of concern.</p>			
Site Photos			
			
2018 aerial imagery of the site		View of site from the Murrumbidgee River	
Risk assessment			
<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
2	3	1	6 / Low
Management options			
No further action currently required.			

Site 40 2012 assessment

Issue: Gully, bed and bank erosion	Location: E 0687441 N 6010492
Waterway: Murrumbucca Creek	Management Unit: Murrumbidgee 2 South
	
Murrumbucca Creek, facing upstream	Localised bank erosion along creek
	
Murrumbucca Creek, facing downstream	Bank erosion present along lower reaches

Condition Assessment:			
Upstream of crossing, the silty/sand banks are eroding with minimal grassy vegetation present. Downstream of the crossing, bedrock control in channel is limiting further incision. This catchment appears to be a significant source of fine grained sediments to the Murrumbidgee. More significant incision, bank erosion and channel widening appears to be occurring in the lower reaches of this valley. This creek has been assessed as having high connectivity for fine sediments due to very fine grained sediments eroded from bed and banks of incising creek transferred efficiently to Murrumbidgee through gorge setting. This valley would once have been a swampy meadow, not an incised channel contributing large amount of sediments as it is today.			
Risk Assessment:			
Likelihood	Consequence	Trajectory	Risk
4	4	4-5	64-80
Risk Rating: Extreme			
Management Option: Install rock beaching to manage bank erosion. Fencing and vegetation of site to be undertaken in consultation with the landholder.			



Site 40 revised assessment

Site 40

Condition assessment

The Bakersdale Creek and Murrumbucca Creek catchments have been subject to past catchment clearing, changes in catchment hydrology and subsequent channel change including large scale incision. While the incision process has now largely finished, ongoing bank adjustment through widening and migration continues through both stream systems. However the systems differ in scale of erosion with the banks on Bakersdale Creek nearing vertical and up to 6 m high in places and continues to adjust predominantly through bank migration. Murrumbucca Creek on the other hand is 2-3 m deep with bank erosion localised and widening being the dominant process. Past rock beaching works along the Murrumbucca Creek, undertaken by the landholder, has been successful at halting bank widening and should be considered for future works within this reach.

Without intervention ongoing bank adjustment has potential to liberate a significant amount of sediment into the receiving system.

Site photos



Bank migration at Bakersdale Creek

Site 40



Bank migration at Bakersdale Creek



Ongoing back migration observed in Murrumbucca Creek



September 2018 aerial image of bank erosion in Bakersdale Creek and Murrumbucca Creek (down-stream of the confluence)



September 2018 aerial image of bank erosion in Murrumbucca Creek upstream from the confluence and site 40.

Site 40			
Risk assessment			
<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	4	3	48 / Very High
Management options			
Due to the number and length of bank migration occurring across the site a detailed reach bank management strategy should be developed to guide investment in the reach. Works are likely to include a mixture of alignment training measures (groynes and pile fields) and bank armouring (rock and logs)			



Site 41 2012 assessment

Issue: Bed and bank erosion	Location: E 0685848 N 6058358
Waterway: Naas River	Management Unit: Naas River



Facing downstream from Bobeyan Rd bridge



Facing upstream from Bobeyan Rd bridge

Condition Assessment:

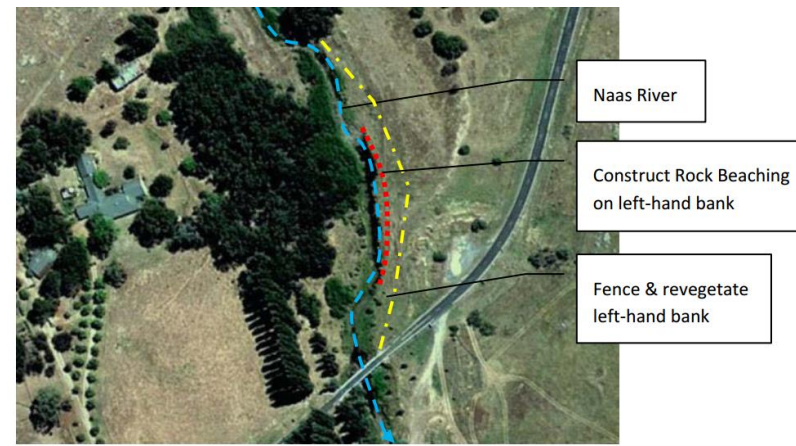
Erosion along both banks is present at this location of the Naas River. It has been assessed as having a high connectivity for fine sediments due to fine grained sediments eroded from channel banks input directly into channel flow.

Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4-5	64-80

Risk Rating: Extreme

Management Option: Install rock beaching to manage bank erosion. Fencing and vegetation to be undertaken in consultation with the landholder.



Site 41 revised assessment

Site 41

Condition assessment

Site is located on the Gudgenby River not the Naas River, as erroneously noted in the previous assessment. Vegetation has established on both banks and channel is stable.

Site photos

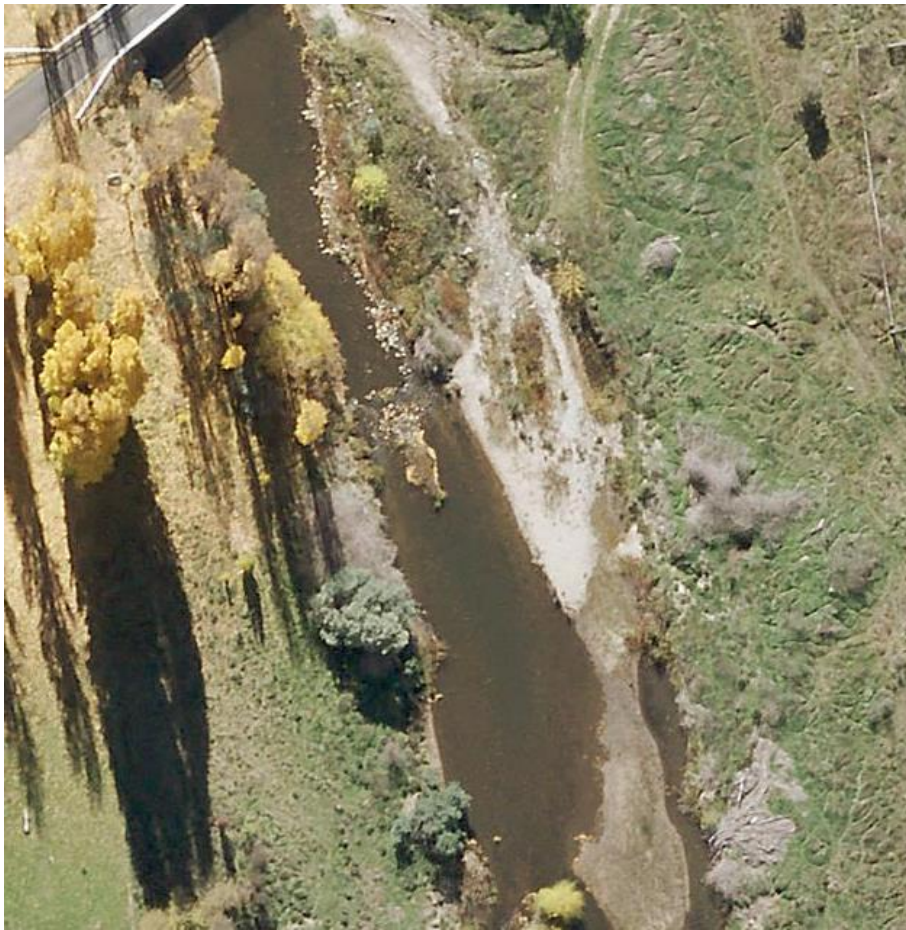


Facing downstream from Bobeyan Rd bridge



Facing upstream from Bobeyan Rd bridge

Site 41



2017 aerial image of Gudgenby River downstream from Bobeyan Rd bridge



2017 aerial image of Gudgenby River downstream from Bobeyan Rd bridge

Risk assessment

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	1	1	4 / Low risk

Site 41

Management options

No need for management aside from broken fencing being fixed. Investigate erosion identified on bend upstream in the Gudgenby River as shown in figure below.



Area requiring further investigation identified upstream from site



2017 aerial image of erosion requiring further investigation identified upstream from site

Site 42 2012 assessment

6.11.2 Site 42

Issue: Gully delivering fine sediment to river	Location: E 0687487 N 6053278
Waterway: Naas River and gullies	Management Unit: Naas River



Large areas of fine sediment deposition



Naas River tributary gully, facing upstream



Naas River, facing downstream



Rock gabion headwalls on Naas Road



Sand deposition and bank erosion



Bank erosion along the Naas River

Condition Assessment:

This Naas River is undergoing active incision and reworking of sediments stored in the stream bed, resulting in the mobilisation of a large amount of sand material. Fine sediments are also being reworked from the channel banks. Incoming tributaries are also delivering significant volumes of sediment to the Naas River. The Naas River and incoming tributaries have been assessed as having a high connectivity for fine sediment transfers through to the Murrumbidgee River.

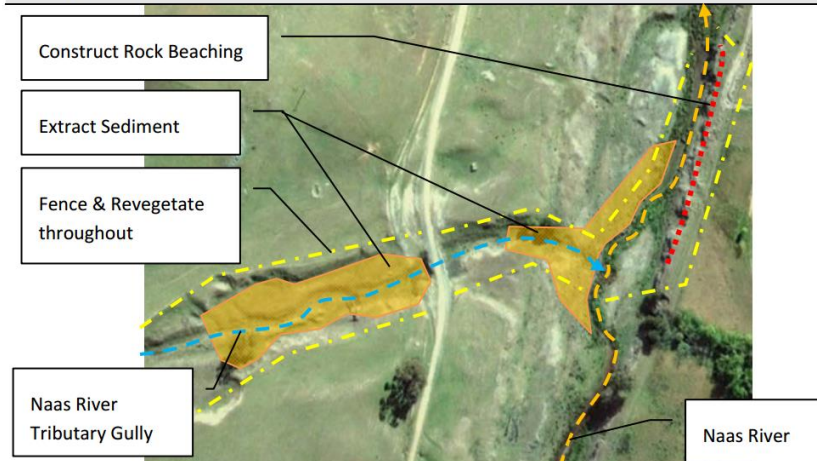
Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4-5	64-80

Risk Rating: Extreme

Management Option: Undertake sediment extraction in gully to reduce sediment delivery. Construct pile fields to manage migration of main waterway. Fencing and revegetation of site in consultation with landholder.

Concept Design:



Site 42 revised assessment

Site 42

Condition assessment

The site concerns the Naas River and a tributary gully. The tributary gully was previously assessed as containing a large amount of sediment, but at the time of inspection in this study very limited volumes of sediment were present. The culverts under Naas Road were observed to be clear of sediment. The culverts (including gabion walls) under Naas Road were very stable. Along the Naas River itself several kilometres of active bank erosion was observed, which is resulting in the mobilisation of a large amount of mixed grain size sediment. The risk assessment score below relates to the Naas River and not the tributary gully.

Site photos



Naas River tributary gully, facing downstream



Naas River tributary gully, facing upstream



Rock gabion headwalls on Naas Road



Bank erosion along the Naas River

Site 42



2017 aerial image of site 42

Risk assessment

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	5	4	80 / Extreme (along the Naas River not tributary)

Management options

No works are required along the Naas River tributary. Reach-scale bed grade and stream power analyses are needed to determine whether the Naas River is still incising. If it is still incising treatment is needed along the whole reach which could include rock beaching, pile fields to manage migration of waterway and fencing and revegetation in consultation with the landholder(s).

Site 43 2012 assessment

6.11.3 Site 43

Issue: Fine sediment in banks	Location: E 0687099 N 6055622
Waterway: Lower Naas River	Management Unit: Naas River



Active bank erosion evident



Further bank erosion downstream

Condition Assessment:

Bank erosion is occurring along the length of the Naas River contributing a relatively high amount of fine sediments downstream. These bank erosion problems are represented at this site, but they extend over kilometres. A high connectivity for fine sediment transfers from eroding banks to the Murrumbidgee River has been assessed. Fine grained sediments eroded from the channel banks are input directly into channel flow, and once in the water column are likely to be conveyed efficiently to the Murrumbidgee River contributing to water quality issues.

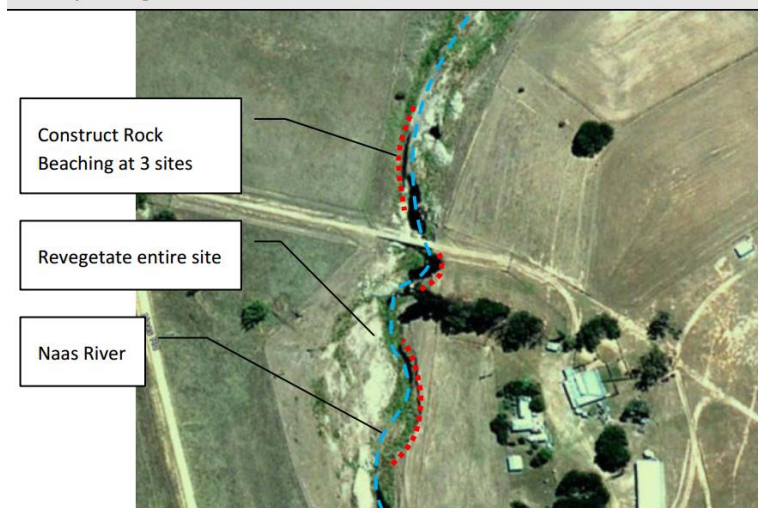
Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	4	4-5	64-80

Risk Rating: Extreme

Management Option: Construct rock beaching to manage bank erosion. Fencing and revegetation recommended in consultation with the landholder(s).

Concept Design:



Site 43 revised assessment

Site 43

Condition assessment

The site was not able to be accessed directly due to the landholder being unable and unwilling to participate further in the study, however just downstream active channel erosion could be seen from the road. Along the Naas River there is several kilometres of active channel erosion which is resulting in the mobilisation of a large amount of mixed grain size sediment.

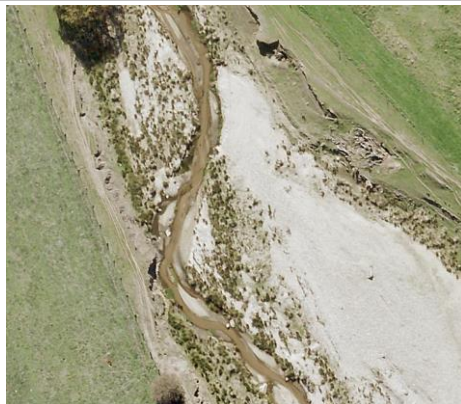
Site photos



2017 aerial image of site 43



Bank erosion along the Naas River just downstream of the site



2017 Aerial of Naas River erosion and sediment deposition upstream of property access bridge



2017 Aerial of Naas River erosion and sediment deposition



2017 Aerial of Naas River and tributary gully erosion and sediment build up, downstream of property access bridge.

Site 43

Risk assessment

<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	5	4	80 / Extreme

Management options

Reach-scale bed grade and stream power analyses are needed to determine whether the Naas River is still incising. If it is still incising treatment is needed along the whole reach which could include rock beaching, pile fields to manage migration of waterway and fencing and revegetation in consultation with the landholder(s).



Aerial showing indicative location of several kilometres of active channel erosion

Site 45 2012 assessment

Issue: Eroding sand bank	Location: E 0687305 N 6052700
Waterway: Upper Naas River	Management Unit: Naas River



Naas River, facing downstream



Widespread bank erosion along Naas River

Condition Assessment:

At this site the Naas has experiencing bed incision, bank erosion and channel widening. The right eroded bank is 8 m high and extends over a distance of 800 m. A mixture of sand and fine silt/clay sediments are being eroded from the channel banks. Assessed as having high connectivity for fine sediments, fine grained sediments eroded from bank input directly into channel flow.

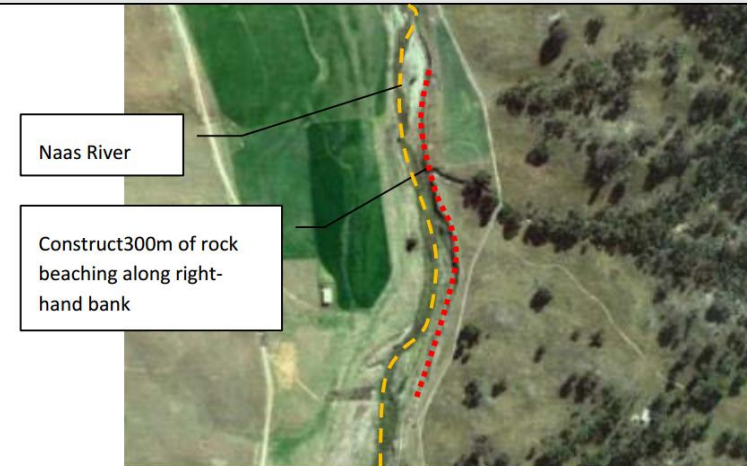
Risk Assessment:

Likelihood	Consequence	Trajectory	Risk
4	5	4	80



Risk Rating: Extreme

Management Option: Install rock beaching to manage bank erosion and channel widening. Fencing and revegetation recommended in consultation with the landholder.

Concept Design:



Site 45 revised assessment

Site 45			
Condition assessment			
Along the Naas River there is several kilometres of active channel erosion which is resulting in the mobilisation of a large amount of fine sediment as can be seen at this site. Risk assessment remains the same as previous assessment (access was not available at this site).			
Site photos			
			
Active channel erosion seen from road		2017 aerial of Naas River and tributary gully erosion.	
Risk assessment			
<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	5	4	80 / Extreme
Management options			
Reach-scale bed grade and stream power analyses are needed to determine whether the Naas River is still incising. If it is still incising treatment is needed along the whole reach which could include rock beaching, pile fields to manage migration of waterway and fencing and revegetation in consultation with the landholder(s).			

Site 51 2012 assessment

Issue: Bank erosion and sedimentation	Location: E 675436 N 6076780
Waterway: Tidbinbilla Creek	Management Unit: Paddys River



Sedimentation downstream of the bridge



Channel braiding



Major widening and sedimentation



Major bank erosion

Condition Assessment:

This site is located on Tidbinbilla Creek at Tidbinbilla Station. Downstream of Gilmore Road major channel development has occurred following recent floods with the channel now two to three times wider than the original channel. The channel has chosen a short course abandoning major outside bends with significant erosion and sedimentation. The channel is braided in a number of locations. If left unmanaged, the creek will continue to change course in subsequent major flow events, with significant sediment movement downstream likely. To manage the site, pile fields coupled with fencing and revegetation could be utilised to maintain a preferred channel alignment.

Risk Assessment:

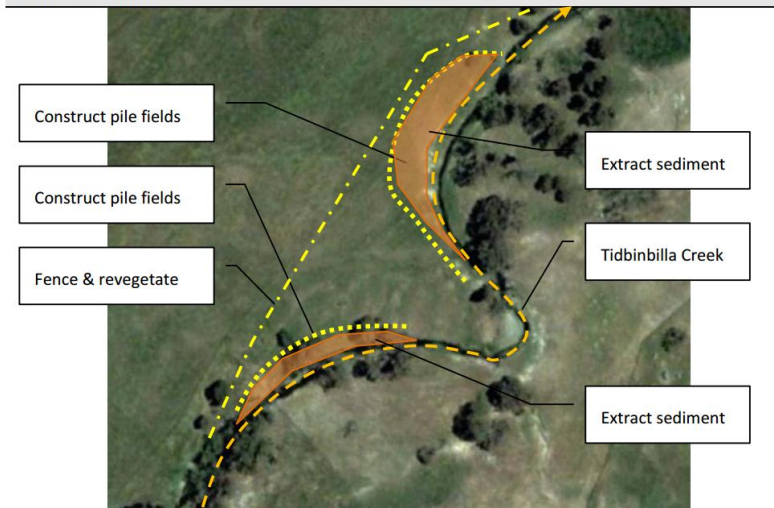
Likelihood	Consequence	Trajectory	Risk
4	5	5	100

Risk Rating: Extreme

Management Option: Install pile fields to manage migration of creek alignment. Undertake sediment removal to assist in definition of waterway alignment. Fencing and revegetation to be undertaken in consultation with the landholder.

7.1.12 Bank Erosion Tidbinbilla Creek (Site 51)

Concept Design:



Site 51 revised assessment

Site 51

Condition assessment

The upstream catchment has been subject to past catchment clearing, changes in catchment hydrology and subsequent channel change including large scale incision. While the incision process has now largely finished, on going bank adjustment through widening and migration continues. The sandy loam banks are vertical and undercut, and are upto 5 m high. The banks continue to adjust predominantly through bank migration. Without intervention ongoing bank adjustment has potential to liberate a significant amount of sediment into the receiving system.

Site Photos



2017 aerial image of site 51

Site 51			
Risk assessment			
<i>Likelihood</i>	<i>Consequence</i>	<i>Trajectory</i>	<i>Overall Score / risk</i>
4	4	4	64 / Extreme
Management options			
Works are required to halt ongoing bank migration and sediment liberation and are likely to include a mixture of alignment training measures (groynes and pile fields) and bank armouring (rock and logs).			