

The Corrowong Wallendibby Erosion and Sediment Control Project 1995-2001: Benchmarking Report

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From 1995 to 2001 the Corrowong Wallendibby Erosion and Sediment Control Project involved the implementation of erosion and sediment control strategies by local landholders under the Corrowong Wallendibby Landcare Group umbrella, and with assistance from the Department of Land and Water Conservation, the Environmental Trust, Greening Australia, Drought Landcare, the Snowy Genoa Catchment Management Committee and the Snowy River Interstate Landcare Committee.

These strategies addressed the necessary soil conservation works needed to control the entry of water into, and contain sediment within, an extensive network of gully systems in the Corrowong Wallendibby catchment area.

The implementation of the project by landholders in conjunction with DLWC staff, involved the construction of soil conservation structures including:

1. Erosion control structures; rock flumes, diversion banks, dams.
2. Sediment mitigation structures; wire mesh weirs, rock groynes, sediment basins,

In conjunction with;

- Fencing for stock management,
- Revegetation with indigenous native trees for bank stabilisation,
- The establishment of *Phragmites australis* (a native reed) to enhance sediment mitigation structures.

In 2006 the Corrowong Wallendibby Landcare group initiated the following benchmarking study, to evaluate the immediate and ongoing effectiveness of erosion and sediment control structures, stock management and revegetation. It was intended that the benchmarking report would provide a depiction of the current status of structures and provide a foundation from which to continue further erosion and sediment control strategies.

Without comparative data available on sediment loads or erosion movement, the following report is based on plausible assumptions, from relatively simple, rapid field and photographic assessments, conducted in conjunction with landholders and original departmental staff.

Although a handful of rock flume failures can be related back to implementation, assessment of a representative sample of control structures, found the majority of control measures to have succeeded in their various sediment retainment and erosion control roles. As expected by departmental staff and landholders, many wire mesh weirs and rock groynes have reached sediment capacity and are in need of replacement.

Evidently the best examples of gully revegetation were found where, along with seepage and flow management, stock access was controlled, although the variable nature of gully systems makes it difficult to create parallels between revegetation and rehabilitation.

In summation, strategies implemented through this private and public sector partnership successfully alleviated some of the immediate impacts of severe gully erosion, as well as contained significant amounts of sediment within the landscape, thus reducing the input of sediment into the Corrowong and Snodgrass Creeks (tributaries of the Snowy River). As well as this, landholders have experienced additional benefits including increased water storage capacity from sediment basins, arrested paddock dissection, shelter provision from revegetation and improved landscape aesthetics.

Although the project proved highly successful, there remain a number of untreated headcuts and lateral headcuts, due to budget restraints and the sheer number works needed. In addition, there is a continued input of sediment from sheer gully sidewalls. Given the exceeded capacity of most sediment retainment structures, it is recommended that the group considers implementation of additional sediment retainment structures.

Acknowledgements	2
Abstract	3
Table of Contents	4
Glossary	6
1. Introduction	7
2. Background to the Corrowong Wallendibby Erosion and Sedimentation Project	
1996 – 2001	9
2.1 The Corrowong Wallendibby Catchment	9
2.2 Gully formation	9
2.3 Erosion and Sedimentation studies	9
2.4 Project Initiation	9
2.5 The Corrowong Wallendibby Erosion and Sedimentation Control Project 1996-2001	10
3. Sediment control structures	12
3.1 Sediment Basin	12
3.2 Wire mesh weir	12
3.3 Rock groyne	12
4. Erosion control structures	14
4.1 Diversion bank with pipe/dam with pipe	14
4.2 Rock and grass flumes	14
4.3 Revegetation	14
4.4 Gully shaping	14
5. Evaluation	16
5.1 Evaluation of sediment containment structure	17
5.1.1 Sediment basin	17
5.1.2 Wire mesh weir	17
5.1.3 Rock groyne	17
5.1.4 Phragmites	17
5.2 Evaluation of erosion control structures	22
5.2.1 Diversion Bank with Pipe and Dam with Pipe	22
5.2.2 Rock Flumes	22
5.2.3 Grass Flumes/Gully Shaping	22
6. Evaluation of revegetation and natural colonisation	25
6.1 Revegetation	25
6.2 Natural re-colonisation	25
7. Rilling and Scouring	29

8. Sidewall rehabilitation	30
9. Repairs and Maintenance Inventory	32
10. Evaluation of project management and implementation	33
11. Discussion	34
12. Conclusion	36
13. Recommendations	38
14. Land use change	40
15. Key Recommendations	41
References	42

Dispersive: A structurally unstable soil, which readily disperses into its constituent particles (sand, silt and clay) in water, due to deflocculation.

Deflocculation: The process by which masses of very fine clay particles or ‘flocs’ separate in water into their constituent particles which go into suspension; it depends on the balance between exchangeable cations on the clay and in solution, and the overall ionic strength of the solution.

Rill: Small concentrated flow channels with a depth of less than 300mm, forming as a result of soil detachment from concentrated runoff (rilling).

Sedimentation: The removal, transport (by flowing water or wind) and deposition (settling) of detached soil particles.

Seepage: The flow of a fluid through soil pores in any direction.

ACRONYMS

DLWC: Department of Land and Water Conservation

EPA: Environmental Protection Agency

NLP: National Landcare Program

SGCMC: Snowy Genoa Catchment Management Committee

SRCMA: Southern Rivers Catchment Management Authority

SRILC: Snowy River Interstate Landcare Committee

1. INTRODUCTION

The following benchmarking report provides a summary of information collected during interviews and site visits with landholders involved in the *1995-2001 Corrowong Wallendibby Erosion and Sediment Control Project*, to provide an assessment of the overall success of erosion and sediment control structures, fencing and revegetation, implemented under that project.

As well as this, and given the associated level of risk with soil conservation structures, the benchmarking report also serves as a stocktake of erosion and sediment control structures, by collating an inventory of works that may require maintenance or repair.

More specifically, the objectives of the benchmarking report are to:

- Evaluate the immediate success of gully and sediment control structures.
- Evaluate the ongoing effectiveness of gully and sediment control structures.
- Evaluate the basic cost effectiveness of structures used.
- Obtain an inventory of works that require maintenance, repair or replacement.
- Provide local feedback as to the best methods of maintenance for structures.
- Incorporate local perspective and knowledge into improved project planning and management for any future control projects.
- Meet the accountability requirements of the various funding bodies involved.
- Recommend a course of action for continuing sediment and erosion control strategies.

In summary, this evaluation asks:

- * **Did we do what we set out to do?**
- * **Did it work; why or why not?**
- * **What would we repeat or do differently next time?**



Figure 1: An aerial photo of Airlie Park taken in 1998, showing paddock dissection by gullies (date and source unknown)



Figure 2: Showing sediment delivery from a gully at Woodborough (date and source unknown).



Figure 3: One of the more impressive gullies at Woodborough (date and source unknown).

2.1 The Corrowong Wallendibby Catchment

The Corrowong Wallendibby area is located on the NSW-Victorian border, 20km west of the township of Delegate and immediately east of the Byadbo area of the Kosciusko National Park. The catchment covers 28,423 hectares and encompasses a pastoral area of dispersive soils. Their consequent instability (to wetting) makes dispersive soils highly susceptible to severe gully erosion (Charman and Murphy 2000).

2.2 Gully Formation

Anecdotal evidence suggests primary gully formation in the catchment occurred in the second half of the twentieth century, in response to high rabbit populations, vegetation clearing or cultivation (or a combination of all three). The exposure of soil to the erosive power of overland flow was further confounded by the catchments undulating topography. Gullies that formed as a result were frequently over ten metres deep, dissecting the farming landscape and causing massive sedimentation issues (figure 2). As well as producing local water quality issues, the catchment is a direct feeder to the Snowy River, where water quality was (and remains) an area of major concern. Although many gullies in the catchment had already experienced the most significant and primary effects of erosion by the turn of the century, the headwall retreat of many gullies combined with the visible movement of sediment in creek systems, remained a concern for many Corrowong and Wallendibby landholders.

2.3 Erosion and Sedimentation studies

The magnitude and significance of gully erosion in the catchment was placed into broader perspective, following studies of the Snowy, Genoa and Wallagaraugh catchments. These studies highlighted gully erosion in upper reaches, such as the Corrowong/Wallendibby catchment, as significant contributing sources to the destruction of in stream habitat and degradation of the riparian environment downstream (Duncan 1991). Duncan (1991) and Ian Drummond and Associates (1995) identified the Snodgrass and Corrowong creeks of the Corrowong Wallendibby catchment, as particular areas of concern (Mathieu and Norris 1995). Investigations into water quality in the Snowy River Catchment estimated that sediment generation from the Corrowong and Wallendibby catchment alone approximated 60,000 tonnes per annum (personal communication Bob Britten).

2.4 Project Initiation

The formation of the Corrowong Wallendibby Landcare group in 1993 provided a foundation for landholders to launch their concern over gully erosion and a forum for the farming community to give direction to remediation projects. With assistance from the (then) SGCMC, a proposal to gazette the Corrowong Wallendibby catchment (a gazetted catchment attracts state funding for large scale soil erosion projects) was submitted to the DLWC in 1995 by the Corrowong Wallendibby Landcare Group. The project was approved on the 31 January 1996 on the basis of a comprehensive catchment wide rehabilitation project between governmental and private stakeholders, and officially opened by the Minister of Land and Water (at the time Kim Yeadon) on the 8 November 1996.



Figure 4: Mark Robertson (Soil Conservation Service) demonstrates the erosive process of a headcut, to local landholders, at Wallendibby in 1993 (date unknown, source unknown).



Figure 5: The 1998 Minister for the Environment, Bob Debus, discusses the project with local landholders, along with Snowy Genoa Catchment Management Committee Chair, Stuart Hood at Airlie Park (date unknown, source unknown).



Figure 6: Local Snowy River Interstate Landcare Coordinator Toby Stephen is interviewed by a Landline reporter during the 1997 drought at Wallendibby East. The Landline Program featured the National Landcare awards, for which local South East ABC Radio rural reporter, Keva Gocher won an award for her coverage of the project (photo courtesy David Mitchell, 1997.)

2.5 The Corrowong Wallendibby Erosion and Sedimentation Control Project 1995-2001

The 1995-2001 project objectives centred on maintaining community and landholder infrastructure and farming land threatened by gully erosion, as well as reducing sediment and nutrient flow delivery into the Snowy River via the Corrowong and Snodgrass Creeks. An overarching goal of the Landcare group was the desire to leave the catchment in a better environmental condition for future generations.

The implementation of the project involved two components:

1. Erosion control.

- Controlling the recession of head cuts with diversion banks and rock flumes.
- Promoting gully floor and sidewall rehabilitation through the control of water entry/seepage with dams and diversion banks.

2. Sediment control.

- Establishing sediment traps with wire mesh weirs and rock groynes.
- Containing on slope sediment arising from active gully erosion with sediment basins.

The project was one of the biggest ever undertaken in Australia and involved a working partnership between government staff and landholders.

A total project cost of \$965,000 included \$400,000 from DLWC, \$193,000 from Environmental Trust, \$20,000 from Greening Australia, \$30,000 from Drought Landcare and \$322,000 of cash and in kind, from landholders and the SGCMC.

3. SEDIMENT CONTROL STRUCTURES

All sediment and erosion control structures were designed and implemented according to established soil conservation principles. The following gives a brief summation and photograph of each structure and its intended role.

- 3.1 Sediment Basins:** On sites with high volumes of runoff such as the more actively eroding mid to upper reaches of the catchment, water was diverted into large dams located in eroding gully lines, to contain coarse sediment (figure 7). The capacity of each sediment basin was in the order of 2,000m³ with variations according to specific site conditions. Sediment basins also provided additional water storage benefits.
- 3.2 Wire mesh weirs:** Provided a low cost sediment containment structure suitable for the upper reaches of actively eroding gullies. These structures are designed to provide raised bed control within the gully, trapping eroded sediment from above and building up the level of the gully floor (figure 8). Being constructed of mesh, wire and star pickets, they can only be used in the upper part of the catchment where flow rates and the associated energy will only be moderate.
- 3.3 Rock groynes:** Have a similar purpose to wire mesh weirs, but are able to be placed in a higher energy environment; that is in steeper gullies or further down the catchment, where the energy of flowing water will be higher (figure 9). Rock size and distribution is the major factor in their strength and their effectiveness is dependent on suitable site selection. The original number of rock groynes was reduced from sixty to forty five owing to the cost of accessing rock, coupled with difficulties due to terrain and distance to sites.

3. SEDIMENT CONTROL STRUCTURES



Figure 7: Sediment basin with pipe at Greenfields (courtesy Sally Anne Thompson 2007).



Figure 8: Bob Britten (DLWC) and Richard Shingles (Soil Conservation Service) discuss a wire mesh weir at Airlie Park (date unknown, source unknown).



Figure 9: Rock groyne at Corrowong (courtesy Sally Anne Thompson 2007).

- 4.1 Diversion banks (with overflow pipe):** Provided simple, low to moderate cost earthworks to lengthen the flow path, divert flow around erosion sites and discharge water onto a more stable area such as a ridge, flume, rock bar or into a dam (figure 11). Removing the excess flow from eroding sites creates the potential for successful revegetation. Diversion banks with pipe are suitable for the upper catchment where peak flows can be adequately managed by the bank. They do not however, work well on steep sites or in larger catchment areas
- 4.2 Rock flumes:** Provide a medium to high cost gully head stabilisation structure, used where banks, dams and pipes would not be suitable; that is too steep or too large a catchment with no re-entry options for dams and banks (figure 10). Flumes are built in situations where gully shape, soil type or gradient won't allow earthworks to be used. Rock flumes were constructed in place of the preferred formless concrete flumes due to the high cost of such structures.
- 4.3 Dams with Pipe:** Are similar to sediment basins where the dam provides additional storage, buffering peak flows before diverting flow around eroded sites. As with diversion banks, removing the excess flow from eroding sites creates the potential for revegetation.
- 4.4 Gully shaping:** A low cost low energy option; gully shaping was only suitable in upper sections of the catchment where erosion has resulted from lack of vegetation, stock trampling and/or seepage. The re-establishment of an even batter grade, revegetation and management of stock is only recommended where overland flow (i.e. runoff) is minimal. Gully shaping needs to be combined with revegetation and stock management to be effective.

4. EROSION CONTROL STRUCTURES



Figure 10: A rock flume controlling the entry of water at Woodborough (date and source unknown).



Figure 11: Diversion bank with pipe at Kangaroo Ground (courtesy Sally Anne Thompson 2007).

Evaluation was broken into three major components:

1. Sediment Control

- sediment basins
- wire mesh weirs
- rock weirs
- phragmites.

2. Erosion Control

- Flow Diversion Works
 - diversion bank with pipe
 - dam with Pipe.
- Flow Line Stabilisation
 - rock flumes
 - grass flumes and/or gully shaping.

3. Revegetation (with fencing for stock management)

- planted vegetation
- natural re-colonisation.

5.1.1 Sediment Basins

All sediment basins were found to have been successful having overcome some initial problems associated with construction during the drought (a lack of moisture presented less than optimal conditions for dam wall compaction). Diversion banks were largely intact, with some occurrences of minor rilling. One sediment basin was found to be missing a protective sock on the overflow pipe. Consequently the adjoining gully floor has suffered severe scouring, undermining the sediment basin to the point where it will eventually fail.

5.1.2 Wire Mesh Weirs

Wire mesh weirs have been mostly successful and have proven a valuable method of sediment control; containing sediment within the gully line, elevating the gully floor and allowing vegetation to naturally establish. A number of failures have been due to considerable challenges to the structures from thunderstorms over the past few years or because of significant silting (filling of the traps with sediment). There are some small scouring issues where water has eroded the sides of the structure, although this is not a significant issue, especially where gully floors have grassed up. Wire mesh weirs appear to be most successful when used in conjunction with stock management and gully revegetation.

5.1.3 Rock Groynes

Rock groynes are successfully retaining sediment within the gully and allowing gully floors to grass up (a similar effect to wire mesh weirs, although a higher cost option). In most instances sediment volume has exceeded the capacity of the groyne to contain fine and coarse sediment. Their success, along with other structures is limited by their capacity, which is directly related to the volume of sediment input. They appear to be most effective when used in conjunction with stock management and phragmites.

5.1.4 Phragmites

Phragmites have had mixed success in different locations/situations across the catchment. The drought years of project implementation proved a limiting factor in their establishment and success; however in many instances they have provided a successful complement to sediment containment structures (particularly rock groynes). Their longevity in most areas is doubtful, given that most have been replaced by other grass species (notably *Phalaris*) or have been overcome by large volumes of sediment.



Figure 12: A wire mesh weir at Airlie Park shortly after construction (source and date unknown).



Figure13: Kerry Payten viewing the same wire mesh weir at capacity, immediately after an intense summer storm. Note the effect of raising the level of the gully floor by containing sediment (source and date unknown).



Figure 14: Wire mesh weir at capacity at Hollyridge. Again note the elevation of the gully floor with retained sediment (figure Emma Platts 2007).



Figure 15: This sediment trap at Kangaroo Ground has reached capacity and is in need of replacement. Again note the effectiveness of the trap in mitigating sediment and elevating the level of the gully floor. Revegetation is better able to establish on the trapped sediment, especially where stock access is managed.



Figure 16: As well as reaching capacity, many sediment traps have minor repair issues. Most have occurred where built up sediment and debris obstructs the flow of water after a rainfall event; an alternative pathway then erodes the weakest point of the structure, usually at the side (as is the case above). Although reducing the overall effectiveness of the structure, it is not of significant concern, (especially given the large number of structures) except where concentrated flow causes bank scouring.



Figure 17a: A rock groyne trapping sediment in conjunction with *Phragmites* (*Phragmites australis*) at Airlie Park (courtesy Sally Anne Thompson 2007). This groyne has been highly successful, elevating the level of the bed with sediment, which has grassed up well. Although there has been some movement of rocks (as to be expected) there has been no significant impact on the structure by overland flow. It should be noted that the control of water by a sediment basin above, is essential in decreasing the

velocity and volume of overland flow (which reduces the challenge to the structure) and affords the gully floor the ability to re-establish revegetation.

Figure 17b: Extension of the above rock groyne (a type of rock ‘sausage’) to armour the adjoining bank. This structure has also proved highly successful. Note grass establishment on the gully floor. The sidewalls were battered back by an excavator at the time of construction, affording grass species the ability to establish on a more stable grade.



Figure 18: This figure demonstrates the finite capacity of rock groynes in relation to sediment input. This rock groyne at Corrowong, (which plays a final sediment retainment role before water is delivered to Corrowong Creek), is close to sediment capacity. Such a structure would benefit from the installation of a number of wire mesh weirs in the gully line above.

Drought conditions provided less than optimal conditions for dam wall compaction, as demonstrated in **Figure 19** . Despite this all sediment basins (and dams for erosion control purposes) have proved successful1. **Figure 20**. Note the colour of the water, indicating sediment input.



Figure 19: Rilling dam wall at Bimbimbie (source and date unknown).



Figure 20: A sediment basin and revegetation at Wallendibby (courtesy Sally Anne Thompson 2007).



Figure 21: A sediment basin at Airlie Park (figure courtesy Sally Anne Thompson 2007).

5.2.1 Diversion Bank with Pipe and Dam with Pipe

Diversion banks with pipe and dams with pipe were all designed according to established soil conservation principles. They have all proved successful, despite less than optimum compaction at construction, due to dry conditions. In most instances there is minor rilling of banks, often as a result of livestock traffic (in particular sheep). In cases where topsoil was unable to be recovered by machinery after soil disturbance, the re-establishment of vegetation is unlikely. This is of no major concern except where rilling is prominent.

5.2.2 Rock Flumes

Flumes were used in numerous instances in place of concrete as a lower cost but higher risk option; consequently there has been a mix of success and some disappointing failures. Rock flumes proved successful in low to moderate energy flow environments, in the upper part of catchments where the vertical drop is no more than two metres. Compromises in grade and rock size (due to a limited budget) along with too steep batter grades (particularly on larger flumes) have resulted in several failures (see figures 25 and 26).

5.2.3 Grass Flumes and/or Gully Shaping

Grass shaping appears to have withstood flow challenges in all instances, although rilling is a significant concern on some structures. Rilling (see figure) is occurring on many diversion banks and batter banks, in response to a lack of revegetation.

Bob's note on pipes: Pipes for trickle flow (from banks and dams) are usually laid on the downstream batter. When incorporated with gully head shaping the lower end of the batter is prone to further erosion. This is difficult to avoid with the given equipment (bulldozer), as the gully head shaping necessitates a degree of 'cut and fill', which is pushed into the bottom of the gully. It is not possible to adequately compact the fill at the base of the batter, rendering it subject to further erosion, particularly on longer batters. As a result, there are some rilling issues associated here.



Figure 22: A rock flume after construction at Greenfields (source and date unknown).



Figure 23: The same flume at Greenfields in 2007. The flume has withstood overland flow and grassed up well – note that this is in a moderate energy environment (figure courtesy Sally Anne Thompson 2007).



Figure 24: Rowan Wright and Bob Britten survey a successful flume at a Willmott Forests owned property. Such a structure should have reasonable longevity with the incorporation of vegetation (figure courtesy Emma Platts 2007).

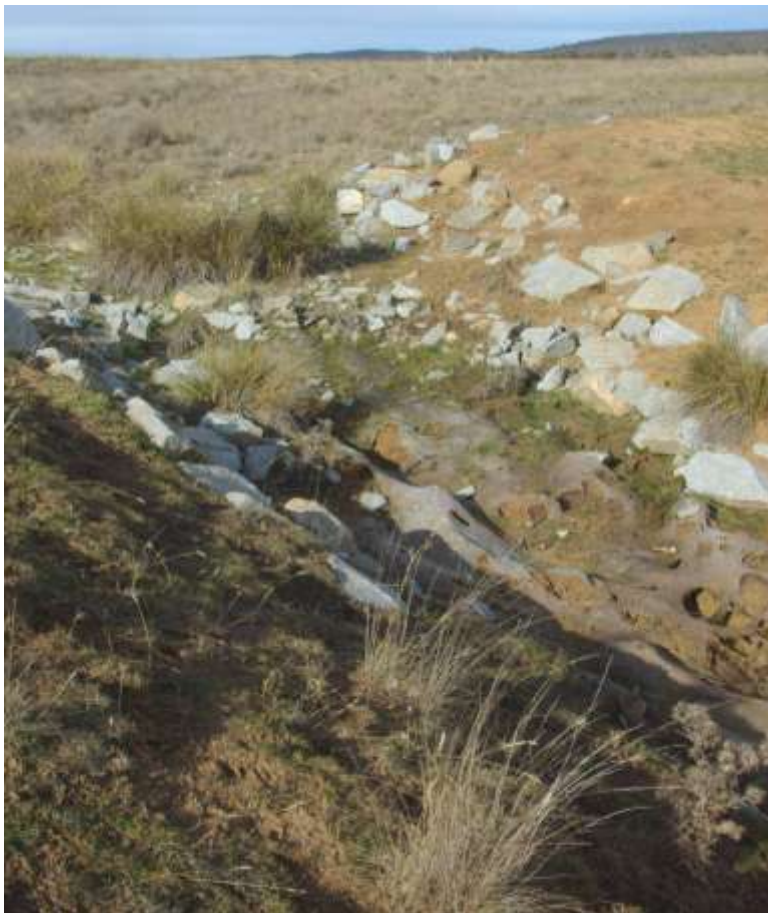


Figure 25 (right): A failed rock flume at Greenfields. Note the exposure of geotextile and movement of rock. Evidently rock selection was too small to withstand the velocity of overland flow after an intense summer storm. This flume will need complete repair, including re-battering by excavator, geotextile and a greater diameter of rock. Fortunately the diversion banks are intact and have grassed up adequately (figure courtesy Sally Anne Thompson 2007).

Figure 26 (below): Greg Walker (landowner) and Emma Platts, discuss a failed flume at Avondale. This failure was due to inadequate rock size combined with too steep batter grades. Note the movement of rock and the exposure of geotextile. The batter banks are actively eroding as a result (figure courtesy Emma Platts 2007).



6.1 Revegetation

The success of planted vegetation (including grass seed) proved variable, depending on the seasonal conditions at the time of planting (over the five year period) and the normal suite of factors that determine the successful establishment of tube stock and seed (such as ground preparation, weed control and follow up moisture). Evidently drought conditions and below average rainfall across the lifespan of the project have provided less than optimal conditions for establishment of both tube stock and grasses. Fortunately, a number of landholders have experienced good growth of species in time since, and where fencing has limited stock access, strong growth of pasture and native grass species.

6.2 Natural Re-colonisation

The natural colonisation of gully floors and walls is one of the most visual indicators of the effectiveness of seepage and overland control by structures such as sediment basins. It is complicated to make assessments based on this as it can be temporary based on seepage and flow levels, however natural vegetation is colonising most gully floors.

In most instances, the steep vertical drop of banks has prevented (and will continue to prevent), the re-colonisation of vegetation. The most ideal situations of bank re-colonisation are found where banks have been battered by machinery or have slumped back to a natural incline.). Gully control structures have further been stabilised and enhanced by the natural establishment of vegetation, such as Poa Tussock.

Aspect appears to be a significant factor in grass colonisation of sidewalls (figure 29).

Revegetation is particularly evident where livestock access has been managed, such as that at Airlie Park (figure 27). This gully is experiencing strong growth of native pasture along with native eucalypts and acacia spp.

Vegetation plays a crucial role in gully stabilisation, as a low cost and long term strategy. It also plays a fundamental role in sediment containment and slows the energy or velocity of overland flow in a gully line after a rainfall event.

Revegetation on soil conservation structures has been variable and depends on a number of factors, including position in the catchment, aspect, stock pressure and the nature of the top soil. Some diversion banks such as figure 28 will never grass up.

Aspect (in combination with bank grade) plays a significant, although uncontrollable factor in grass re-colonisation (figure 29).



Figure 27: Revegetation at Airlie Park (courtesy Sally Anne Thompson 2007).



Figure 28: Diversion bank, Corrowong (figure courtesy Emma Platts 2007)



Figure 29: Figure demonstrating natural colonisation as a factor of aspect and bank grade, Airlie Park (figure courtesy Sally Anne Thompson 2007).



Figures 30a (above) and 30b (below) demonstrate one of the most successful examples of gully rehabilitation of the Section 10 project. This gully at Bimbimbie, demonstrates strong growth of native and introduced pasture species, and native trees, after stock management. The yellow line in figure 30a marks the original gully line (it should be noted that this gully drains a relatively lower energy catchment than many other gullies).





Figure 31: A successful example of grass colonisation at Greenfields. The sidewall of this gully has a subtle angle, affording revegetation when combined with fencing for stock management (figure courtesy Emma Platts 2007).



Figure 32: Showing revegetation of a deeply incised gully at Tingaringi. The control of overland flow by a dam in the gully line above has facilitated the growth of revegetation on the gully floor and sidewalls (Figure courtesy Emma Platts 2007).



Figure 33: Demonstrates colonisation of grasses on gully floors and sidewalls. Before flow control by a sediment basin and sediment containment by rock groyne, this gully was actively eroding (figure courtesy Sally Anne Thompson 2007).



Figure 34: The outer edge of a rock flume at Ron Reed's property Woodborough. Overland flow has eroded along the edge of the rock armour causing further erosion.

Rilling has occurred on a number of structures following the disturbance or removal of topsoil by machinery during implementation. The shallow almost skeletal nature of the topsoil in some parts of the catchment makes re-establishment by vegetation difficult, especially where topsoil was not able to be recovered and replaced. Scouring or the development of rills following a rainfall event exposes soil to further erosion which can become quite incised overtime (Charman and Murphy 2000). Greg Walker, owner of Avondale recommends creating a seed bed by packing rill with old pasture hay as an effective way to prevent further erosion from rilling.



Figure 35: A fenced and revegetated gully at Wallendibby. Note the lack of vegetation on banks. This is endemic throughout most gullies, where steep vertical banks present less than optimal conditions for grass to establish (courtesy Sally Anne Thompson 2007).



Figure 36: Another example at Greenfields (courtesy Sally Anne Thompson 2007).



Figure 37a: Battered banks and a rock groyne at implementation, Woodborough (source and date unknown).



Figure 37b: The same gully ten years on. Grass is beginning to colonise sidewalls as they gradually erode to a more natural incline, although complete colonisation is not likely (photo courtesy Emma Platts 2007).

9. REPAIRS AND MAINTENANCE INVENTORY

Only a small percentage of structures failed, although many are in need of maintenance. The risky nature of earthworks on dispersive soils is such that in some instances, earthworks have often remediated one problem only to cause another, such as scouring or rilling.

The following table lists the structures needing complete repair or significant maintenance. ‘Significant’ defines those structures where maintenance is needed to prevent failure in the future. There are many structures that would benefit from maintenance but are not likely to fail without it.

It should be noted that given the large number of structures (most notably wire mesh weirs), not all could be visually assessed, although a sample of each was evaluated and combined with landholders detailed knowledge of the condition of structures.

Name of Structure	No. Of Structures	No. needing replacement or significant maintenance
Sediment Basin	12	1: Bimbimbie
Wire Mesh Weir	250	Numerous
Rock Groyne	45	Numerous
Rock Flume	15	2: Avondale and Greenfields

As discussed earlier the incorporation of local perspective and knowledge into project planning and management for any future projects is dependent on a frank evaluation of the limitations and issues encountered in project management and implementation. A number of issues occurred and warranted inspection:

1. **Project Planning and Management**

At the outset of the project a departmental project manager was not clearly defined, resulting in grey areas in project management, supervision and the communication of work timetables and budgets. The lack of a project manager often resulted in confusion of the responsibilities of the various departmental staff involved and meant the Snowy River Interstate Landcare coordinator at the time spent an increasing amount of time on project implementation, at a disadvantage to other Landcare groups under the SRILC banner. Changes in department structure (DLWC) were sometimes a cause behind the confusion.

2. **Working to a Budget in a 'High Cost, High Risk' Project**

Working to a budget involving high cost, high risk earthworks, to meet the needs of numerous landholders and catchment wide erosion and sediment control objectives, meant there were often works compromises due to cost (most notably rock size selection) and consequently some disappointing structural failures.

3. **Maintenance and Repair**

Towards the conclusion of the project there was discussion as to the cost of any repair works or follow up maintenance, following the exhaustion of the project budget. The creation of a maintenance fund was considered and \$9000 was allocated to the group by the Snowy Genoa Catchment Management Committee, for the group to use at their discretion. At the conclusion of the project however, the maintenance funding was immediately needed for the repair of a blown out dam (an anomaly to the designated budget) and unfortunately, this exhausted the maintenance fund.

4. **Provision/Exclusion of Water Infrastructure**

On a few occasions, a dam already constructed in or near the gully line by a current or preceding landholder was expanded to more adequately cope with the site's volume of flow (based on catchment size). Many of these dams were then entered into an agreement whereby the dam was to be fenced off within the gully line, to aid stock management for rehabilitation purposes. This then meant that many landholders had restricted access for stock watering purposes.

Originally benchmarking funding was allocated to a “comprehensive monitoring program to assess the impact of soil conservation works on sediment movement within and from the project area” (Landcare Group Minutes, January 1997). Although the group demonstrated timely forward thinking in planning a monitoring system, time and funding limitations prevented any such programs being put into place. Without comparative data available this report is based on plausible assumptions, from relatively simple, rapid field and photographic assessments.

The unique nature of each gully as defined by catchment size, soil type, revegetation capacity (including sidewall angle) and stock pressure makes assessment of gully rehabilitation as a whole imprecise. Therefore it is not the intent of this report to categorise or define gully rehabilitation as a whole unit. It is merely to assess the effectiveness of control structures in mitigating the head ward advance of headcuts (and lateral headcuts), containing fine and coarse sediment, and to consider the success of these measures in stabilising gullies across the catchment.

It should be noted that expectations about the success of the project should incorporate the impact of time lags and external factors including recent below average rainfall; many landholders noted that erosion and sedimentation structures have not been significantly ‘challenged’ due to below average rainfall since implementation.

Another factor for consideration is the integrity of structures based on implementation. As discussed above structures failed in some instances due to implementation. This is certainly true for rock flumes, especially given that at the time soil conservation did not have well-established guidelines for the design and construction of these structures (personal communication Bob Britten).

Emphasis should also be placed on the element of risk involved with soil conservation works. The long-term viability of a structure can be attributed to initial construction *in combination* with ongoing maintenance, including revegetation, managing stock access and repairing minor rills. In addition to this, it should be considered that benchmarking/evaluation is not a static process, and needs periodic consideration for the lifespan of the structures. This is particularly true for rock and wire weirs, where structures are likely to reach capacity, (depending on the input of sediment over the coming years) and signify the need for ongoing management of sediment retainment structures in particular.

Most importantly, it should be eminent that numerous headcuts remain untreated across the catchment and the success of the structures in this report does not refer to complete erosion and sediment control across the whole catchment. In addition to untreated headcuts, sidewalls continue to contribute significant amounts of sediment. Estimates from the original project suggest that the soil conservation project has reduced the input of sediment to the lower part of the catchment and the Snowy River by 50% (Bob Britten 2002). As more than half the sediment derived from a gully system

may result from sidewall erosion (Charman and Murphy 2000), it should be emphasised that there remains work needed to address this input [although erosion rate declines to a relatively low value when the sidewall reaches a stable angle with a plant cover (Charman and Murphy 2000)]. Furthermore, a sediment monitoring program would be required to quantify sediment loads and containment.

12. CONCLUSION

Overall all erosion and sediment control structures can be deemed successful over the last ten years in terms of their immediate effectiveness and ongoing capacity to retain sediment and mitigate further erosion. From this it may be surmised that the Snowy River tributaries feeding from the Corrowong Wallendibby catchment are experiencing decreased sediment loads. In addition, landholders have an increased capacity of water storage as well as stock shelter benefits from vegetation.

There are a number of structures needing repair, maintenance or replacement, however these are only a small percentage of the overall amount implemented, and in most instances can be attributed to initial design or implementation.

In Summary:

- Rock flumes proved variable in their success, although this is true of rock flumes in any environment (personal communication Graham Scott) and the risk may reduce with the integration of vegetation over time. Their success is predetermined by suitable rock selection at implementation.
- Rock groynes, although proven effective, have in many instances exceeded their capacity to contain sediment.
- Phragmites have a limited lifespan when swamped by large volumes of sediment; their success is also determined by seasonal conditions at implementation.
- Wire mesh weirs were proven highly effective in containing sediment and elevating the gully floor to a stable bed level, protecting the gully floor from scouring and affording vegetation recovery.
- Sediment basins and dams with pipe are also highly effective in controlling overland flow and containing fine and coarse sediment.
- Diversion banks proved effective in diverting overland flow, with minimal rilling issues

Sidewall angle is a predeterminate factor in the capacity of vegetation to colonise sidewalls, and in numerous instances bank grades remain too steep for colonisation. Over time banks may slump back to a natural batter and vegetation should re-establish. Aspect appears to be a significant, although uncontrollable factor in grass colonisation of sidewalls.

Minor rilling has occurred on numerous structures, especially where topsoil is shallow or was not able to be recovered after construction. Although not of foremost concern on many structures, it is proven to be ameliorated to some respect by the establishment of a seedbed with the use of pasture hay (pers. Comm. Greg Walker)

Fencing remains a debatable issue with some landholders identifying the control of seepage and overland flow by sediment basins as the most essential factor in the rehabilitation process, and found proven results of revegetation in unfenced areas. In the same instance many landholders identified fencing as a key process in sidewall and floor rehabilitation. As discussed earlier, vegetation and

erosion control have a directly proportional relationship and the most *ideal* situations for short and long-term revegetation were found where fencing managed stock pressure. This has important implications for sediment containment as well as erosion control.

Lower than 'average' rainfall coupled with problematic establishment on disturbed dispersive soils has significantly impeded the capacity of vegetation to thrive although reasonable rainfall in sporadic periods since has seen some areas revegetating well.

Erosion and Sedimentation Control Structures

As discussed earlier there is an element of risk in all earthwork activities and structures should not be considered permanent solutions to erosion and sedimentation within the catchment. The lifespan of structures is subject to many factors, including initial implementation, ongoing maintenance, the maximum capacity to hold sediment and the ability to withstand unpredicted challenges such as one in one hundred year floods.

Rock Flumes

Follow-up maintenance should be included in any future budget for rock flumes. As witnessed by two failures, suitable rock selection and batter grades are critical in implementation. A mixture of material containing large enough rock to ensure immobility and smaller rock to fill voids is essential.

For batter grades, Bob Britten (DNR) recommends the following key points be kept in mind:

- For up to 1 metres vertical fall a maximum batter grade of 1:1 is recommended.
- For 1 to 2 metres vertical fall a maximum batter grade of 2:1 is recommended.
- Over 3 metres vertical fall a maximum batter grade of 3:1 is recommended.
- Flume grades need to be at least 5:1 (horizontal: vertical).

Wire Mesh Weirs

As discussed, the ability of wire mesh weirs to contain sediment is limited by their volume, although reaching capacity is directly proportional to sediment input over the coming years. Numerous sediment traps have reached capacity and need replacing to maintain sedimentation containment within these gullies (i.e. new traps between old structures) and continue to elevate gully floors. As discussed above, the continuing sediment contribution from sidewalls places particular emphasis on the significance of wire mesh weirs in sediment containment. Given the low cost/high impact nature of these structures, it is recommended the Landcare group consider replacing these structures (in a step like fashion along the gully line) and place a heightened focus on the use of wire mesh weirs in future erosion and sediment control projects. Fortunately wire mesh weirs can easily be constructed by the landholder.

Rock Groynes

Unless rock groynes can be replaced by rock from on farm, they are an expensive item to replace. Although wire mesh weirs are a low cost alternative, rock groynes remain the only option for high energy environments. The placement of numerous wire mesh weirs in the gully line above rock groynes would reduce the sediment load experienced by rock groynes.

Sediment Basins

Sediment basins will most likely need maintenance (sediment removal/de-silting) in the future, although this will be directly proportional with sediment input over the coming years.

Ongoing Maintenance

In this environment of wet, dispersive soils the maintenance of structures becomes even more significant. A few key factors are essential to the longevity of structures including:

- The continuing care or establishment/re-establishment of vegetation (grasses, trees and shrubs) vital to the long term rehabilitation of severely eroded gullies. Vegetation should be recognised as the most crucial component in insuring longevity of structures.
- Rilling in structures can to some extent, be prevented and controlled by encouraging vegetation through continual planting, stock management, or by the establishment of a seed bed with the use of hay. Addressing minor rilling on diversion and batter and diversion banks early on may be able to prevent larger erosion issues in the future.
- Maintenance of stock management fencing in conjunction with the control of pest species and overpopulations of wildlife.

Project Management

The success of project implementation depends predominately on the working relationship between government staff and landholders. Therefore a project manager (departmental or otherwise) to facilitate effective communication within that relationship needs to be clearly defined from the outset of any future projects.

Maintenance and Repair Funding

Although unavoidable, it was unfortunate that the maintenance money was needed immediately. Although only a small percentage of structures have failed or are in need of maintenance, the ability to cover the cost of maintenance and repair is limited given the high cost of most earthwork structures (machinery and rock cartage costs). It also becomes difficult to apply for funding through government grants which require a 50:50 matching contribution, such as fencing labour and revegetation, as these activities were already completed in the initial project. Any future earnings from interest or group grants could be set up as a maintenance fund and allocated at the discretion of the group under an EOI (expressions of interest) and agreement process. Attempting maintenance and repair activities together as a group provides economy of scale when funding excavators and rock cartage.



Figure 38: Pinus radiata plantation establishment on Airlie Park (courtesy Sally Anne Thompson 2007).

The Corrowong Wallendibby area has been experiencing significant changes in land ownership over the past five years, due to the acquisition of land by a Managed Investment Scheme (MIS), planting Pinus radiata. At the time of publication four of the properties involved in the original project were under MIS ownership. The key point in regards to land use change of any nature and consequent new management is that these structures are sacrosanct and crucial to the effectiveness and longevity of the original erosion control strategies. They must be cared for, regardless of ownership change. This involves the maintenance of fencing for stock management, the management of rilling, the replacement of vegetation as necessary and the replacement of structures if they reach their capacity and/or fail. In conclusion all these management activities rely on the relevant caretaker's periodic assessment of structures and consequent management actions.

15. KEY RECOMMENDATIONS

Benchmarking the Corrowong Wallendibby Sedimentation and Erosion Control Project provides three valuable lessons to other community groups wishing to undertake similar projects:

- 1. The importance of planning timely monitoring and evaluation activities early on in a project.**
- 2. The need to clearly define a project manager at the outset of the project; whether community or departmental. A project manager is essential to the ease of project delivery.**
- 3. The importance of a maintenance fund; with high cost structures that are prone to failure or have limited capacity/lifespan, a maintenance fund is absolutely essential.**

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