Australian and New Zealand Geomorphology Group Inc.

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11th Meeting – Mt Buffalo, Victoria, Australia

15-20th February 2004

ANZGG Occasional Paper No. 2

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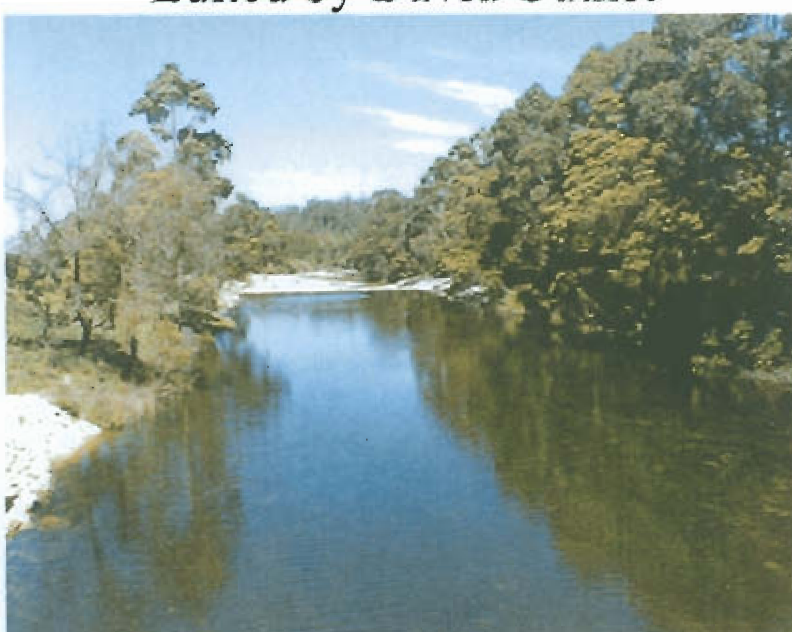
Fluvial Geomorphology Variety and Applications

A selection of fact sheets and maps compiled for the Australian and New Zealanc Geomorphology Group Inc. pre-conference tour, 13-15 February 2004

Edited by David Outhet



ANZGG Pre-Conference Tour Itinerary
"Fluvial Geomorphology Variety and Applications"
Times Approximate
Local Guides Shown in Bold

Friday 13 Feb,. 2004

7:45-8:00 Meet and load passengers Sydney Airport Qantas Domestic terminal 3 arrival level Budget desk
8:00-11:00 travel airport to Manar Crk via Goulburn, meet **Peter McAdam** and John Field's group at junction Kings Hwy/Manar Rd
11:00-2:15 field: channelised fill and palaeodrainage, Shoalhaven R bedrock nick point, picnic lunch, Araluen area valley fill preserved by Rivercare works
2:15-5:00 travel Araluen to Bega, meet **Don McPhee** at Bega Cheese Factory at roundabout N side of Bega.
5:00-6:30 field: Bega R sand slug and willows, avulsion control

Overnight Bega Central Hotel/Motel (02 6492 1263) and Bega Caravan Park (02 6492 2303)

Saturday 14 Feb. (Valentines Day)
7:30 pick up packed lunch Central Motel
8:00 Depart Bega, guided by **Andrew Brooks**
8:00-2:00 field: Genoa R, Thurra R, lunch, Cann R comparisons intact vs degraded, palaeochannel dating
2:00-4:00 travel Cann R mid-catch to Snowy R at Dalgety, meet **Teresa Rose** at bridge
4:00-5:00 field: Snowy channel contraction, flow releases needed, monitoring project, response to willow clearing
5:00-6:30 travel Dalgety to Adaminaby, buy fuel before 7:30

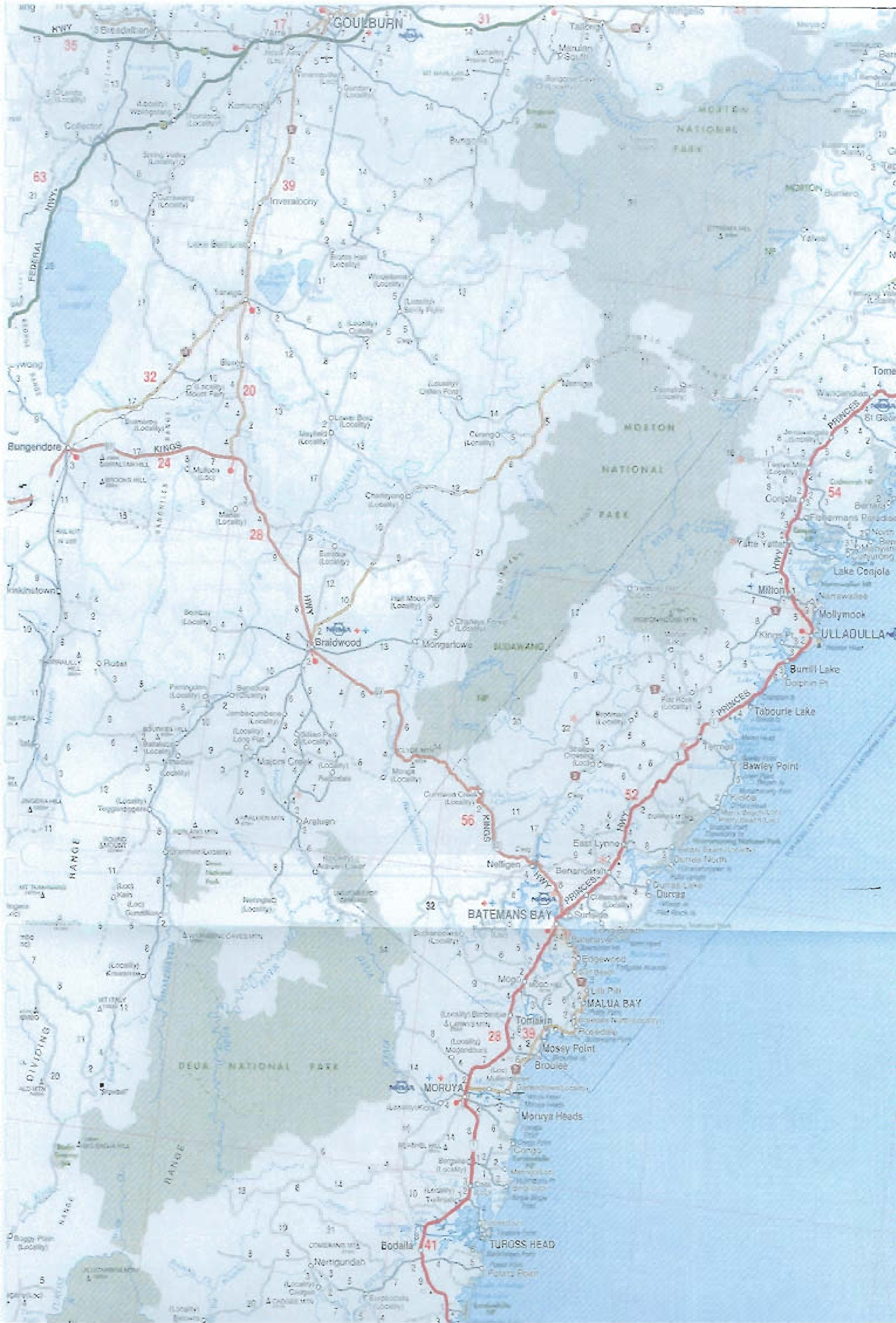
Overnight Adaminaby Snow Goose Motel (02 6454 2202) and Alpine Tourist Park (02 6454 2438)

Sunday 15 Feb

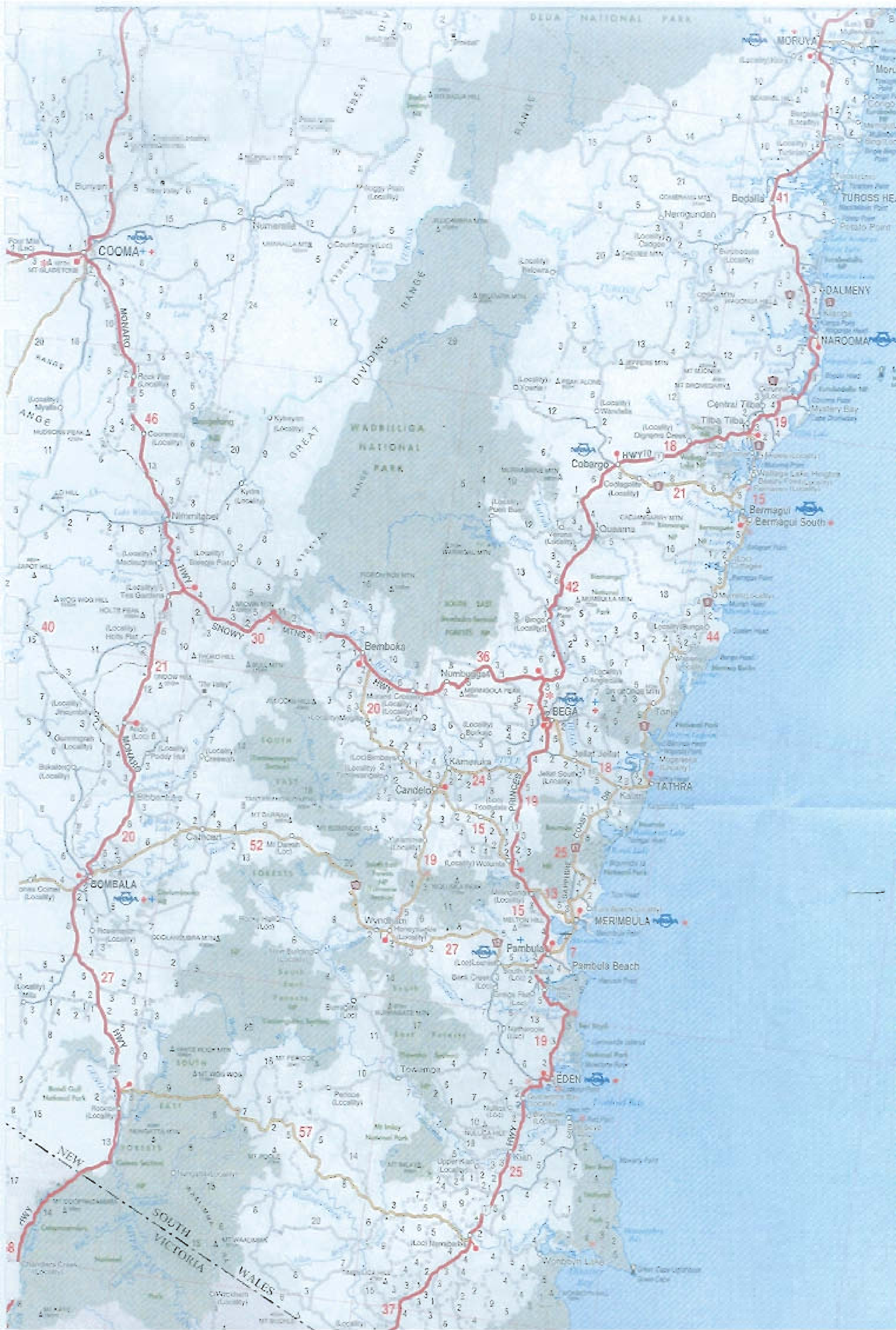
7:30-8:30 travel Adaminaby to Murrumbidgee R Long Plain reference site for alpine bedrock controlled Style
8:40-9:30 travel upper Murrumbidgee to Shelleys Crk at Snowy Mtns Hwy bridge where meet **Glenn Ferguson**
9:30-11:00 field: Tumut R regulated release erosion and control story, comparison with Tumut palaeochannel on Shelleys Crk
11:00-12:00 travel Tumut R to Tarcutta Crk, meet **Tim Smith** at Sport and Rec camp on Sturt Hwy
12:00-1:30 field: lunch, Tarcutta Crk story: management of slug vs expansion reaches
1:30-3:30 travel Tarcutta to Albury, meet **Tony Crawford** at boat ramp
3:30-5:30 field: Murray R boat tour ('Firefly'), dam causing sed starved reach, erosion control, willow control and native plant revegetation
5:30-7:30 travel Albury to Mt Buffalo
7:30 'til late? BBQ at Chalet

Overnight Mt Buffalo

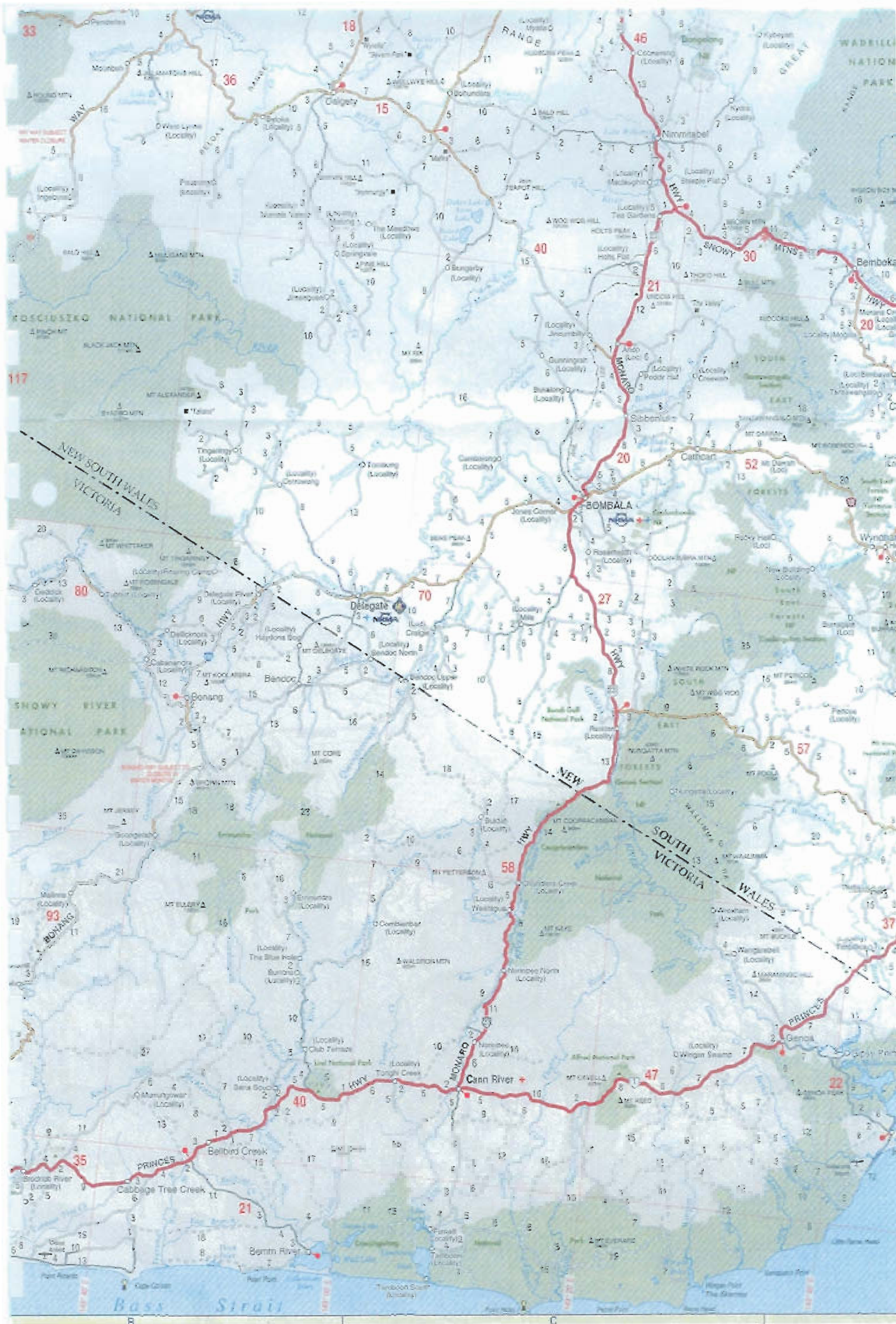
SOUTH EAST
LEGE
Scale
kilometres 20 10 0 20 40
Freeway, Tollway
Sealed Unsealed
Highway
Other Road
Intermediate
Distances
Cumulative
National Route Marker
State Route Marker
ROAD SURFACES AT NOVEMBER 1994
Travelling conditions on some roads may be affected by road works or prevailing weather.
CAMDEN
Picton
BOWRAL
Moss Vale
Crookwell
GOULBURN
Bundanoon
BOMADERRY
NOWRA
Berry
YOUNG
Temora
Ardlethan
Ariah Park
Murrumburrah
Harden
COOTAMUNDRA
Boorowa
Taylors Flat
Coolamon
Junee
Bethungra
Coota
Yass
Gunning
Jugiong
Gundagai
WAGGA WAGGA
The Rock
Tarcutta
Adelong
TUMUT
CANBERRA
QUEANBEYAN
Bungendore
Braidwood
Batlow
Talbingo
A.C.T.
Holbrook
Culcairn
Tumbarumba
Captains Flat
Googong Dam
ULLADULLA
Milton
Sussex Inlet
Huskisson
BATEMANS BAY
Moruya
Moruya Heads
Bodalla
Narooma
Cobargo
Bermagui
Wallaga Lake
COOMA
Nimmitabel
Jindabyne
Berridale
Thredbo Village
KOSCIUSKO NAT. PARK
Corryong
Tallangatta
Bright
Mount Beauty
Dartmouth Dam
Omeo
Swifts Creek
VICTORIA
Bega
Tathra
Candelo
Merimbula
Pambula
Eden
Twofold Bay
Bombala
Delegate
Cann River
Genoa
Mallacoota
Gabo Is.
Cape Howe
ALFRED N.P.
CROAJINGOLONG NAT. PARK
Orbost
Marlo
Cape Conran
Lakes Entrance
BAIRNSDALE
Bruthen
Paynesville
Stratford
SALE
Golden Beach
Seaspray
THE LAKES N.P.
Jack Smith Lake
Tambo Crossing
MITCHELL RIVER NAT. PARK
GREAT DIVIDING RANGE
Disaster Bay
Wingan Inlet
Sydenham Inlet
Point Hicks
Ram Head
Lake Hume
Lake Eucumbene



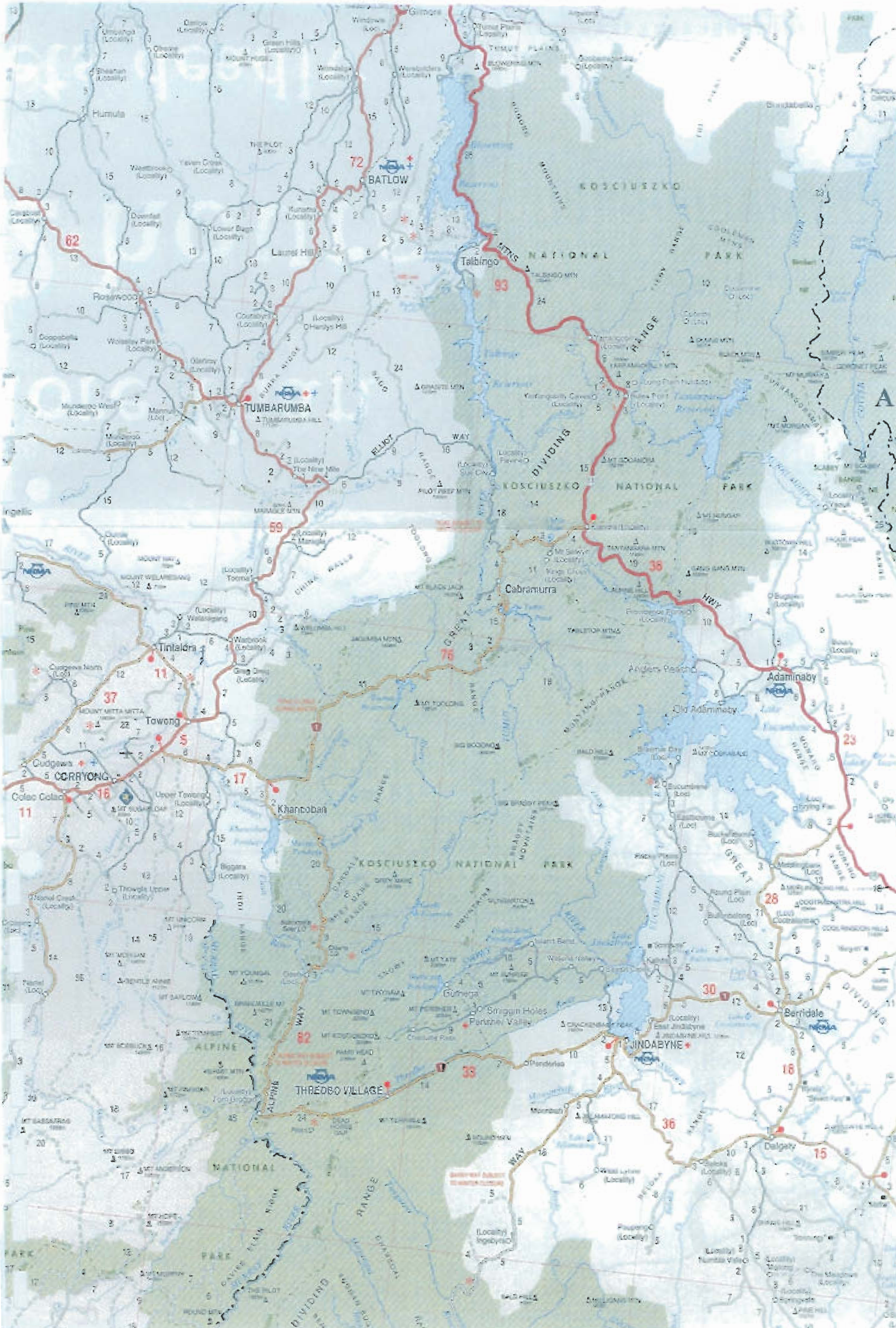
GOULBURN
Breadalbane
Yarra
Collector
Komungla
Tallong
Marulan South
Bungonia
MORTON NATIONAL PARK
Inveralochy
Lake Bathurst
Tarago
Bungendore
KINGS
Mulloon
FEDERAL HWY
Nerriga
Charleyong
Braidwood
Mongarlowe
BUDAWANG NP
Majors Creek
Araluen
Nelligen
BATEMANS BAY
Surfside
Batehaven
Mogo
Tomakin
MALUA BAY
Broulee
Mossy Point
MORUYA
Moruya Heads
Congo
Bodalla
TUROSS HEAD
Narooma
DEUA NATIONAL PARK
DIVIDING RANGE
Kinlochtown
Rossi
Tomerong
Wandandian
St Georges Basin
Conjola
Lake Conjola
Fishermans Paradise
Yatte Yattah
Milton
Mollymook
ULLADULLA
Burrill Lake
Dolphin Pt
Tabourie Lake
Termeil
Bawley Point
Kioloa
Durras
East Lynne
Benandarah
PRINCES HWY
Durras North
Nerrigundah



DEUA NATIONAL PARK
MORUYA
Bodalla
TUROSS HEAD
Potato Point
Nerrigundah
DALMENY
NAROOMA
Central Tilba
Tilba Tilba
Mystery Bay
Cobargo
Bermagui
Bermagui South
Quaama
COOMA
Bunyan
Numeralla
GREAT DIVIDING RANGE
WADBILLIGA NATIONAL PARK
MONARO
Nimmitabel
SNOWY MTNS HWY
Bemboka
Numbugga
BEGA
Tathra
TATHRA
Candelo
Kameruka
PRINCES HWY
Cathcart
BOMBALA
MERIMBULA
Wyndham
Pambula
Pambula Beach
EDEN
Towamba
Kiah
NEW SOUTH WALES
VICTORIA



Dalgety
Nimmitabel
Bombala
Delegate
Bendoc
Bonang
Cathcart
Bemboka
Wyndham
Cann River
Genoa
Bellbird Creek
Cabbage Tree Creek
Bemm River
Tonghi Creek
Sibbenluin
Rosemeath (Locality)
Jones Corner (Locality)
Craigie
Bendoc North
Bendoc Upper (Locality)
Delegate River (Locality)
Dellicknora (Locality)
Cabanandra (Locality)
Goongerah (Locality)
Club Terrace
Noorinbee (Locality)
Noorinbee North (Locality)
Weeragua
Chandlers Creek (Locality)
Wingan Swamp
Mallacoota
KOSCIUSZKO NATIONAL PARK
SNOWY RIVER NATIONAL PARK
SOUTH EAST FORESTS
WADBILLIGA NATIONAL PARK
NEW SOUTH WALES
VICTORIA
MONARO HWY
SNOWY MTNS HWY
PRINCES HWY
BONANG HWY
Bass Strait
B
C

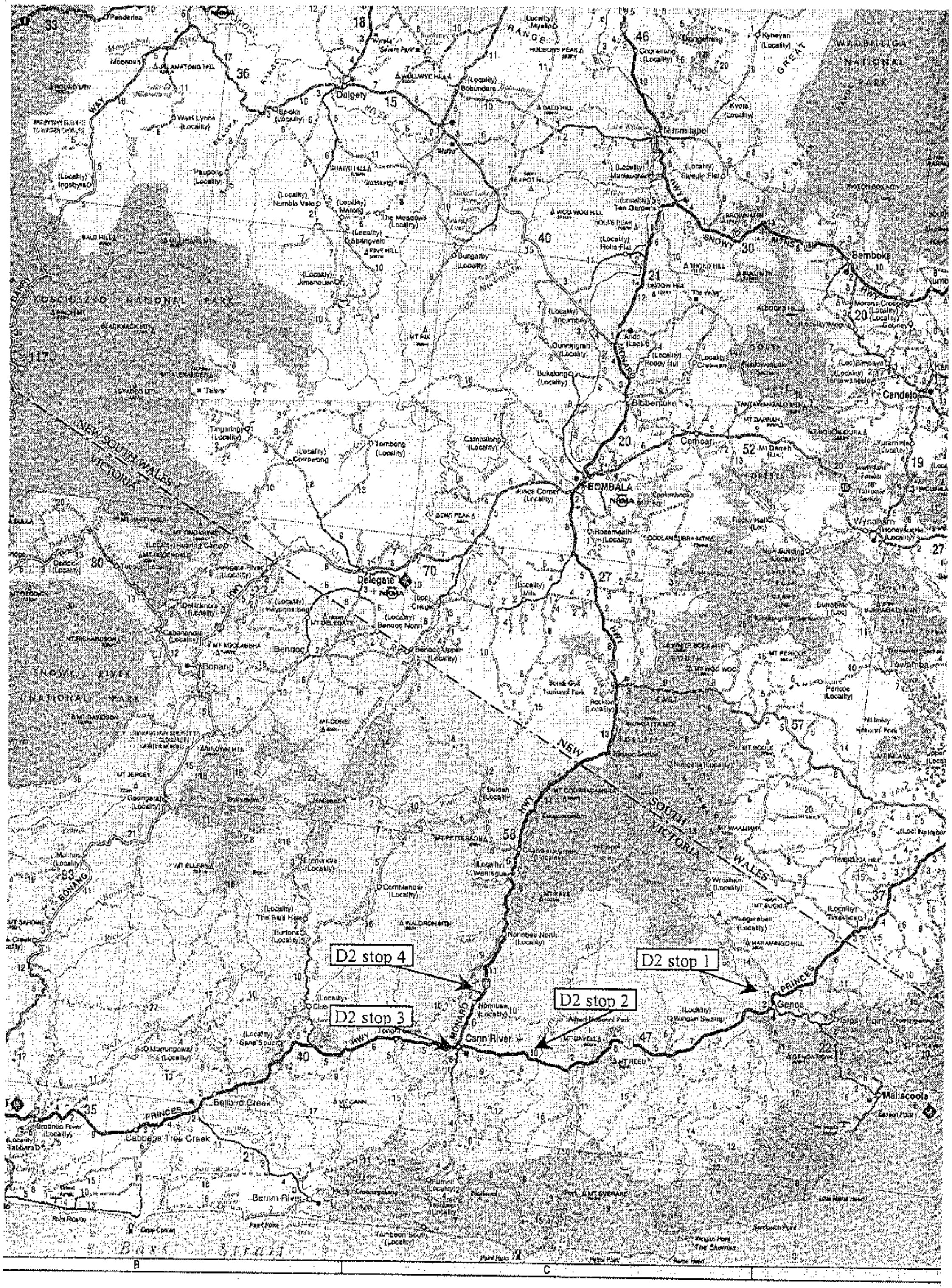


Gilmore
Humula
BATLOW
Laurel Hill
Rosewood
TUMBARUMBA
Talbingo
KOSCIUSZKO
NATIONAL
PARK
DIVIDING
RANGE
KOSCIUSZKO NATIONAL PARK
ELLIOT WAY
HWY
Cabramurra
Tintaldra
Towong
Cudgewa
CORRYONG
Colac Colac
Khancoban
GREAT
Adaminaby
Old Adaminaby
Anglers Reach
KOSCIUSZKO NATIONAL PARK
Guthega
Smiggin Holes
Perisher Valley
ALPINE
WAY
THREDBO VILLAGE
JINDABYNE
Berridale
Dalgety
NATIONAL
PARK
DIVIDING
RANGE

Coolac
GUNDAGAI
South Gundagai
Nangus
Wantabadgery
Alfredtown
HUME
Tarcutta
Mount Horeb
Gocup
Brungle
Grahamstown
SNOWY
Adelong
Gilmore
TUMUT
Tumorrama
Humula
BATLOW
Laurel Hill
Rosewood
Talbingo
KOSCIUSZKO NATIONAL PARK
TUMBARUMBA
ELLIOT WAY
NSW
Jingellic
Walwa
VIC
Tintaldra
Towong
Cudgewa
CORRYONG
Berringama
Colac Colac
Khancoban
Cabramurra
Anglers Reach
Adaminaby
Old Adaminaby
HWY

ANZGG 2004 Pre-Conference Field Trip Guide "Fluvial Geomorphology Variety and Application"

Day 2 - Geomorphic Impacts of European disturbance on Rivers in South-East Australia - and implications for management (*Dr Andrew Brooks, Griffith University, Centre for Riverine Landscapes*)



Overview of Geomorphic Changes to Rivers in SE NSW and East Gippsland

The sand bed rivers in East Gippsland and southern NSW, are some of the most profoundly altererd rivers in Australia (see Erskine, 1993; 1999; Erskine & White, 1996; Brooks & Brierley, 1997; Brierley & Murn, 1997; Brooks 1999a,b, Brooks and Brierley, 2000; Brooks et al, 2003). For river management to be effective, it is critical that realistic objectives are formulated for river management that are mindful of the profound geomorphic, hydrologic and hydraulic changes that have occurred in most rivers in this region.

The magnitude and permanence of river changes and the implications for 'recovery potential' are best illustrated using the example of the Cann River, as outlined by Erskine and White (1996), Erskine (1999) and Brooks (1999a,b); Brooks et al., (2003), Brooks and Brierley (in press). The floodplain reach of the Cann River has experienced dramatic channel incision and expansion since European settlement associated with desnagging and extensive clearance of riparian vegetation. The Cann River channel expanded from a cross-sectional area of around 35 m^2 to approximate dimensions today of around 250 m_2 (Erskine and White (1996), Erskine (1999)). The primary control on the pre-European condition of the Cann River was the dense riparian vegetation and the extensive volumes of woody debris within the channel bed (Erskine and White (1996), Erskine (1999) and Brooks, (1999a, b) Brooks et al., (2003). Without the control of the riparian vegetation and the woody debris in the bed of the channel or management intervention, it is not possible for this sand bed channel to aggrade and remain stable in the medium to long term. It was also shown in Brooks (1999a,b) that the channel erosion over the last 100 years had removed the equivalent of 1500 years of floodplain aggradation, and that the channel had incised into sediments deposited more than 10000 years ago.

Even if it was possible to induce deposition and sustained aggradation within this now entrenched channel, having reintroduced the same vegetative controls on the channel, the timeframe for this recovery would not simply be the same as the time taken to deposit the sediment originally lost (ie. 1500years). Brooks and Brierley (in press) estimated it would require at least 31000 years to infill the incised channel trench, and this was predicated on the riparian vegetation and wood loading being able to return to something like its original condition. The reason for this being that the energy conditions with the channel trench are fundamentally altered and that a number of key thresholds have been crossed. It has been estimated that the peak instantaneous sediment transport capacity in the contemporary Cann River channel is 3 orders of magnitude greater (ie. 1000 times) than that of the pre-disturbance channel. This has resulted in bed degradation and can only be reversed if in-channel roughness is substantially increased and/or depth and slope are greatly reduced (Erskine and ID&A, 1997). In-channel roughness can be increased through the reintroduction of Large Woody Debris. However, as the channel width (at around 65m) is now greater than the length of any logs that might find their way into the channel, it is unlikely that cross spanning logs or log jams can form as is. Without cross spanning logs, sustained bed aggradation cannot occur in this sand-bed stream if catchment-derived sediment supply is limited. Other thresholds crossed, include:

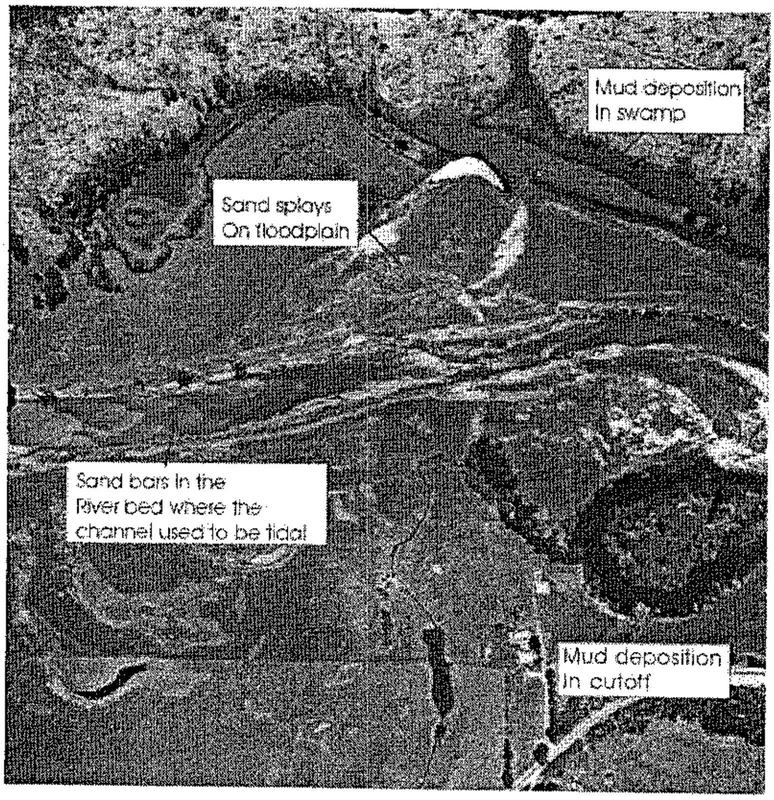
- bank height, which has now increased to the point where it is subject to mass failure;
- bank stratification, which is now an important control on bank stability.

The purpose of outlining this example is do demonstrate the point that channel recovery is often complex and re-establishing the former channel condition is often not an option. Under these circumstances a new recovery target condition is required, and achieving it may involve a significant degree of interventionist management. Disturbed sand-bed rivers have generally experienced the greatest changes. In sand-bed rivers, in particular, the role of vegetation and woody debris is often critical to channel 'stability' and long term evolution given the erodibility of the sand bed material. An example of the way that recovery principles are being considered is evident in recent investigations undertaken in the Cann River.

The Cann River in the floodplain reach has altered significantly since European settlement. Despite the dramatic channel changes as outlined above, local residents do not want the channel to revert to its original dimensions (even if this were possible) due to the increased frequency of overbank flows and subsequent negative impacts on farming. A new target condition has therefore been established for the floodplain reach of the Cann River. To prevent the ongoing degradation and erosion of the river, additional measures must be introduced to increase the resistance of the banks and bed to erosion. This can be achieved by introducing various engineered structures into the bed of the river (both rock and vegetative based) and creating a dense riparian vegetation community along the river banks and on bars within the channel. (Erskine and ID&A, 1997).

Stop 1

Lower Genoa River - Channel and Riparian rehabilitation using assisted natural regeneration.



Geomorphic impacts of disturbance on the lower Genoa River (1986)

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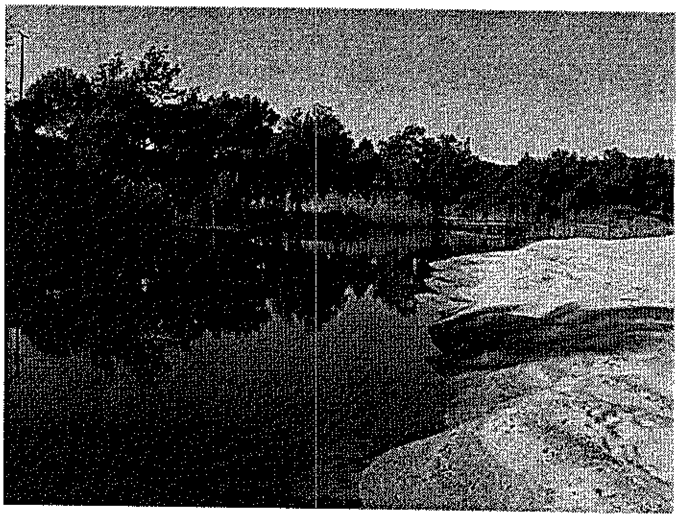

Lower Genoa River 1986 and 2001

ASSISTED NATURAL RECOVERY (Brooks et al., 2001)

Alluvial rivers that have been subjected to major geomorphic changes can recover of their own accord given sufficient time provided they retain, or can recover, all of the elements necessary for 'natural' channel and floodplain evolution and functioning. However, given the magnitude of historical disturbance to most rivers and the associated changes to channel morphology and dynamics, 'sufficient time' will often be in the order of hundreds to thousands of years. Such timeframes are generally beyond that which is acceptable for management purposes. Furthermore, due to the effective permanent loss of some of the key controls on channel conditions and the fact that fundamental thresholds have often been crossed that are not easily reversed, unassisted recovery is often not possible.

In situations where some degree of recovery is possible, the recovery process can be accelerated through the utilization of appropriate interventionist management strategies that work *with* the river dynamics. This can only occur through the development of a sound understanding of the disturbance processes within a catchment context. In river management, it is important to realise that the rate of recovery can be accelerated by management intervention. However there is a risk that channel conditions altered by a large flood are likely to result in subsequent floods having a greater disturbance effect. Implications are that managers and community need to be aware of the risk of management intervention not being initially successful because the success of

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management intervention is dependent on subsequent flood conditions. The following are some general principles that need to be adhered to when attempting to undertake enhanced recovery:

a) Understanding your catchment, its disturbance history and its evolutionary pathway

1) Through evaluation of the pre-disturbance river conditions and evolutionary history, develop models of the channel and floodplain evolution for key parts of the catchment concerned. This will include an assessment of the key controls on channel and floodplain dynamics in different parts of the catchment prior to disturbance.

2) Develop an understanding of catchment processes and linkages (eg. Through something like the River Styles framework - Brierley, 1999)

3) Reconstruct the river and catchment disturbance history

4) Assess the disturbance state of channel reaches within a catchment context. This will include the identification of minimally disturbed parts of the catchment, and critical parts yet to be fundamentally altered. These areas should be the highest priority for interventionist mangement aimed at preventing degradation. Position in the catchment is critical for understanding the potential for on-going elevated sediment supply, the potential for bed degradation due to sediment exhaustion, the availability of sediment for inducing channel contraction etc. The construction of a sediment budget will be an important tool in this component of the assessment procedure.

b) Having undertaken (a), assess recovery potential for various river reaches. Factors influencing recovery potential, include:

1) The magnitude of change within the reach - which is partly a function of the river style. Different reaches or river styles have different capacities for adjustment in terms of threshold changes, catchment hydrology, sediment supply conditions, reach hydraulics (including, roughness characteristics and the connectedness of the channel to the floodplain).

2) Upstream conditions (hydrologic changes, sediment supply conditions, vegetation conditions – ie. the potential for native plant propagule supply and LWD supply)

3) Downstream conditions. (e.g. upstream migrating nickpoints)

c) Enhanced Recovery Utilising native vegetation

As a general rule, vegetation provides the key to enhanced river channel recovery. The more vegetation that can be encouraged to establish within a channel, on the banks, and on floodplains, the better the results that will be achieved in terms of enhanced river recovery. Vegetation within channels performs multiple functions:

. inducing roughness within the channel, and thereby lowering available energy, and hence work performed on the channel boundary.

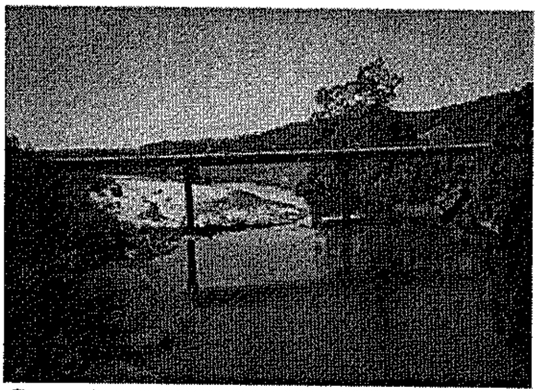
- Increased boundary roughness is the primary mechanism for inducing sediment deposition within the channel (particularly enlarged channels) and thereby increasing the residence time of the sediment within the catchment
- Increases bank strength, thereby stabilising banks and reducing sediment supply
- Providing a source of woody debris (woody debris performs the role of inducing roughness within channels, providing armour on mobile beds, inducing form roughness, physically reinforcing beds)

It is generally better to utilise the remaining native vegetation within channels, assuming some still remains either locally or upstream, and encouraging the regeneration of these species. This will generally involve the suppression of weeds that tend to have a competitive advantage over native species (Newsome & Noble, 1986; Hobbs, 1989).

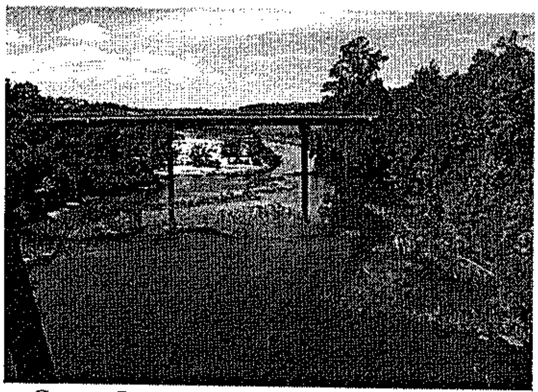
In situations where a sufficient seed source for native species still exists, and where suppression of weed is logistically possible, the optimum situation is to encourage natural regeneration. Obviously this will only apply in moderately disturbed landscapes, probably with intact portions of the catchment upstream. Natural regeneration will tend to have more chance of success than planted tubestock or direct seeding. In situations where there are remnants of the pre-existing vegetation, planting of tubestock and/or direct seeding will be required. In both cases, weed management will be critical to success. There will be some cases where it is not necessarily ideal to only have the remnant native species. In this situation, further investigations are recommended to ascertain the original vegetation. There are a number of situations where this may be necessary:

- Where the remnant community is incapable of self regeneration;
- Where channel conditions are altered so much that the pre-existing riparian species no longer occur locally.

Furthermore, given that river management needs to take a long-term view, there is increasing recognition of the effect that global climate change is going to have on natural ecosystems. Current global climate change models predict that ecological boundaries will shift at the continental scale as a result of climate warming. Hence, if a tree species is currently at its southern limit, it may be unwise to use such a species as part of a long term recovery scheme.



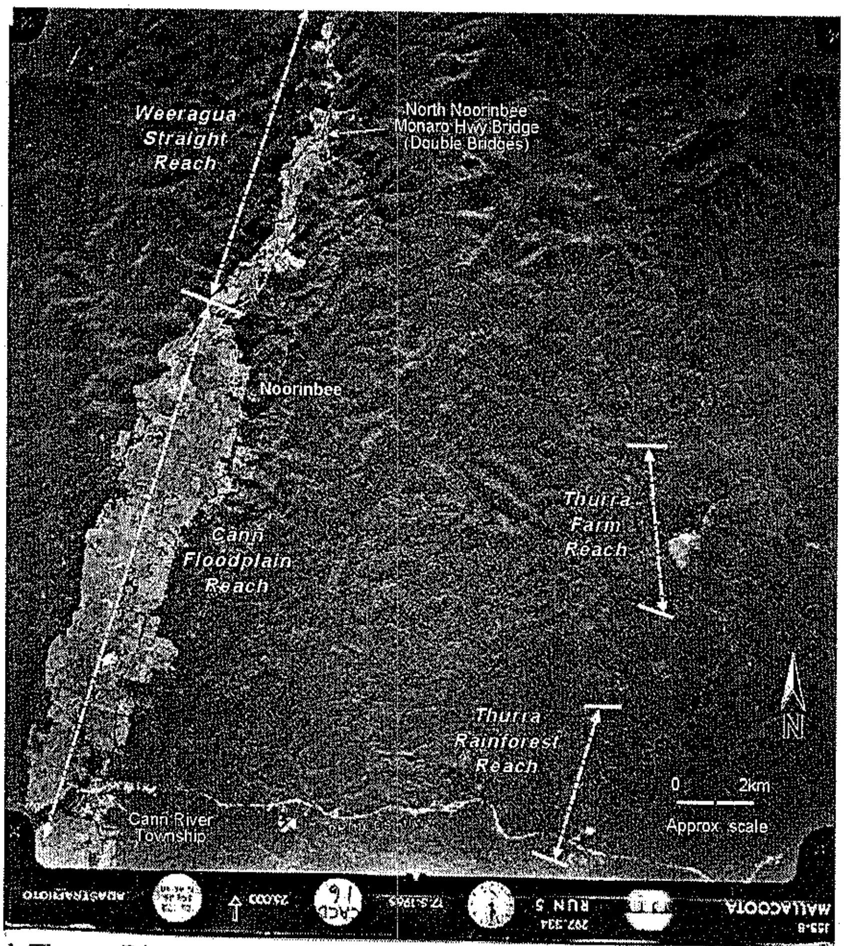
Genoa River 1996



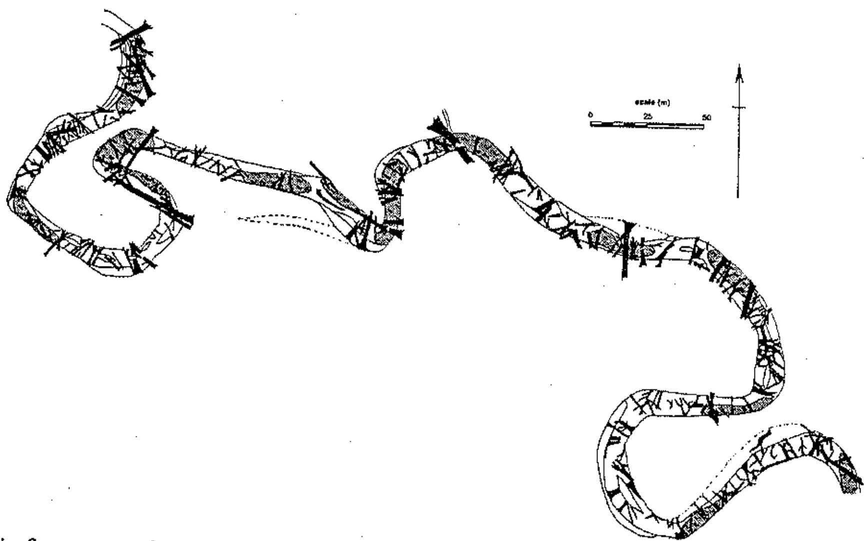
Genoa River 2001

Stop 2 Thurra River (The Fluvial TARDIS)

Mediated Equilibrium – LWD and Vegetation as a long term control on channel morphology and floodplain evolution.



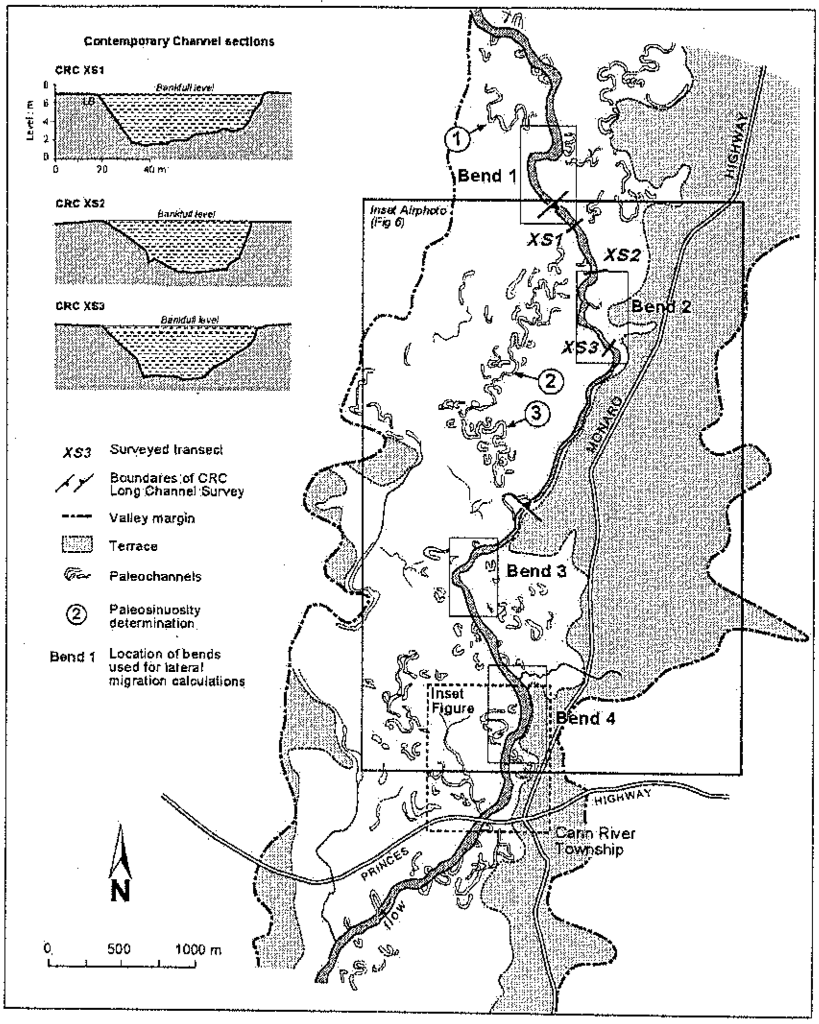
The forested Thurra River catchment adjacent to the Cann River catchment showing the contrasting cleared floodplain

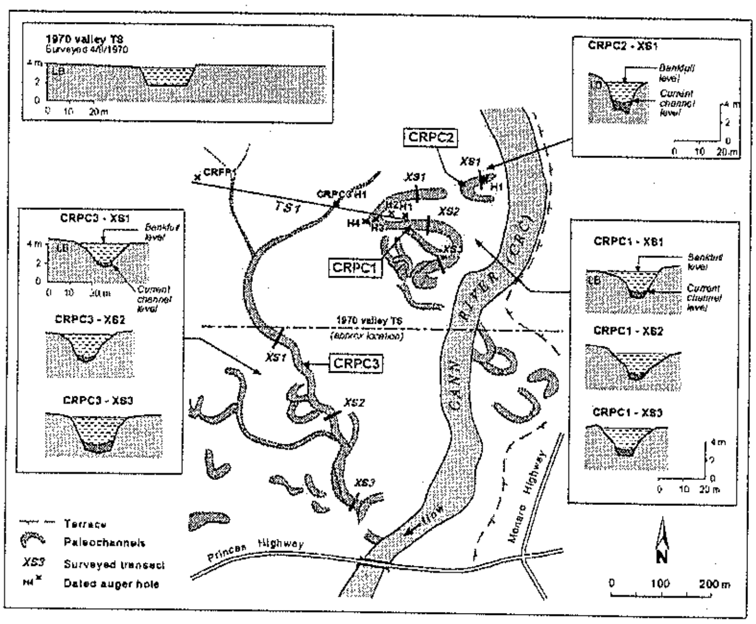


Thurra rainforest study reach (Stop 2) – showing the high LWD load.

Stop 3 Cann River Floodplain

Channel metamorphosis following LWD removal and riparian vegetation clearance –.





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Key parameters characterising the channels in the study reaches of the Thurra and Cann Rivers.

	Thurra River		**Cann River**	
Characteristic symbol and units	**ThFR**	**ThRF**	**CRPC**	**CRC**
Width *W (m)*	13.2	13.2	17.9	65.7
Av. Depth *Y (m)*	1.4	1.3	1.9	3.8
XS area *A* (m^2)	18.7	16.8	34	248
Hydraulic radius *Rh (m)*	1.14	1.06	1.53	3.38
Methods	Mean of a number of surveyed cross sections determined at morphological bankfull (n=9)	(n=8)	(n=7)	(n=3)
Bed slope *S*	0.0017	0.001	0.0007	0.0018
Methods	Regression fitted to detailed bed and water surface slope survey	Regression fitted to detailed bed and water surface slope survey (see Fig. 8)	Regression fitted to bed levels in CRPC1 ?	Regression fitted to bed and water surface levels in CRC (see Fig. 8)
Valley slope S_V	0.0027	0.0023	0.002	0.002
Methods	*S* x *P*	*S* x *P*	*S* x *P*	*S* x *P*
Sinuosity ***P***	1.6	2.3	2.6	1.1
Methods	Measured sinuosity of study reach	Measured sinuosity of study reach	Mean sinuosity of CRPC channels + additional 4.5 km paleochannels as shown in Fig. 2	Measured sinuosity of study reach
Bed material D_{50} (mm)	0.83	0.60	0.59	1.27
Methods	Mean value from bulk sample analysis (n=9)	(n=8)	(n=10)	(n=10)
Unit wt of bank material $\gamma_t (KN/m^3)$	16.4	15.1	15.9	18.3
Methods	Mean value from bulk sample analysis (n=54)	(n=48)	(n=28)	(n=12)
Saturated bank material cohesion c_u (KN/m^2)	20.2	18.2	20.2	18.2
Methods	Measured *in situ* with a shear vane at bank base (i.e. saturated zone) (n=18)	(n=16)	Assumed value from ThFR	Assumed value from ThRF
Factor of safety as a function of Critical bank height H/H_{crit}	0.29	0.27	0.42	0.9
Methods	See Millar and Quick (1998)			
Woody debris load	0.032 m^3m^{-2} (n=326; Lc=400 m)	0.044 m^3m^{-2} (n=587; Lc=450 m)	Assumed value from ThRF	Negligible
Methods	Census method – volume of wood/water surface area at bankfull			
Channel migration rates (mm/yr)	25.3	7.7	29.5	4500
Methods	Dated transect	Dated transect	Dated transect	Air photo interp

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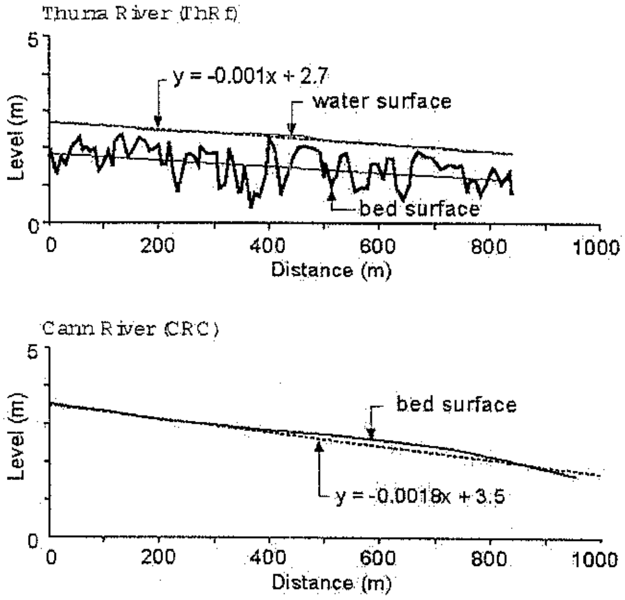
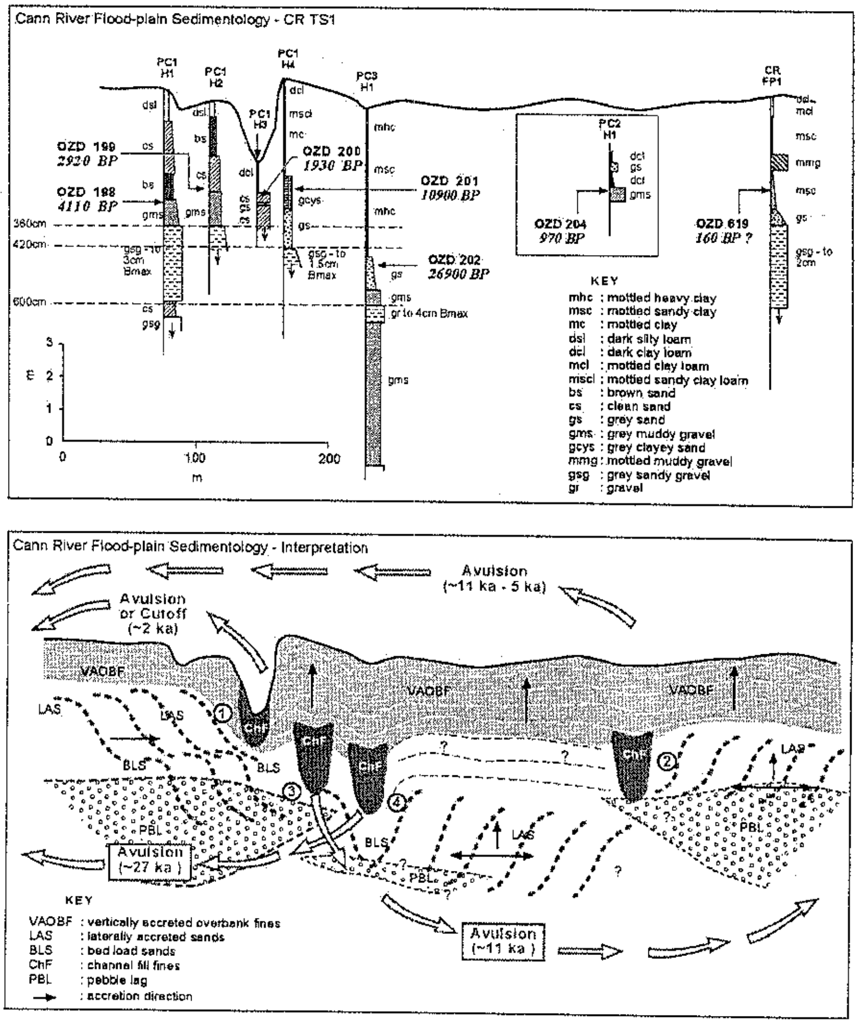


Bed longitudinal profile changes following LWD removal and channel enlargement



Sedimentology and chronology of Cann River Floodplain at stop 3

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Stop 4 Cann River at West Cann Bridge - Channel incision and works to control channel incision

Cann River at West Cann Bridge 1998 (*cf* today)

Bibliography

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THE SNOWY RIVER Rehabilitation Project

THE PATHWAY TO RECOVERY

THE SNOWY RIVER WILL FLOW AGAIN...

Department of
Infrastructure, Planning and Natural Resources

The Mowamba River was released back into the Snow River on the 28th of August 2002 by the Premiers of NSW and Victoria, having been diverted into Jindaby Dam for 35 years. As a result, the Snowy River is now running at approximately 6% of its natural volume before it damming for the Snowy Mountains Hydro-electric Scheme.

The New South Wales and Victorian Governments are investing $300 million to have the Snowy River flowing at 21% of its original volume over 10 years. Further investmen planned to take this up to 28%.

These flows will increase the river's minimum flow, and simulate natural seasonal peaks that occurred in the Snowy River before damming.

Much work is still to be done to ensure the river is best to respond to the increased flows.

THE PATHWAY TO RECOVERY.......

THERE ARE MAJOR CHALLENGES . . .

Following years of low water flow and few significant flood events, the Snowy River's active channel has dramatically reduced in size. Large quantities of silt, sand and organic matter have accumulated along a number of river sections.

Extensive populations of willow and blackberry have established within the river channel. These weeds will continue to be targeted for control under the Snowy River Rehabilitation Project as they have significant impacts on river ecology.

REVEGETATION AND CHANNEL FORMING . . .

One of the major aims of the river rehabilitation project is to stabilise sediment deposits by revegetation using native plants.

Revegetated sandbars along the river's edge will direct high flows back into the main river channel, so as to scour and deepen it. This is essential for recreating a deeper, faster flowing and more natural river, which will provide a wider range of aquatic habitat.

The revegetation is being done using native trees, shrubs and grasses propagated by local nurseries. Species will vary according to the location of the sites as plantings will be similar to the natural vegetation of each area.

HOW WILL THE RECOVERY PROCESS BENEFIT US?

Recovering the ecology of the Snowy River will ultimately lead to a much healthier river system with many real benefits to the wider community.

- Recreation and tourism, including fishing, canoeing and eco-tourism opportunities will develop as the river recovers
- Ongoing rehabilitation works provide continuing local and regional employment opportunities for many people
- Increasing opportunities in river management are being realised for Aboriginal people who have traditional links to the Snowy River
- Higher flows will lead to a much lower risk of water quality problems like algal blooms
- The Snowy will become a more productive river as it regains the typical characteristics of a river of this size.

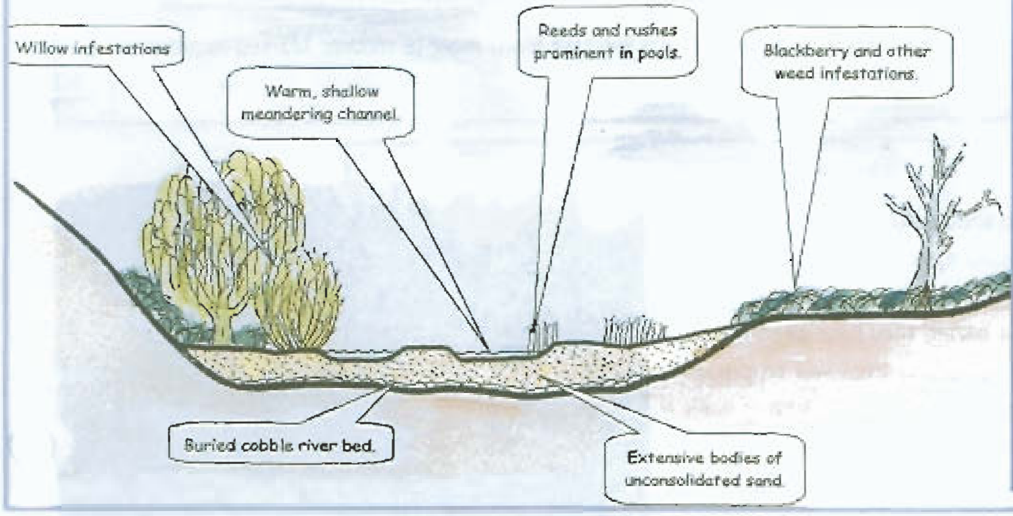
As the river deepens and high water periods become more frequent, caution will be needed when traversing crossing points in use for the past 30 years, as their condition may change significantly.

Pumps and other structures placed on or near the river since the river's diversion may now need to be relocated as higher water levels become more common.

River Rehabilitation and Channel Forming

through weed and stock control and revegetation

Degraded river cross section



Representation of the degraded condition of much of the Snowy River.

Degrading influences include:

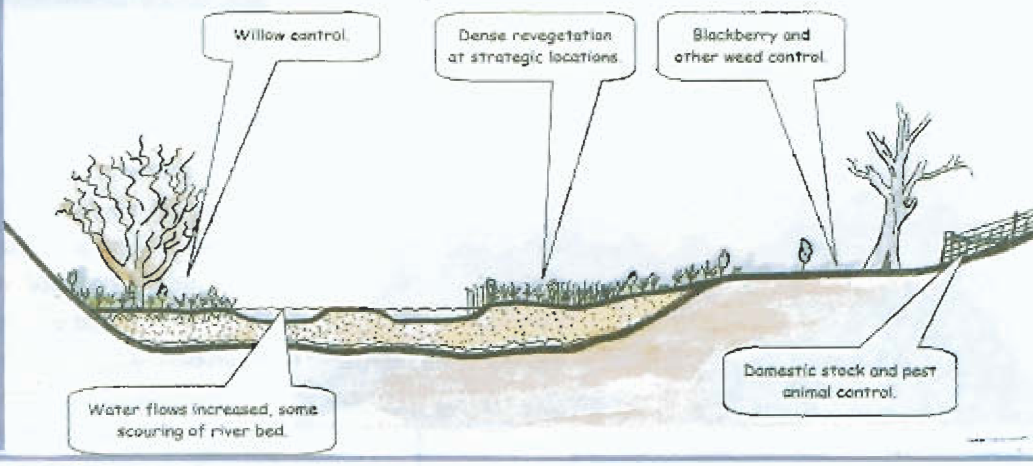
- Extensive unconsolidated sediment deposits
- Willows and other weeds encroaching on the river channel
- Controlled minimum flow resulting in shallow water with wide temperature variation and poor habitat value.

Rehabilitation: the channel forming process

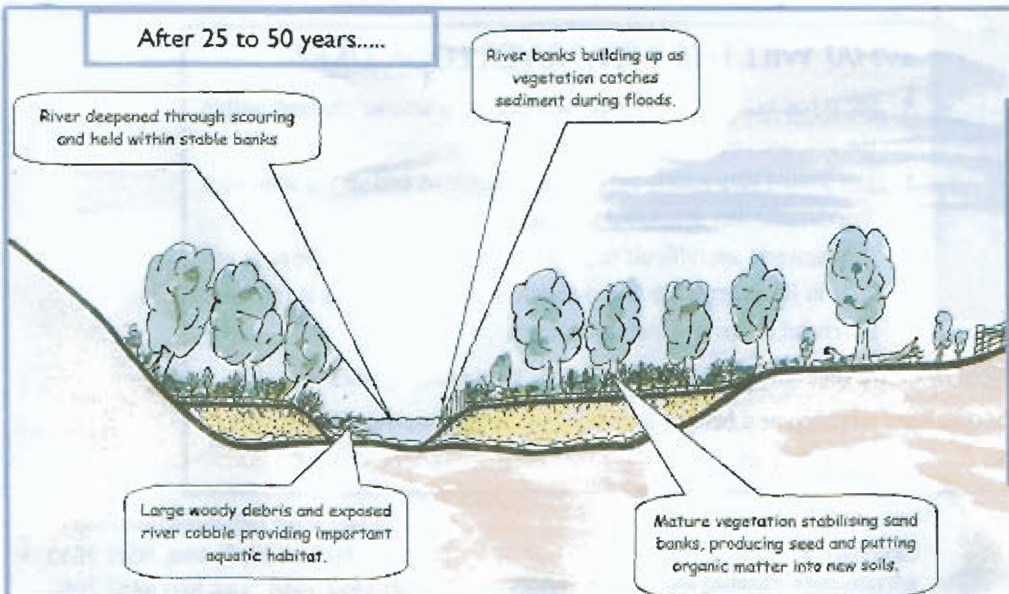
Rehabilitation works typically nclude:

- Willow and blackberry control
- Revegetation of strategic areas
- Stock control.

Revegetation aims to stabilise arge bodies of sand, act as a filter' to trap sediments mobilised by the increased flows, and ncourage the river channel to wi and deepen, especially under more frequent flood onditions.



After 25 to 50 years.....



Over a period of perhaps 25 to 50 years we expect to see a much healthier river, flowing in a deeper, colder and more dynamic channel.

River and riparian habitat is expected to improve greatly, as are recreational and aesthetic values.

HOW LONG WILL THE RIVER'S REHABILITATION TAKE?

- A scientific monitoring program has been collecting river data since 1999. This will allow the changes that occur to the river to be accurately measured and reported.
- Changes in the river are already indicated after only a few months of natural flow variation following the Mowamba River release.
- It has taken many years for the river to degrade to its current state, and it will take many more to recover. Marked improvements, however, are expected within 5 to 10 years.

THE DEAD WILLOWS…

Dead willow trees left in the river channel should break down within 3 to 6 years. As this happens the timber is expected to become useful fish habitat and a food source for insects living in the river.

Where the dead trees are considered a hazard they have been removed from the river channel and burned. The remaining trees will be prone to falling and should be treated with caution.

…AND THE REEDS?

- The apparent increase in the population of Flag Reed and Cumbungi may be partly attributed to willow removal and increased water flows
- Reeds have always been in the river but are now much more visible because of willow and blackberry control.

These plants would not normally thrive in an active river channel. It is therefore expected that with increased flows and regular flood events the reeds will tend to only grow at the pool edges where they play an essential role in stabilising sediments.

Tupong, (G. Aland) - a freshwater flathead

WILL THE FISH RETURN?

The establishment of fish populations in the Snowy River is dependent on water quality and habitat improving to a point where they can survive and breed. This will happen, given time and increased water flow.

Work will need to be done in the future to encourage and promote the return of native fish species and improve trout populations. The Snowy River Rehabilitation Project team is keen to hear of changes to fish populations in the Snowy River and its tributaries.

WHAT WILL THE 'NEW' RIVER LOOK LIKE?

- The rehabilitated Snowy River will occupy a smaller channel within the old riverbed
- Flow should vary widely between summer lows and spring snowmelt 'floods', whether simulated or natural
- River systems are difficult to predict, but we know that the river will alter in its appearance and dynamic state over time as it responds to rehabilitation and increased flows.
- The riverside vegetation will be dominated by native vegetation from the area, rather than exotic species.

With commitment, care and time the Snowy River will become a healthy and wonderfully diverse river, similar in many ways to the 'Snowy' many knew years ago.

Department of
Infrastructure, Planning and Natural Resources

Snowy River Rehabilitation Project
PO Box 26, Cooma, NSW 2630
Ph: (02) 6452 1455 Fax: (02) 6452 2080

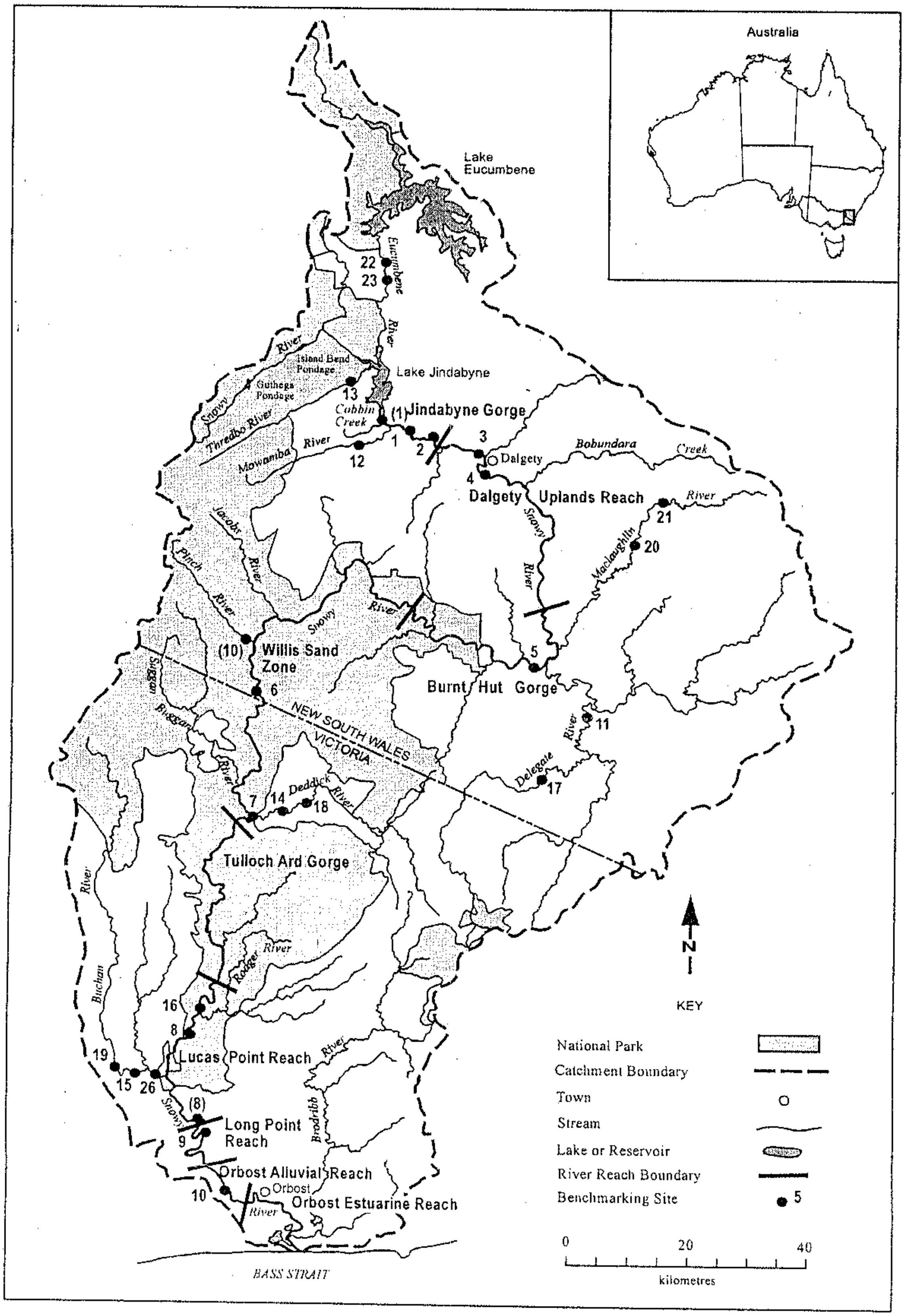
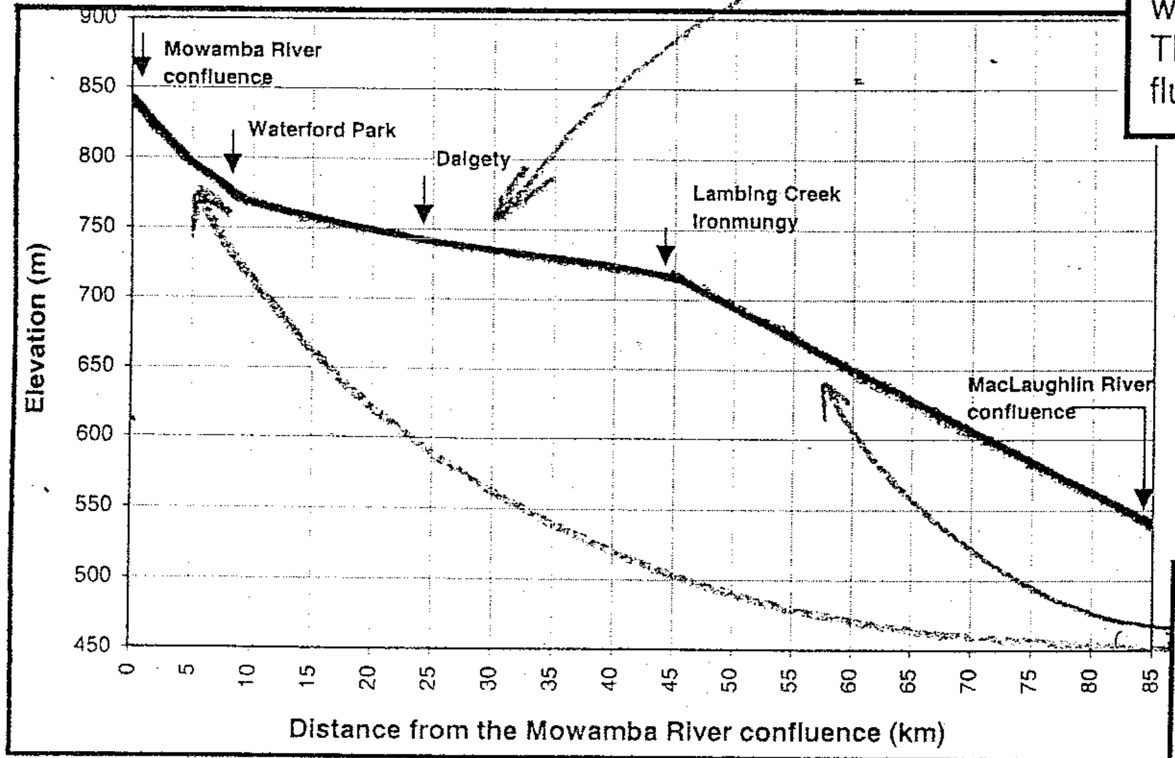


Figure 2. Snowy test, reference and control river sites (Webb and Erskine, 2000).

Snowy River long section: vertical fall and how that affects the rehabilitation project.



Dalgety Uplands:
Why it needs a lot of rehabilitation work....

This section of the river is broader as well as flatter, only falling 50 meters in 40 km, which means the planned flow releases will have less stream power to re-define the river channel and clean out sediment and weeds.

Broad scale revegetation is being undertaken in numerous areas to help slow water flow in the shallower margins, which will in turn increase the rivers power in the main channel. This is expected to lead to sediment being reworked, reeds flushed out and a deeper, healthier channel being formed.

In the Beloko and Bungarby reaches, the planned flows will do most of the work....

These are steep, narrow bedrock confined river channels.

Planned flow releases should have enough energy to re-define the river channel, clear sediments and algae from the river cobble, and remove seedling weeds like willow and blackberry over time.

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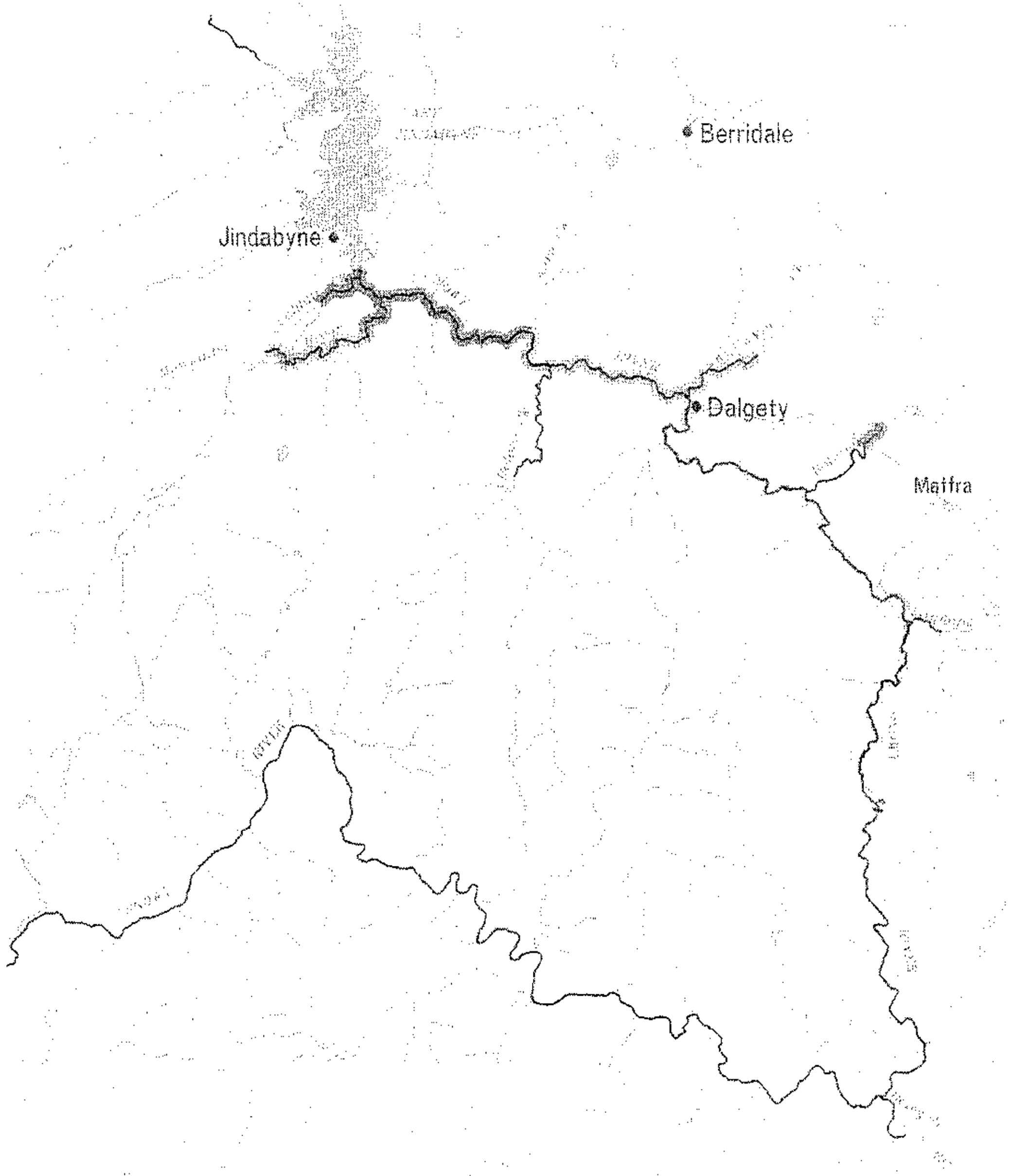
Department of
Infrastructure, Planning and Natural Resources



Department of Infrastructure, Planning and Natural Resources

Study area.........
1999.................
2000.................
2001.................
2002.................
2003.................

Selective willow control has occurred in all areas since 1997.

SNOWY RIVER WILLOW CONTROL PROGRAM

Scale 1:350 000

3.5 The enterprise will be funded as follows:

- New South Wales Government: $150 million;
- Victorian Government: $150 million;
- Commonwealth Government: $75 million.

These are the total financial contributions which will be made by the Governments towards achieving the target levels of water flows specified in Clause 1.2. All financial contributions will be provided in the first ten years. The Commonwealth financial contribution will be provided, in particular, to secure environmental releases to the River Murray.

Commitment of funds and the allocation of water savings for environmental purposes can only be varied by agreement between the three Governments.

3.6 The enterprise will be non-profit. It will have a defined annual cash flow and a limited capacity to carry out short-term investment, carry over of funds between financial years, and borrowing. The annual business plan of the enterprise including the proposed savings projects or package of projects will require the approval of the three Governments.

3.7 The parties recognise that NSW and Victoria are moving to establish fully functioning water markets consistent with COAG principles and MDBC resolutions and the parties also note that NSW is currently in a program of active water policy reform and that these initiatives will underpin the operation of the enterprise.

3.8 Pending the establishment of fully operating water markets, the State Governments will take all reasonable steps to promote access by the enterprise to water entitlement and water rights holders (including individuals) in both States for the acquisition of water for the purposes of this agreement.

4. STAGES FOR INCREASED FLOWS

4.1 First Stage (Initial release)

4.1.1 An initial increased release of water to the Snowy River below Jindabyne will be made from the Mowamba River and Cobbon Creek aqueducts at a time agreed by all three Governments following the proclamation of the Snowy corporatisation legislation.

4.1.2 Water to offset the increased flows in the Snowy River resulting from releases from the Mowamba River and Cobbon Creek aqueducts will be sourced for up to the first three years from Snowy Scheme storages. These borrowings will be paid back over a time scale which does not affect water allocations for irrigation farming. The repayment schedule will be part of the agreed annual business plan of the joint government enterprise. Within three years, inflows to the Snowy River from the Mowamba River and Cobbon Creek will be offset by verified water savings from the enterprise. Reductions in assured releases to the west made by Snowy Hydro Limited equal to these verified water savings will be implemented when this offsetting commences.

4.2 Second Stage (2 to 7 years)

4.2.1 Water releases from the Snowy Scheme to the Snowy River below Jindabyne will be progressively increased in tandem with increases in the verified volume of water acquired by the joint government enterprise. For this stage, the target flow in the Snowy River below Jindabyne is 15% ANF. To enable these releases to be made, within three years of corporatisation Snowy Hydro Ltd will build an outlet at Jindabyne Dam to enable a flow in the Snowy River of at least 28% ANF.

4.2.2 Dedicated environmental flows allocated to the River Murray of up to 70 gigalitres per annum will be progressively implemented in tandem with increases in the verified volume of water acquired by the joint government enterprise. The River Murray flows will be matched to the allocation to the Snowy River on the basis of one gigalitre allocated to the River Murray per two gigalitres allocated to the Snowy River over the Second Stage (2 to 7 years).

4.2.3 The MDBC will be responsible for managing a variable inflow regime, including above-target water from the Snowy Scheme to provide dedicated environmental flows to the River Murray downstream from the Hume Dam.

4.2.4 NSW will develop schedules for increased water releases to the Snowy montane rivers, including the upper Murrumbidgee River, of a total volume of water equivalent to foregone Snowy electricity generation of 100 gigawatt-hours per annum. If necessary to enable releases to the upper Murrumbidgee River, within three years of corporatisation Snowy Hydro Ltd will build an outlet at Tantangara Dam.

4.2.5 Water releases to the Snowy River below Jindabyne and to the Snowy montane rivers will mimic natural flows under prevailing climatic conditions to the extent possible, depending on the availability and reliability of offset water and the capacity of constructed outlet works at Jindabyne and Tantangara Dams.

4.3 Third Stage (8 to 10 years)

4.3.1 Water releases from the Snowy Scheme to the Snowy River below Jindabyne will be progressively increased in tandem with increases in the verified volume of water acquired by the joint government enterprise. For this stage, the target flow in the Snowy River below Jindabyne is 21% ANF.

4.3.2 In this stage, the security of the further offset water required to achieve a 21% ANF flow in the Snowy River will be at the level of reliability measured at the point of acquisition or purchase, not at the reliability level for annual inflows to the Snowy River.

4.3.3 Water allocated from the Snowy Scheme to the River Murray for dedicated environmental flows will continue to be matched to the allocation to the Snowy River on the basis of one gigalitre allocated to the River Murray per two gigalitres allocated to the Snowy River up to a maximum allocation of 70 gigalitres per annum to the River Murray within 10 years.

4.3.4 Water releases from the Snowy Scheme to the Snowy montane rivers will be increased to a total volume of water equivalent to 150 gigawatt-hours per annum of foregone electricity generation.

4.3.5 The target is to complete this stage in 10 years.

4.4 Fourth Stage (beyond 10 years)

4.4.1 The additional 7% of further flows in the Snowy River up to a total of 28% ANF may be achieved following the implementation of an additional major capital works program to achieve water savings in the southern Murray-Darling Basin beyond those required to offset the 21% ANF flows in the Snowy River. This program will be undertaken through public private partnerships in which the water saved is shared between the governments and private sector partners. Water savings allocated to the governments will be used to offset increased flows in the Snowy River and to provide further dedicated environmental flows in the River Murray.

5. COMPENSATION PAYABLE TO SNOWY HYDRO LTD

5.1 The three Governments agree that compensation for all net foregone revenue resulting from reduced availability of water flows will be paid to Snowy Hydro Ltd, by arrangement between NSW and Victoria, for any flows in the Snowy River above 21% ANF.

5.2 No flows in excess of 21% ANF will be implemented before arrangements for sharing the cost of the compensation are agreed between the NSW and Victorian Governments.

6. WATER ACCOUNTING ARRANGEMENTS

6.1 The measuring point for all Snowy River flows will be immediately below the confluence between the Snowy and Mowamba rivers.

6.2 The three Governments will present each water savings project or package of projects proposed by the joint government enterprise or by the Governments themselves to the Murray Darling Basin Commission for comment under clause 46 of the *Murray Darling Basin Agreement*.

6.3 A methodology for verifying the water savings actually acquired through each project for the purposes of offsetting increased flows to the Snowy River below Jindabyne and dedicated environmental flows to the River Murray will be developed for comment by the MDBC and approval by the three Governments.

6.4 An auditor appointed by the three Governments in consultation with the MDBC will review the calculation of prospective water savings from each project, certify that the calculations are reasonable and verify the actual water savings achieved by each project.

6.5 Victoria and NSW will create specific environmental water entitlements for the Snowy and Murray Rivers. The water contained in these entitlements will represent the water savings and purchases made by the joint government enterprise.

6.6 The allocation of water to the Snowy Scheme for increased flows in the Snowy River below Jindabyne and for dedicated environmental flows in the River Murray will be made when the offsetting water savings actually acquired have been verified by the auditor. However, the initial release of water from the

Penny

River to rivulet and back: Rehabilitating the Snowy River.

Born and bred in Canberra and a very keen fisher from an early age, I spent a lot of time fishing the rivers of the Southern Tablelands and the Monaro. Whilst at the Australian National University, I spent the summer vacations (1960-1963) as a technician with the Alpine Ecology Unit of the CSIRO Division of Plant Industry working with Alec Costin and Dane Wimbush. Initially, we were based at Island Bend and then at Waste Point. From this experience, I got to know the moods of the Snowy River very well and was acutely aware of the essential integrity of the unregulated Snowy compared with the degraded state of the Eucumbene as it joined the Snowy between Waste Point and the original Jindabyne. Thus, one can say that I'm very aware of what was lost in the damming the Snowy reducing it from being a surging river to a degraded rivulet below Jindabyne.

The Snowy Scheme is a massive scheme; rated by American Society of Civil Engineers as one of the seven civil engineering wonders of the world in the 20th century. It is a massive scheme encompassing 16 major dams with total capacity of 7,000Gl or 13 Sydney harbours, 145 km of interconnected inter-mountain tunnels, 80 km of aqueducts and 7 major power stations with generating capacity of 3,756 megawatts from 31 turbines. The scheme is a stark case of **concretophilic developmentalism** with scant environmental concerns for the rivers and for the overall environmental values of the Kosciusko National Park. The Scheme has dammed 7 major rivers, diverted flow from 5 of these (Snowy, Murrumbidgee, Geehi, Tooma, Eucumbene), supplemented greatly flow of two (Swampy Plains and Tumut), diverted water by aqueducts into the scheme from 4 major waterways (Goodradigbee, Mowamba or Moonbah, BogongCreek, Gungarlin River). Now within the Snowy Mountains and the Kosciusko National Park, there are now only three fairly natural rivers, the Crackenback, the upper Murray and the Yarrangobilly. From the aquatic ecology point of view, the Kosciusko National Park is a badly degraded national park, with all but three of its rivers badly damaged.

The scheme was primarily built to generate electricity and not to supply irrigation water. To quote the draft EIS for the Corporisation of the Snowy Mountains Hydro-Electric Authority (2000) " unlike electricity, there are no specific entitlements to water from the scheme under the current legislation, apart from during specified drought situations". There was no recognition of the need for environmental flows in the enabling acts, the Snowy Mountains Hydro-Electric Power Act 1949 and the Snowy Mountains Hydro-Electric Agreement 1957. The once free-flowing rivers had their flows greatly reduced to the very low levels of "riparian releases". These water releases have been set by the Snowy Mountains Council (with no freshwater ecologist) that is also supposed to be responsible for the environmental implications of the Scheme's activities from the point of the rivers' ecological condition. Thus, the minuscule riparian releases are supposed to supply riparian demands, but have lead to major disruption of the riparian zones, and may meet no more riparian demands than those of blackberries, gorse, rabbits and sheep.

In the early 90's, the need for rehabilitating dammed rivers by implementing environmental flows started to arise. For example, the commissioning of the Thomson River Dam lead to the setting of an environmental flow—originally quite substantial but with further committees, it has been steadily whittled down. In NSW, under the leadership of John Harris (then of NSW State Fisheries), an Expert Panel approach for developing recommendations for flow management to rehabilitate regulated rivers was developed. I was a member of a small team that trialled the Expert Panel approach in severely regulated rivers in NSW (e.g., Tumut, Macquarie, Namoi). This trial was followed by the invitation from Snowy Genoa Catchment Management Committee to devise an environmental flow regime for the Snowy below Jindabyne. So we studied the river from Jindabyne to Orbost seeking to identify the environmental parameters that currently influence the ecological functioning (or non-functioning) of the Snowy River, to identify critical environmental thresholds within the flow regime that may amplify the ecological functioning of the Snowy River, to develop a set of recommendations for flow management to maximize ecological benefit and to recommend a strategic environmental flow research program. The results of the Panel were published in a precise multi-authored report in February 1996.

The release of the report triggered trenchant criticism of the expert panel approach by other experts and consultants- especially the Centre for Water Policy Research (1996). It is very apparent that there is a critical schism between two approaches in methods for setting environmental flows. First, there is what may be called the **Hydrol-Ecological**, such as Expert Panel Assessment Method (EPAM), Instream Flow Incremental

Methodology (IFIM) and PHABSIM. Hydrol-ecological methods are concerned with the river and its biota and have outcomes pitched in hydrological, geomorphological and ecological terms, and recognizes thresholds, both for habitat maintenance once it has been recreated, and for large hydro-geomorphological thresholds that mould and generate habitat. The second approach can be called the **Enviro-socio-economic.** This approach uses hydrological and ecological expertise, but also includes an assortment of interests of users and stakeholders; the very interests that have used and may have damaged the river. Thus, in the very devising of the flows, the incorporation of the socio-economic exploitative interests may compromise the ecological, so that the environmental flow may be set at a compromised mean value, below critical thresholds. For example, the Snowy Water Inquiry (1998) had to" be consistent with a much wider brief that requires the Inquiry to assess economic and social trade-offs associated with re-diversions back to the east". In the usual case with this approach, environmental flows are set at low levels (10% or so) that may not achieve any improvement any ecological improvement and which, even if there is ecological monitoring, are unlikely to produce detectable ecological effects.

Perhaps the most galling attack on the Expert Panel Approach has been the claim that " it is not science". To me, this criticism suggests a poor misunderstanding of what science is about. Setting an environmental flow is initially an educated guess or hypothesis, and the value of the hypothesis lies in setting up the project as an experiment—an experiment in adaptive management. In the best case, we're looking at a before-after (BACI) study. Sadly, in most cases of environmental flow setting to date, before- and after monitoring is either non-existent or perfunctory, and the monitoring is of such poor design or quality that to pick any effect would be well-nigh impossible. This is the challenge; the necessity for sound reliable monitoring in a statistically and logically rigorous design so that you can test the validity of the hypothesis that the set environmental flow is having (or not having) ecological effects.

The monitoring, which is rarely properly implemented, can be linked with an adaptive management framework. This framework means that you learn from the monitoring data how the river and its biota are reacting to the flows in relation to the hypothesized responses. Dependent on assessing these responses after an adequate time period, it may be necessary to set a new flow regime that is again monitored. The procedure allows one to learn by doing. It has been successfully used, for example, in such environmental flow work as the release of floods from the Glen Canyon Dam down the

Colorado River to improve habitat for native biota. One would like to see the Snowy River Benchmarking Project as a well-funded, long-term ecological experiment embracing adaptive management. Given the costs in the whole exercise, hopefully Federal and State Governments will be eager to have an adequately funded monitoring and adaptive management program for environmental flows down the Snowy River.

In the Jindabyne Gorge and Dalgety Uplands Reaches, the Snowy River is a travesty. From the dam, a trickle of water flows to be joined by the treated sewage of Cobben Creek. The channel has shrunk greatly and has been invaded by invasive and native riparian vegetation. Indeed, a common feature of shrunken channels is that riparian areas, permanently exposed by low flow, are colonized predominantly by exotic invaders (willows, gorse, blackberries, Californian poppies etc). Still pools are joined by small trickling driffles (derived from dribbles flowing through would-be riffles). These driffles are most unusual in that they are not lined with stones and cobbles but consist of unconsolidated sand, silt and gravel. You can push a sampling net handle up to a metre or two into the driffle bed. Dwelling in the pools is a fauna resembling that of farm dams, whereas in the driffles, there dwells a most strange fauna dominated by oligochaete worms, chironomid fly larvae and sphaeriid bivalve molluscs.

Restoring adequate flow is the major goal, but one should also recognize other issues besides those of the river channel also need urgent attention, such as spoil dumps, the lamentable catchment condition, and the degraded riparian zone. We must recognize that " the natural flow regime plays a critical role in sustaining native biodiversity and ecosystem integrity in rivers." Clearly, the river in this whole upland reach needs three things, more water to cover the channel, flow variability on a seasonal basis, and a mimicked spring flood to reshape the channel and provide new habitats

The Expert Panel built a flow pattern by examining the river and its biota, and what we conservatively thought then would substantially return the ecological integrity of the river and return important functions such as habitat replenishment and maintenance, connectivity, and seasonal and short-term variability.

If full flow restoration is impossible, mimicking certain geomorphic processes can provide critical ecological benefits by identifying flow thresholds for effective river ecological functioning. Our recommendations were based on depths that were then converted to flows. Three flow types were set in the overall flow regime:

Absolute minimal flow. From the Dam the flow is now a constant 50ML/d. The Panel recommended a minimal flow immediately below Jindabyne dam of 200 ML/d; this approximates to 95th percentile exceedence for the driest month.

Minimum habitat flow utilization flow regime: This is a minimal seasonal flow regime that allows aquatic biota to use a reasonable amount of resources and to have a diversity of habitat for survival and life cycle completion, and to allow in-stream transport and nutrient processing to operate. This entails not only habitat inundation, but also flow variability and requires enough water to maintain moderate water quality parameters, such as temperature and oxygen availability. Thus, the Panel used the natural 95th percentile exceedence flow by month.

Channel Maintenance Flow: This was regarded as flows of sufficient strength to reconfigure the river channel and substrate and riparian zones, thus regenerating much of the structural habitat. Thus, as in other upland streams, such flows (floods) reconfigure pools, riffles and runs, flood out barriers, move large debris, and remove sand and silt and reinvigorate and reshape the riparian zones. In addition, in the Jindabyne-Dalgety Reaches the flow could remove macrophytes (eg., *Phragmites*, *Typha*) and invading riparian plants, and re-invigorate the riffles- blowing away the sand, gravel and fines- that now comprise the driffles. This means that to re-mould riffles/runs, to reshape pools, to rebuild and replenish habitat and to maintain the river in a good functional condition, it is necessary to implement large and extended channel maintenance flows as near as possible to the natural high flow condition. If these high spring flows are restored, then channel reshaping will occur and an array of riffles, pools and runs will return and the emergent macrophytes will be greatly reduced. Such high flows could also augment longitudinal connectivity by flooding out barriers to migration eg., Snowy Falls for fish. We recommended a flood flow event of 3-5 days between May-October each year, with a minimum peak of 12,000 ML/d below Jindabyne and at least 20,000 ML/d at Dalgety.

Finally, to introduce some natural variability into the flow and to provide some longitudinal connectivity for the Jindabyne- Dalgety section, we recommended the decommissioning of the aqueducts of Cobbin Creek and of the Mowamba River and the breachingl of the barriers. At present, it is very evident below the dam that the water coming from the dam does not favour a normal stream fauna. It encourages algal growth, especially attached blue-greens, and filter-feeding invertebrates. Thus, the recommendation to remove the aqueducts was made so that the river may gain an upstream source of colonists, but may also gain allochthonous energy (detritus), sediments and nutrients.

In building the scheme there seems to have been a strong determination to extract every drop of water from streams. Thus, there are 80 kilometres of aqueducts extracting flows from streams and delivering their flows into dams. Such aqueducts exacerbate the lack of water in rivers downstream of dams, have greatly reduced the extent of middle order streams in the National Park, and have isolated completely upland streams from their natural downstream reaches. Thus, cut-off streams may contain isolated populations, cut off ecologically and genetically, from other populations. In short, in the Kosciusko National Park, connectivity involving middle order streams has been very severely disrupted. Rivers naturally have connectivity that is critical to a river's functioning and to the river's role in the surrounding landscape. Hitherto, the issue of river connectivity has been neglected in landscape planning in general, and much more sadly in the planning and management of conservation reserves and national parks. Thus, in the Kosciusko Park serious thought should be given to the elimination of some aqueducts e.g., Gungarlin , Burrungubugge.

In terms of the biological responses to the flow, the most immediate ones are going to happen in the upland reaches, and I gather that some reshaping of habitat, especially in the driffles has already occurred. Currently, these driffles are very abnormal and need reworking by some high flow events to blow out all the fine sediments. With that process occurring, I predict that it won't take long for the normally expected riffle fauna, of such groups as Ephemeroptera and Trichoptera, to recolonize. I expect with increased flows, especially the high flows, that large amounts of bamboo grass and cumbungi will be removed –and become detritus for stream invertebrates. The killing of willows and the donation of dead willows to the rivers I can only see as beneficial. Willow wood rots quickly and is a food resource for a guild of wood borers and gougers in the stream. I hope that steadily in the upland reaches with the very dilapidated riparian zones and with the removal of such exotics as willows, gorse etc., that native vegetation (tea-trees, acacias etc), is encouraged to replace them. Such plants are hubs of aquatic and terrestrial insects and spiders that provide food for fish, as opposed to willows etc., that are bereft of much macroinvertebrate life. With more flow and an improvement in water quality and an increase in stream insect/ crustacean abundance, I expect an increase in trout biomass.

With increased flows increasing longitudinal connectivity in the river, there may be some movement up into the upland reaches of eels, galaxiids, tupong, possibly even bass. With releases from Jindabyne Dam, I expect that the upland reaches will become a somewhat smaller version of the original upland river—not the original size but similar in biota and ecological functioning.

The timing of recovery is largely driven by the provision of the required flows. With suitable flows, connectivity will be restored and good habitat, in form, amount and variety, will be created. The recovery will also depend on which part of the river one is concerned about, as the more downstream one goes the more diluted will be the effects of the flows from Jindabyne Dam. In the uplands reaches, I expect water quality to be improved first, followed by the steady development of patches of habitat. With new habitat, one would expect short-lived and mobile macroinvertebrates –especially insects— to increase in variety and abundance. Fish may then start to increase in abundance and finally, and dependent on both flows and active bankside rehabilitation, the riparian zone may return as an intact system dominated by native plants.

In Australian and international spheres, we must recognize that the environmental flow project of the Snowy River is extremely important. First, it is the iconic Snowy River known to most people through poetry, films and television. Second, it is one of the few rivers to get an environmental flow that may be of an ecologically appropriate magnitude. Environmental flows have been set for some rivers, but they tend to be no more than tokenistic (e.g., 10%), or agreed upon but never implemented (Campaspe River below Eppalock). Third, the Snowy is valuable as the effects of the flow are being monitored to see if the flow works. The monitoring program is rigorously set out as a before-after (BACI) design (with 3 years of before data), and with 26 control, reference and treatment sites. The team from DLWC is monitoring hydrology, water quality, channel morphology, riparian, littoral and submerged vegetation, macroinvertebrates and fish. Then, following the adaptive management procedure, if the flow is inadequate after 28%, the monitoring results may be used to increase the flows. Finally, it could be a very encouraging example of how community, scientific, political and management interests can work together to resolve a difficult and large scale environmental problem This is very important as it demonstrates that good progress resolving environmental problems can be made without endless prevarication, delays and broken promises. It also vividly illustrates that resolving a difficult environmental problem can bring together a community made up of many different interests and that this community willingly accepts that solving the problem is a long-term venture.

From : Professor Sam Lake
Snowy River Recovery Forum, Dalgety 2003.

Snowy River

Benchmarking and Environmental Flow Response Monitoring Project

Background

Flows in the Snowy River below Jindabyne Dam have been reduced to 1% of mean annual natural flow since 1967.

Community concern about the degraded Snowy River led to a rapid Expert Panel Assessment in 1996 of the impacts of Jindabyne Dam on the river's ecology. The panel recommended a minimum release of 28% of mean annual natural flow.

To measure the effectiveness of flow releases, the Snowy River Benchmarking and Environmental Flow Response Monitoring Project began in 1997.

Objectives

1. **Assess the condition of the Snowy River before the release of environmental flows.**
2. **Assess the condition of the Snowy River after the environmental flow releases.**

Note: The comparisons will be made against other rivers with and without dams.

The Snowy River at Dalgety in 1997, showing the extent of vegetation encroachment into the channel as a result of reduced flows from Jindabyne Dam (26ML/d^{-1}).

The Snowy River at Dalgety during a 781ML/d^{-1} flow event. An environmental flow release of this size would likely result in an improvement of in-stream habitat.

We are monitoring changes in:

Water quality and hydrology (continuously)

Geomorphology, habitat and sediments (every 2 years)

Vegeta
(twice
year)

Algae (twice per year)

Macroinvertebrates (twice per year)

Fish (once per year)

The results to date indicate:

- Greatly reduced channel size.
- Pools infilling with sand.
- Loss of habitat diversity.
- Greater abundance of in-stream vegetation.
- Greater abundance of macro-algae.
- Invertebrate fauna is typical of silty, slow flowing conditions.
- Reduced abundance of native fish.
- In general, the condition of the Snowy River is poorer than nearby rivers without the impact of dams.

These results and continued monitoring will be used to:

- Report on how the environmental flows have changed the condition of the Snowy River.
- Provide data to the Snowy Scientific Committee (to be formed under the Snowy Hydro Corporatisation Act 1997) so it can advise on the pattern of environmental flow releases and their adequacy for ecological benefits.

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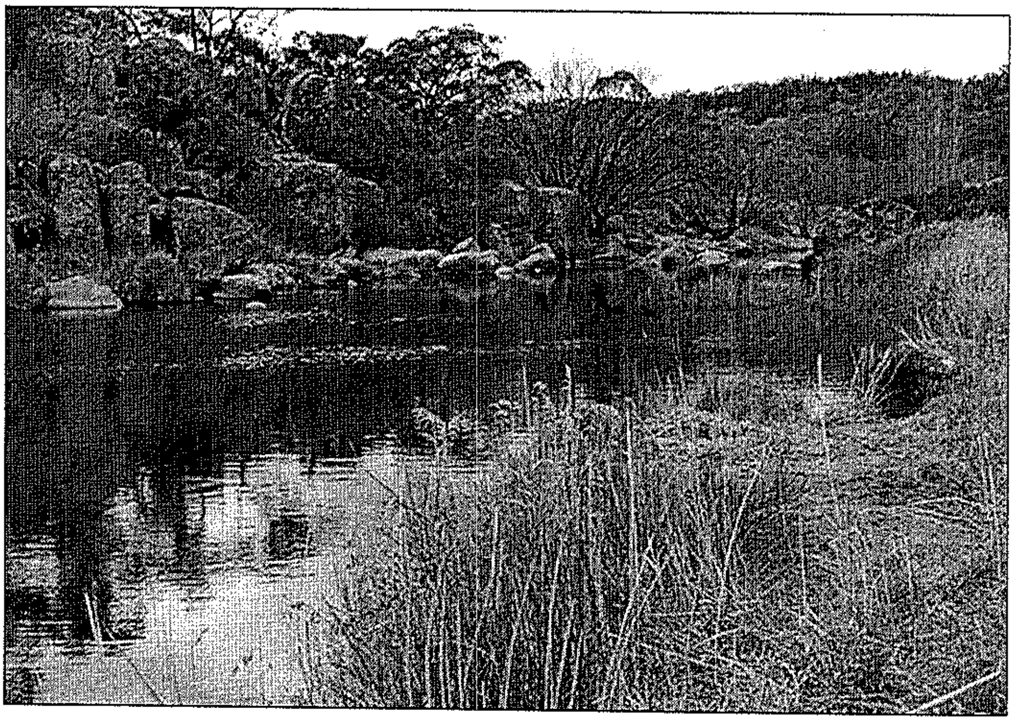
EAST GIPPSLAND CATCHMENT MANAGEMENT AUTHORITY

A Report Card on the recovery of the Snowy River



Presented to:

NSW Treasury, November 2003

The Snowy River Recovery program has a single and overriding ecological purpose, to recover the health of the Snowy River in NSW by the introduction of environmental flows and by rehabilitation of the river channel. It also has a broader aim, which is to maximise the economic and social benefits accruing from the regeneration of the river. This is in accordance with the expectations of river communities and the Government's principles of achieving sustainability in management of natural resources.

Active intervention to rehabilitate the choked Snowy River channel is being carried out, and a pilot program is running to develop and demonstrate community and economic benefits arising from increased environmental flows. This program is being delivered to generate positive outcomes for the communities living on, or living with links to, the river. This includes the Aboriginal communities of the south-east, who have rich cultural ties to the Snowy River.

Teresa Rose

A Report Card on the recovery of the Snowy River

Recovery Objective: A healthy Snowy River

Target	Current Status
Environmental Flows • 3% additional flow to be delivered from Mowamba River (up to 38GL/a), balanced by 38GL water efficiency savings in inland irrigation areas by 2005. • 7GL montane area releases to be made to the Goodradigbee River, when the first flow allocations (post-Mowamba) are made to the Snowy River.	• 3% flows released 28 August 2002, and the NSW-VIC Joint Government Enterprise has been established (Dec '03), to make water savings in inland irrigation areas. • There is an accumulated 'Mowamba Borrowings Debt' of about 37GL (to Jan '04). • Goodradigbee flow delivery arrangements have been agreed with Snowy Hydro.
Willow removal/Vegetation management • All willows clogging the Snowy River to be removed in NSW and Victoria (except for selected amenity trees, eg. around Dalgety township) by 2007. • Blackberry masses to be removed from badly infested margins of the river by 2007. • 70km of Snowy River margins needing treatment to be revegetated by 2007.	• Willows have now been killed in a 100km section of the Snowy River below Jindabyne (60km completed, 40km initial treatment - 3 treatments required to complete). • Blackberry removed from 25km of river in NSW (additional blackberry was removed by summer fires, but requires spring herbicide follow-up). • 3 km of river now revegetated with native riparian vegetation in NSW.
Dalgety Township environs • Township river environs to be fully rehabilitated by 2004: - All problem Willows killed and removed, - All blackberry masses removed, - 100,000 native trees & shrubs established.	• Willow treatment and removal complete. • 80% blackberry masses removed. • 50,000 native riparian trees and shrubs planted.
Native Fish Populations • Australian Bass to be re-established in lower 90km of river by 2007 • River Blackfish to be re-introduced to selected habitat locations in the middle reaches of the Snowy River by 2010	• Workshops with Fish Ecologists and Native Fish Australia have been held to inform and support the program. • Snowy Fish Recovery Strategy in Preparation. • Objective agreed with SE Aboriginal communities.
Ecological Health of the River • Decline in ecological condition of the Snowy River to be halted by 2003. • Measurable signs of ecological response to environmental flows to be evident by 2005. • Flow Response monitoring to inform government and communities on the return to health of the Snowy River.	River condition is benchmarked, with 3Yrs pre-flow and over 1Yr post-flow monitoring showing that: • Mowamba flows have already stripped algae and expanded the flow channel in the upper reaches. • Natural regeneration on mobile sand-banks has commenced. • Storm run-off after the summer bushfires has caused a significant decline in river health.

Summary: By 2007, the Snowy River will have been physically rehabilitated to a level that provides for maximum benefit to be achieved from the increased environmental flow allocations. River rehabilitation works are currently occurring ahead of schedule, however the 'JGE' arrangements to deliver the environmental releases are behind schedule. A critical point will be reached in Sept 2006 when the Jindabyne Dam outlet is completed and the community will expect to see increased releases.

A Report Card on the recovery of the Snowy River

Recovery Objective: Stronger Snowy River communities

Target	Current Status
Listening to river communities • NSW Agencies understand the outcomes expected by river communities at the outset of the river recovery program, and refresh this understanding as it progresses. • The desire of Aboriginal people to be active participants in Snowy recovery is realised. • The values that support the legendary spirit of Snowy River people are understood and communicated. • Support is provided for Snowy River communities to celebrate their river and their identity.	• Major consultation with South East Aboriginal communities held. • ANU study of community perceptions undertaken for 3 river towns in NSW as part of a Masters Degree research. • Inaugural NSW-Victoria '**Snowy River Journey**' event undertaken, linking Snowy River communities from Charlotte's Pass (NSW) to Marlo (Vic). 'Spirit of the Snowy' booklet and video produced, and ABC broadcast of stories from the Snowy River Journey (Nov. 2002). • An ABC Book project is under way.
Communities are part of decision making • A mechanism for community involvement in river recovery is established by 2002.	• Snowy River Rehabilitation Plan committee in place, meets locally every 2-3 months. There is a high level of confidence in NSW Agencies to deliver river recovery.
Building River Networks • People with an interest in Snowy River recovery are brought together periodically in a relevant forum. • People working on the river have opportunity to exchange ideas and learning.	• A River Recovery Forum was undertaken in May 2003 at Dalgety, and a second at Orbost in August. • A NSW-Victorian exchange program has been initiated with a Visit to Orbost in October 2003, and a return visit planned for April '04.
Social Capacity – leadership and learning • Snowy River recovery provides opportunities for development of community leadership. • People, particularly young people, from Snowy River communities understand and learn from the river recovery process. • Active steps are taken to add value to the intellectual capital generated by Snowy River recovery.	• Government Agencies have recognised the role of community leaders in Snowy River recovery. • Local school students have been involved in Snowy River recovery events and activities, and an education program is currently being expanded from Victoria. • A 'Snowy River Institute' concept paper is in circulation.

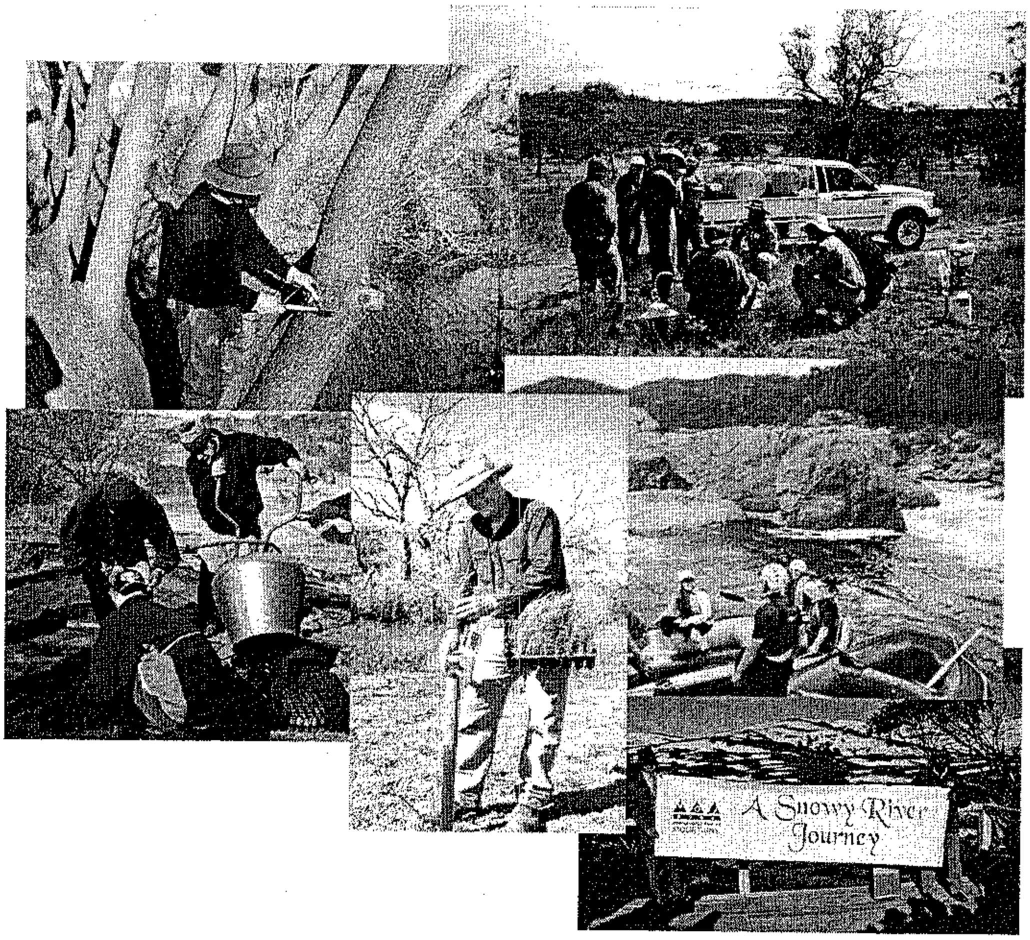
Recovery Objective: Increased local/regional economic activity

Target	Current Status
• Snowy River recovery acts as a catalyst to local and regional economic activity. • There is local economic participation in Snowy River Recovery activities. • NSW Agencies contribute to overcoming barriers to participation, such as equity, education, or social situation. • River rehabilitation projects generate local and regional employment.	• On-ground training and support has been provided for local people to gain river work. • An Aboriginal group has been trained and supported to engage in rehabilitation works generating ongoing employment for 6 people. • $ 600,000 investment in willow control and riparian revegetation has been directed to a growing number of local contractors and suppliers.

A Report Card on the recovery of the Snowy River

Increased Regional Tourism • New/increased river recreation opportunities are identified arising from Snowy flows. • New river-based local and regional tourism opportunities are identified. • Tourism organisations participate in development of Snowy River tourism product.	• Informal consultation has been carried out with recreation operators e.g. canoeing, rafting and fishing. • Informal consultation with tourism bodies and operators is in progress. • Premier's Dept. is working with Tourism operators in the Snowy Mountains to develop Snowy River concepts and capacity for regional tourism.

Summary: There is a dialogue between river communities and the Government, jobs are being created, the capacity of communities to take advantage of increased Snowy flows is being developed, and people are celebrating their identity and spirit around the central thread of the Snowy River.



"Recovery of The Snowy River is one of the most ambitious river restorations in the World today" *(Melbourne Age, May 2003)*

Murrumbidgee River at Long Plain
Reference Reach for Geomorphic Condition Assessment

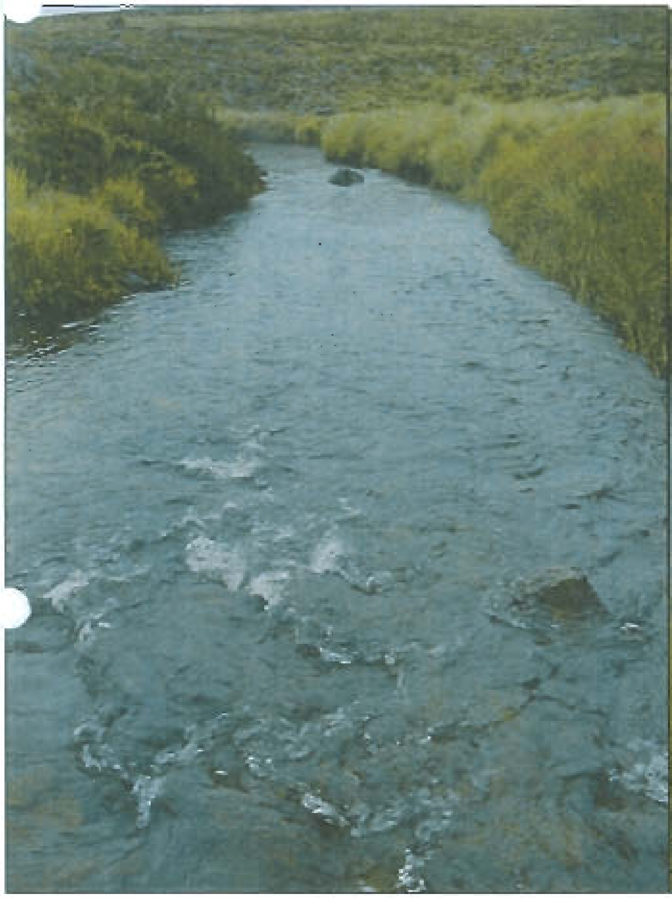
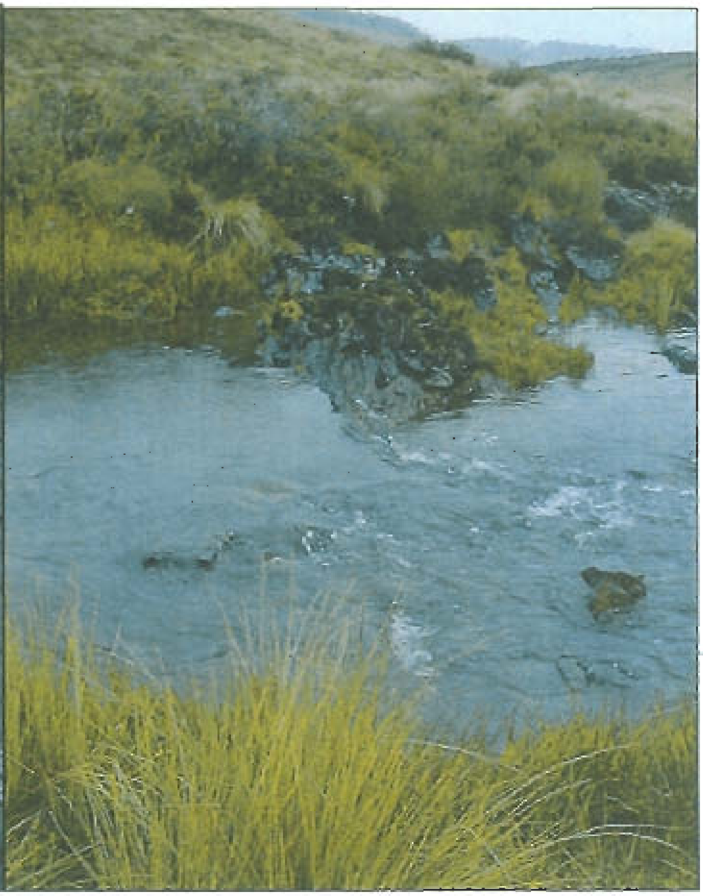
bedrock controlled, gravel bed (alpine/treeless) type

A reach 200m downstream of the Port Philip Fire Trail bridge (away from fishermen's access tracks) is being used as a 'natural condition' reference reach because it has no detectable disturbance and full vegetation cover, mainly due to its location in a National Park. The site is 15 km from the source of the Murrumbidgee.
It exhibits the main characteristics of the bedrock controlled geomorphic type:

- a sinuous valley with bedrock spurs on the inside bends, forcing the river to follow the planform of the valley
- up to 90% of the outside bends are against the valley margin (so laterally stable)
- narrow multi-level floodplain segments on inside bends with a flood runner and backswamp
- boulder/cobble/gravel/sand bed between bedrock steps
- compound point bars/benches with chute channels where the channel can expand in major floods

The lack of trees means that this sub-type naturally has no large woody debris.
The attached data for the reach are used by people comparing their test reach parameters with this reference reach to determine the relative condition of the test reach. An internal DIPNR course is provided for staff doing this work. Furt details on the course and the reference reach project can be obtained from Carolyn Young, DIPNR, Queanbeyan. (carolyn.young@dipnr.nsw.gov.au)

David Outhet

DETAILS OF SITE

River Style	evolution type	stream name	catchment	survey date 1			survey date 2			described by	site location	landowner	landowner	landowner	landowner	landowner	n sheet	map sheet	map sheet	grid reference	grid reference	locational accuracy	aerial photo	aerial photo	aerial photo	aerial photo
				day	month	year	day	month	year			contact name	contact phone no.	private owner address	permission required?	key required?	name	number	scale	E	N		name	scale	year	run no.
Bedrock Controlled	1	Murrumbidgee River	Murrumbidgee	10	April	2002	15	October	2003	DO, CY, TS	Long Plain approx. 0.2km d/s from Bridge on Port Philip Fire Trail	NPWS	6947 7025	Tumut	No (except during snow season)	No (B1 key needed during snow season)	Rules Point	8626-IV-S	1:25000	55H 0640188	6047892	GPS	Tantangara	1:25000	1998	6

aerial photo	aerial photo	field photo	field photo	field photo	flow at time of survey.	climate conditions	land use		CHANNEL ATTRIBUTES bank material for homogeneous banks		sketch of cross section	Mannings n	channel shape	bank morphology	LWD	channel survey			slope	width/mean depth ratio	bankfull shear stress (N/m2)	vertical relief of bed	bankfull q return period		RIVER PLANFORM number of channels	river planform	sinuosity
photo no.	photo no.	at xsection	looking upstream from xsection	looking downstream from xsection					approx. D50	presence		average for whole channel			present?	cross section survey method	long profile survey method	type of hydraulic control used	(m/m)		radiusxSx 9800	riffle max elev minus pool min elev)/mea	using Mannings equation (m3/s)	return period estimate (years)			
166		Yes	Yes	Yes	Low to mod	Wetter than normal	National Park		Sand	Sand, bedrock	Yes	0.03	Compound	Stepped and undercut banks	No	Level and staff	Level and staff	Riffle and bedrock sill	0.0038	15.27	24.76	47.64	5.84		1	Continuous	1.5

lateral channel activity	bank erosion migration rate at	channel geomorphic units	channel geomorphic units	floodplain geomorphic units	floodplain geomorphic units	river planform sketch	riparian vegetation	riparian vegetation	trees present?	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata - structure	shrub strata abundance	ground cover	ground cover	ground cover
	cm/year	presence	condition	presence	condition		right bank - width of riparian zone (m)	left bank - width of riparian zone (m)		geomorphic unit 1	crown cover 1	geomorphic unit 2	crown cover 2	geomorphic unit 3	crown cover 3	geomorphic unit 4	crown cover 4	geomorphic unit 5	crown cover 5	geomorphic unit 6	crown cover 6	geomorphic unit 7	crown cover 7	dominant sp 1	geomorphic unit 1	foliage cover 1	geomorphic unit 2
Stable		Riffle, run, pool, glide	Active and stable	Flood runner, floodplain, backswamp	active and stable	Yes	Continuous	Continuous	No	Run	Very sparse	Riffle	Very sparse	Glide	Very sparse	Pool	Very sparse	Floodplain	Very sparse	Floodrunner	Very sparse	Back swamp	Very sparse	Alpine bottlebrush	Run	None	Riffle

ground cover	ground cover	ground cover	ground cover	ground cover	ground cover	ground cover	ground cover	ground cover	ground cover	ground cover	ground cover - abundance	riparian vegetation composition			riparian floristic association/vegetation community	riparian vegetation longitudinal extent	floodplain deposition		BED CHARACTER hydraulic diversity	bed compaction on surface of lowest geomorphic unit	bed level changes - degradation	bed level changes - aggradation	sediment regime	geomorphic unit surface material
foliage cover 2	geomorphic unit 3	foliage cover 3	geomorphic unit 4	foliage cover 4	geomorphic unit 5	foliage cover 5	geomorphic unit 6	foliage cover 6	geomorphic unit 7	foliage cover 7	dominant sp 1	tree	shrub	ground cover			deposition rate (mm/year)	reference point						unit
None	Glide	None	Pool	None	Floodplain	Dense	Floodrunner	Dense	Back swamp	Dense	Poa tussock	none	Native	Native	Alpine heathland	Continuous heathland			Chute, broken standing waves, unbroken standing waves, rippled, smooth	Packed but not armoured	None	None	Sediment transfer	Riffle

		geomorphic unit surface material			geomorphic unit surface material			geomorphic unit surface material				GENERAL character and behaviour anomalies	valley planform sketch	source of data	data entry
approx. D50	presence	unit	approx. D50	presence	unit	approx. D50	presence	unit	approx. D50	presence	presence				
Cobble	Sand, gravel, cobble, boulder, bedrock	Run	Gravel	Sand, gravel, cobble, bedrock	Glide	Gravel	Sand, gravel, cobble	Pool	Gravel	Sand, gravel		No	No	Field trip	CY

Tumut River

Summary of River Management Issues

Background

The Tumut River is the primary conduit for the supply of water from the Snowy Scheme via Blowering Dam to the Murrumbidgee River System water users. Additional water, as required, is supplemented from Burrinjuck Dam via the Murrumbidgee River upstream of the junction with the Tumut River.

The length of the Tumut River from Blowering Dam to the Murrumbidgee River just above Gundagai is approximately 75 km.

Managed flows in the river during the irrigation season are restricted to a maximum of 9,000 ML/Day from Blowering and 9,300 ML/Day through the Tumut township. Higher flows, whether they be operational (man made) or rainfall events, cause flooding problems at various points along the river. The minimum winter environmental flow is 560 ML/Day.

There is a perception that problems in the river started after Blowering was constructed in 1969. History shows that the first complaints (mainly about bank erosion) were registered with the NSW government in 1928, and continue through Ministerials to this present day.

History also shows that the first of the major remedial works were carried out in the 1940s and continued until just before the final construction of Blowering dam in 1969.

It was recognised in 1945 that ".... this river and the Peel are the two streams in this State which call for urgent attention ...".

In August 1949 the Tumut River Improvement District (TRID) was gazetted as a result of representation to Government by the landholders to assist in addressing the problems in the river. When they realised there would be an impact ($) on them they petitioned the Premier of the day and TRID was not enacted. The grounds for objection are given in Attachment A. The Land Owners maintain the same views today.

The land owners' perceived problems are:

- loss of land due to erosion caused by snags and willow growth in the river,
- high flows (including flooding), and
- water logging of adjoining lands.

Environmental degradation is one of the current issues.

After the commissioning of Blowering, works of a limited nature were carried out until about 1985, when, as a result of further complaints by the landholders to Government, action was again implemented to rectify the problems in the river.

Current Situation

Each year an inspection of the river is carried out by boat to identify the problems along the river. This information is collated and forms part of the annual works program. As can be seen from the attached cross sections, the channel has been expanding laterally on both banks on straight reaches and on the outside bank on bends. Some bed erosion is occurring but it is limited by the large size of bed particles (cobbles) and the armouring effect. Some bend cutoffs have occurred.

The 1995 boat inspection was the basis for the development of the Tumut River Management Strategy 2000 (TRMS) document. This document was the first major public document presented for the purpose of presenting a Management Strategy to address ongoing erosion and channel capacity problems in the Tumut River. A Value Management Study (VMS), involving many interested parties, was conducted in 1996 and endorsed a number of recommendations in the TRMS.

Rock protection works are a major component of the current Tumut River Annual Works Program. The other major components are snag alignment rather than removal, as was the situation up to 1985, and willow control. There are other small programs eg revegetation along the riparian zone forms part of the annual works.

One of the recommendations was that the annual budget should be $1m for 5 years to be used for the backlog of works and address recurrent problems. Thereafter the annual budget should be $0.5m for maintenance purposes. The recommended split for cost apportionment being 20% State Government, 40%, Snowy Hydro and 40% irrigators.

The annual budget was negotiated down to $850,000 with the cost sharing arrangement being State 20% (unchanged), 24% Snowy Hydro and 56% State Water.

Another recommendation of the VMS was to form the Tumut River Advisory Committee (TRAC). TRAC is the Community Consultative process that endorses and or modifies the annual works program prepared by the Department.

The TRMS commenced 1997/98 and officially ceased in June 2003. The TRMS has been extended. for 1 year with the same agreed funding arrangements while the new Management Plan is being prepared.

The new Plan will cover a 10-year period with other issues to be considered in the ongoing 5 years.

Summary of Major River Management Issues

The major issues for the river are:

- With the average of $850,000 per year for the last 5 years, the rate of bank protection has not matched the rate of erosion. When the TRMS was developed in 1995 it was recognised that there was a backlog of 5.5 km of rockwork to be completed with a recurrent rate 1.2 km (total 11.5 km for the 5 years). Since the report was prepared a total of 26.8 km of rockwork has been completed to June 2003. It is now estimated that approximately 23.4 km of erosion control works need to be carried out. We have gone backwards.
- There are currently 6 claims for compensation from landholders totalling upwards of $2.4m. The claims are predominantly based on impacts of managed high flows by the Department since the completion of Blowering, causing erosion, loss of production, and waterlogging. The claims have been assessed and the assessor is currently dealing with the claimants on behalf of the Department.
- The landholders have been pushing for some time for a reduction of high flows in the river during summer and complemented with increased winter flows.
- The recent Scoping Study for the reduction of high flows addressed a number of options. The best case scenario cost wise of diverting water through Tantangara was in the order of $250m.
- The landholders support erosion control through increased funding above the current annual $850,000 budget for rock protection works, and continuing that funding beyond June 2004. If an undertaking was given that this would occur, one of the claimants has indicated that his claim may be dropped.

Prepared by:-

Glenn Ferguson
Senior Natural Resource Officer (River Management)
Murray – Murrumbidgee Region, DIPNR
October 2003.

Attachment A
Grounds for Objection to the Tumut River Improvement District

1. *Part of the Snowy River Scheme provides for the diversion of a considerable volume of water into the Tumut River for Hydro-electricity development and irrigation.*

2. *To carry this extra water it is imperative that the Tumut River be snagged and cleared of all impediment and other necessary improvement work be carried out to provide for this extra water, the Tumut alluvial lands would be subject to frequent flooding and consequent erosion of valuable soil.*

3. *As water for irrigation is of a greater importance to the farmers of the Murrumbidgee Irrigation Area, than the farmers of the Tumut Flats, to ask the Tumut farmers to bear any cost is unreasonable.*

4. *That the advantages to the farmers on the Tumut flats would be problematical.*

5. *In the Tumut River Improvement District, as set out by the Water Conservation and Irrigation Commission, the area proposed to be rated includes many acres not affected by past floods.*

6. *Therefore, all things taken into account, this national work becomes a Government responsibility; and your petitioners therefore pray that the cost, or even part of the cost should not be borne by the landowners occupying the Tumut River flats which would be unjust.*

Shelleys Creek

Shelleys Creek runs parallel to the Tumut River along the Tumut's floodplain on the eastern side. Geomorphically, it is 3 things:

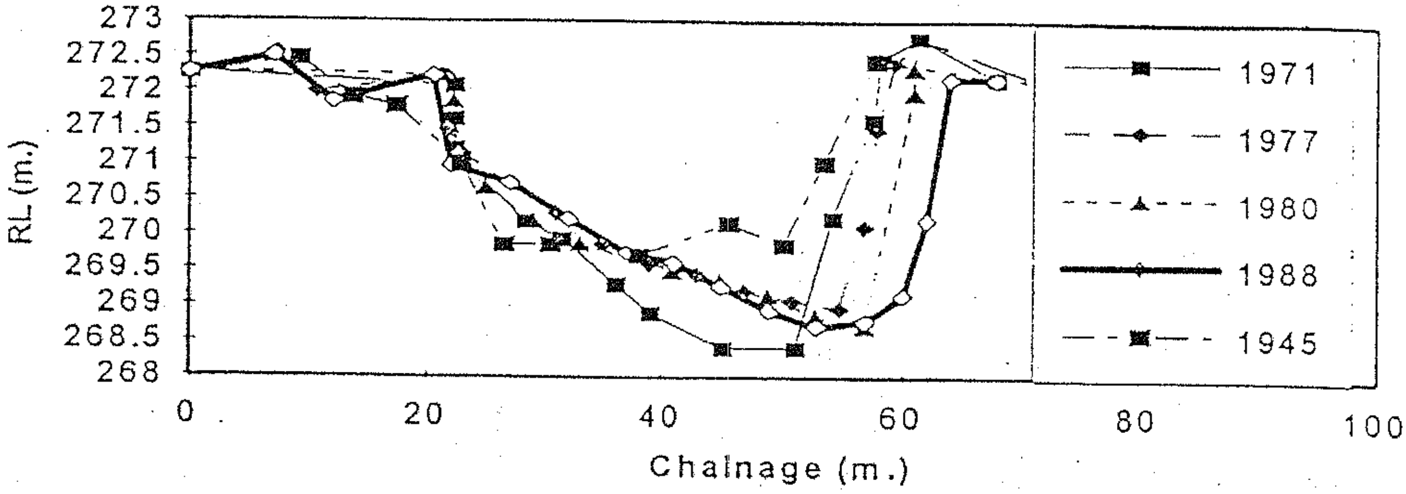
- a palaeochannel of the Tumut River
- a flood runner
- a small intermittent creek with a small catchment in the hills to the east

It can be easily seen on air photographs taken just after large floods that remove fine sediment and vegetation that may have accumulated between floods. These flood runner flows expose the armoured cobble bed of the Tumut River palaeochannel. The flood flows have also caused bend cutoffs so Shelleys Creek now has a lower sinuosity and a steeper slope than the Tumut.

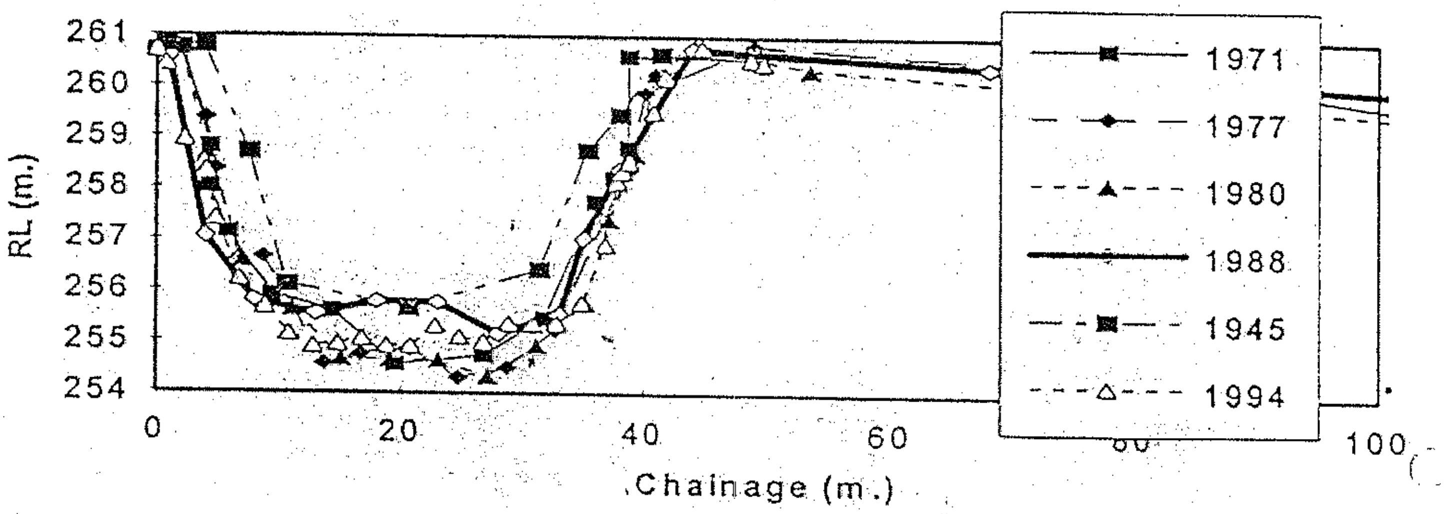
One option investigated for reducing the expansion of the Tumut River was to put some of the irrigation releases down Shelleys Creek to take pressure off the Tumut. However, due to the discontinuous nature of the creek, a lot of earthwork would have been required. Also, the resulting steep 'canal' would have to be rock or concrete lined to prevent it from eroding in the same way as the Tumut. Along with the major environmental impact and purchase of valuable land, these things made the option far more expensive than the ongoing Tumut River bank erosion control program or even large pipes (also investigated).

David Outhet

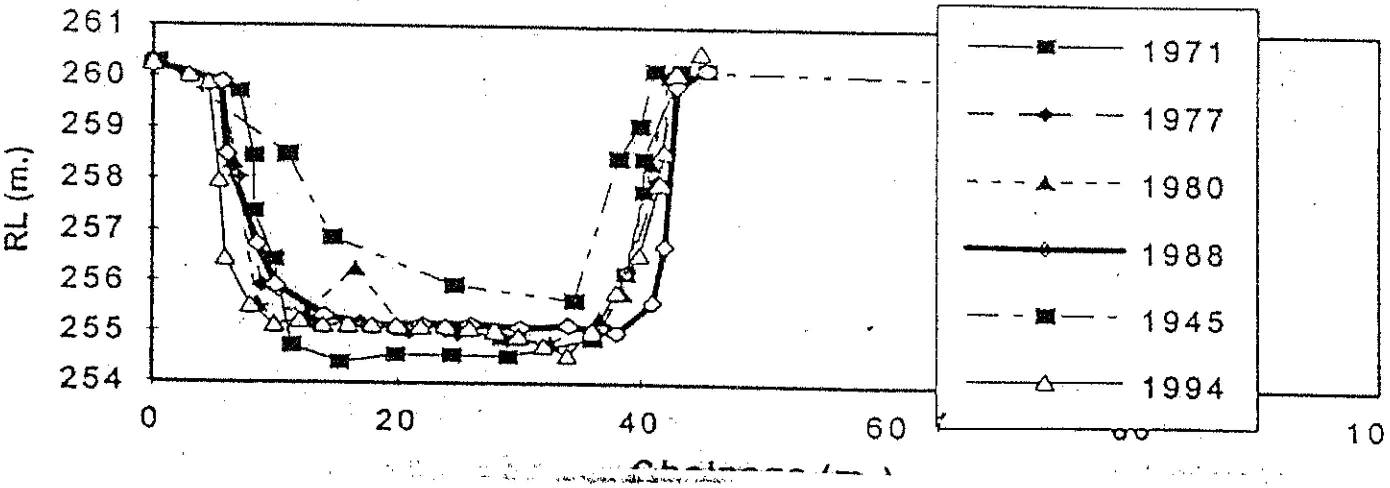
TUMUT RIVER
CROSS-SECTION 7

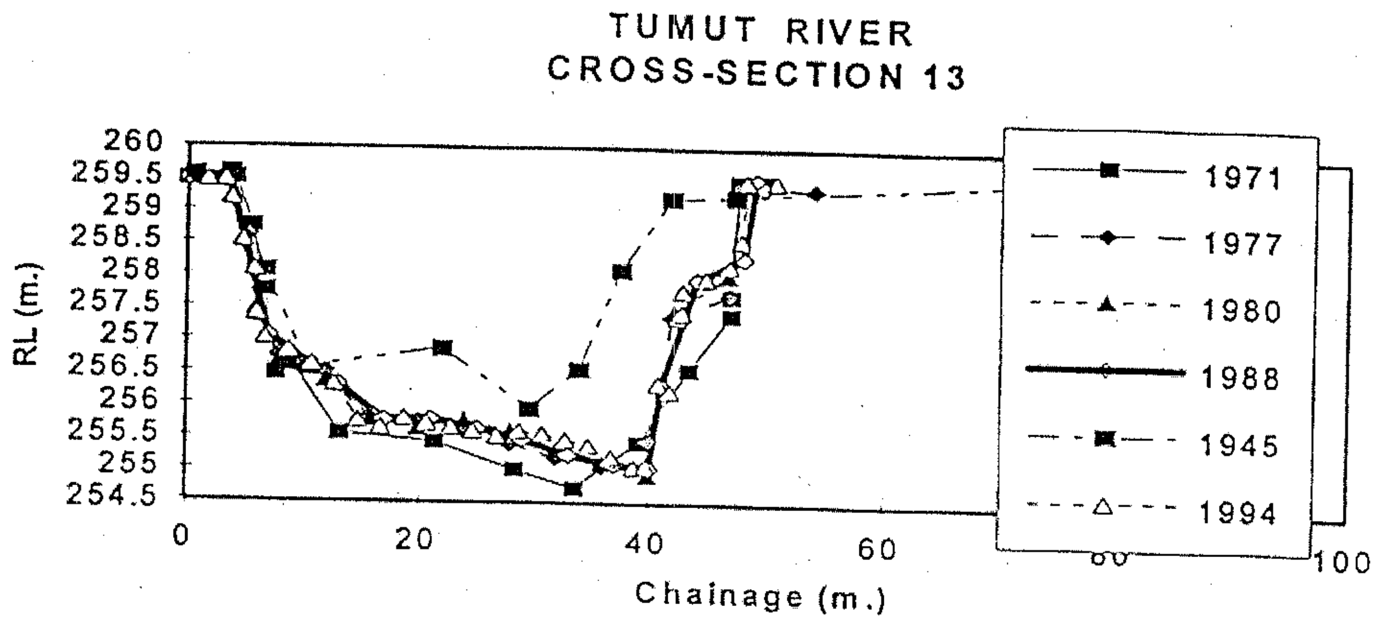


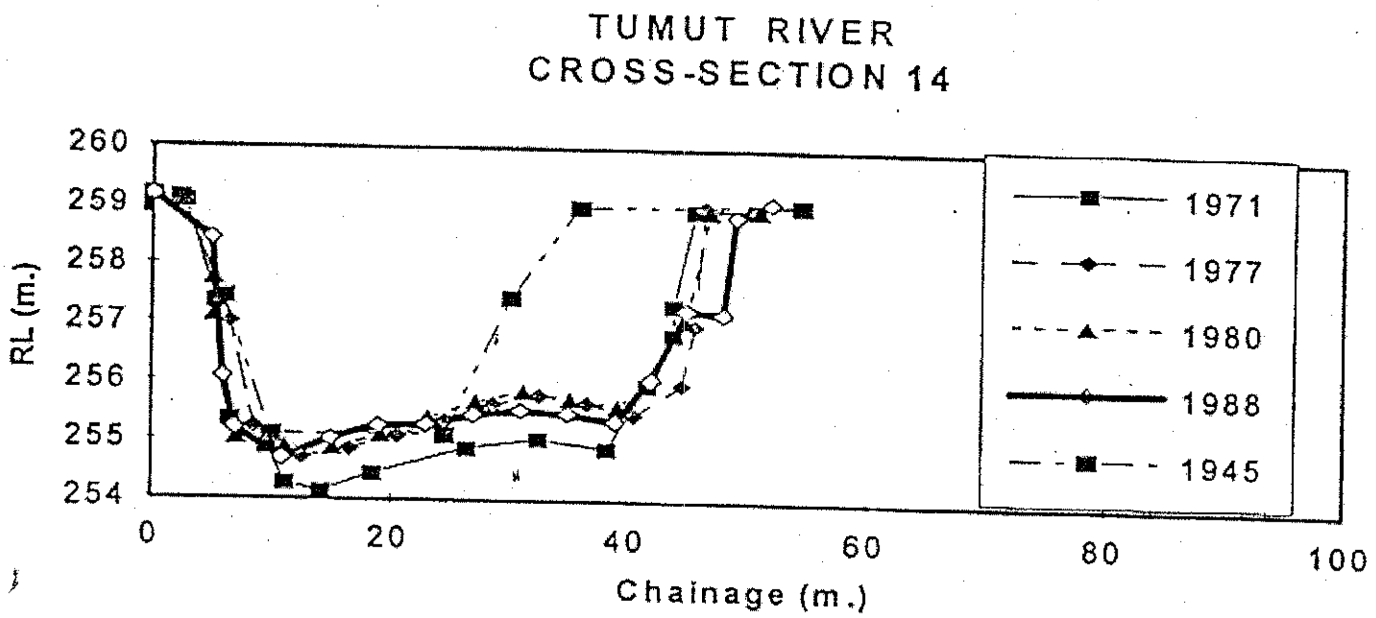
TUMUT RIVER
CROSS-SECTION 11

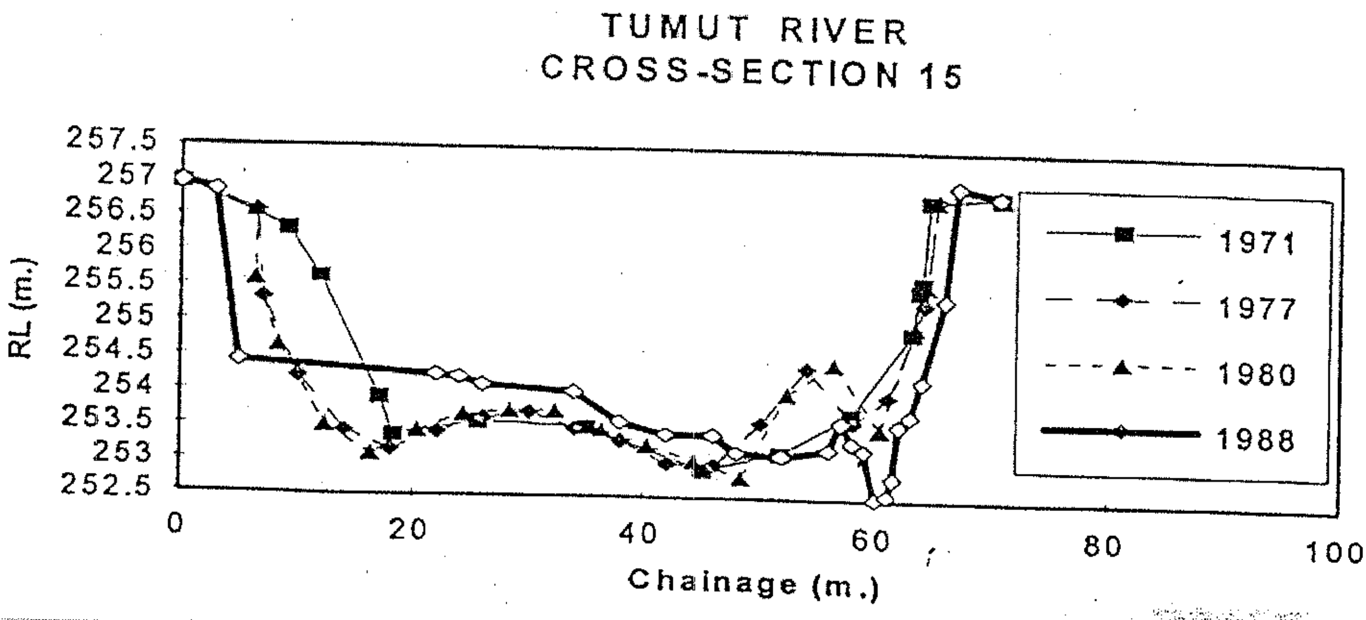


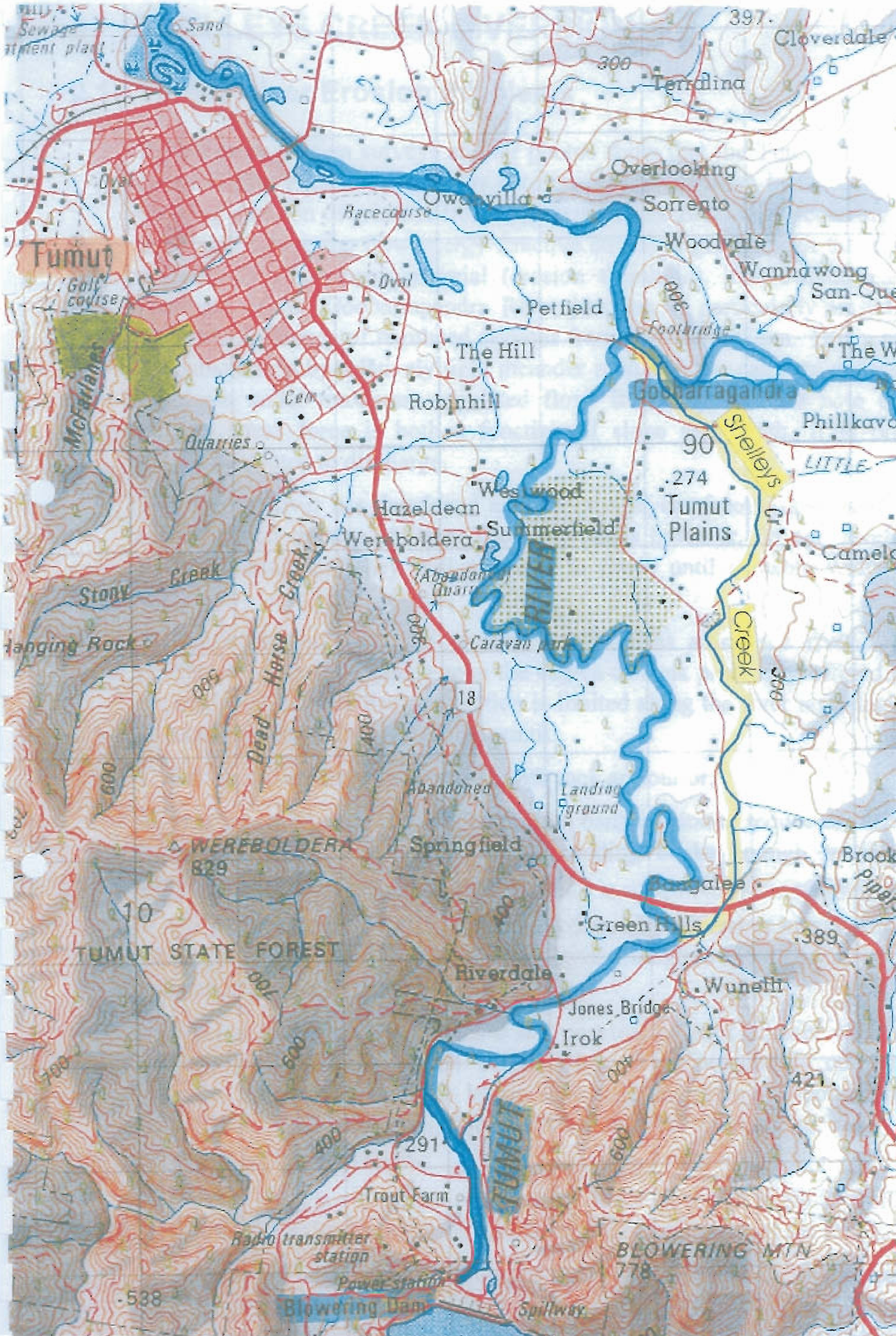
TUMUT RIVER
CROSS-SECTION 12




TUMUT RIVER
CROSS-SECTION 13
260
259.5
259
258.5
258
257.5
257
256.5
256
255.5
255
254.5
RL (m.)
0
20
40
60
100
Chainage (m.)
1971
1977
1980
1988
1945
1994


TUMUT RIVER
CROSS-SECTION 14
260
259
258
257
256
255
254
RL (m.)
0
20
40
60
80
100
Chainage (m.)
1971
1977
1980
1988
1945


TUMUT RIVER
CROSS-SECTION 15
257.5
257
256.5
256
255.5
255
254.5
254
253.5
253
252.5
RL (m.)
0
20
40
60
80
100
Chainage (m.)
1971
1977
1980
1988



Sewage treatment plant
Sand
397
Cloverdale
300
Terralina
Overlooking
Owenvilla
Sorrento
Racecourse
Woodvale
Wannawong
San-Que
Tumut
Golf course
Oval
Petfield
Footbridge
The Hill
Gocharragandra
Robinhill
Phillkavo
Shelleys
Cr
90
274
Tumut Plains
McFarlanes
Quarries
Westwood
Hazeldean
Summerfield
Wereboldera
Camelot
RIVER
Creek
Stony
Creek
Abandoned Quarry
Hanging Rock
Caravan park
Dead Horse Creek
18
Abandoned
Landing ground
WEREBOLDERA
829
Springfield
Brook
Bangalee
10
TUMUT STATE FOREST
Green Hills
389
Riverdale
Wunelli
Jones Bridge
Irok
421
291
TUMUT
Trout Farm
Radio transmitter station
BLOWERING MTN
778
Power station
538
Blowering Dam
Spillway

THE TARCUTTA RIVERCARE PROJECT

TARCUTTA CREEK CATCHMENT COMMITTEE

Department of
Infrastructure, Planning and Natural Resources

Project Duration:	2.5 years (not including initial negotiations to receive money).
Total cash budget:	$620,000
Total cash and in-kind Budget:	$1,380,000

Science behind project:

- This has (impressively) ranged from the broad to fine scales. (Even today, few catchments have such information available at variable scales).
- Within the Murray-Darling basin, the Murrumbidgee was targeted as a high priority.
- Within the Murrumbidgee the Upper and Mid Murrumbidgee were identified as areas contributing the greatest amount of sediment from in-stream (or connected) sources.
- Within the Upper & Mid catchments Tarcutta was seen to have the most informed and prepared community ready to adopt a large-scale project.
- Within the Tarcutta catchment funding was only given to stream-bank / stream-bed erosion and the erosion of *connected* gullies.
- Within the in-stream areas, particular reaches were targeted based upon their ecological condition (which was assessed by biota (including native and introduced plants and macroinvertebrates) and geomorphology).
- Initially invested centred around "hotspots" as these were the obvious areas to see and treat.
- Interestingly, during the project the community adopted the concept of giving higher priority to those areas that *weren't* eroding. ie. Rutherfurd's stream prioritisation theory. This may be the first time ever in Australia that the theory of stream restoration has been adopted and implemented.

Note: In terms of the amount of science used at each project site, it would have to be described as "none to minimal". Once the prioritisation information had been used and there was land-holder interest and support to conduct works at a "priority" site, there was usually no further use of science, scientific methods, any technical geomorphic surveys or even monitoring (other than photos) to quantify changes at the site post-works. So far, the experience of officers (either Rivercare, Landcare or Soilworks) is relied upon most heavily in making design decisions on-site. This is of course poor. Essentially we are using experience-based guesswork to design works or select the scale of works (ie. percentage of willow control to be conducted annually).

Question: What can academic geomorphologists provide (eg. decision tools) so that their wealth of detailed knowledge can guide the designs of works at specific sites? ie. How can we improve on our "suck-it-and-see" method?

For getting information, or dropping-off ideas, please contact:
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Murray-Murrumbidgee Region
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Tarcutta Creek Rivercare Project
Project Summary

The Tarcutta Creek Catchment Committee is nearing completion on an innovative and targeted project aimed at improving water quality in the Tarcutta catchment. The project is based on implementing the Tarcutta Rivercare Plan.

The Tarcutta Creek is a 170,000 ha catchment on the South West Slopes of NSW and is part of the Murrumbidgee Catchment.

The Tarcutta community received a major grant to undertake targeted works as both the local community and government authorities recognised that the Tarcutta Creek was a major source of nutrients and sediments within the Murrumbidgee catchment and the Murray Darling Basin.

The project is the result of 10 years of community efforts towards improving the health of the Tarcutta creek catchment. This was initiated with the preparation of the Rivercare plan, followed by intensive ecological research as well as lobbying for support funding and culminating in extensive on ground works.

The project is unique in that way in which it has struck a balance between the community's desire to target environmental hot spots and research findings on protecting the best sections of the creek.

The project has offered landholders incentives to change their land management practices and to undertake activities that are essential in the rehabilitation of the Tarcutta Creek system. This has included fencing off creeks and gullies to control stock access, providing off creek water storage, stabilising eroding creek banks and gullies, undertaking strategic willow control and revegetating using native trees and shrubs.

Over the past 24 months the project has encouraged more than 100 landholders (approximately 40% of the total farming community) to undertake Rivercare projects on their own properties. As a result, the project has been instrumental in the protection of over 107 km of stream and flow lines in the Tarcutta catchment. This has included more than 126km of fencing and the planting of approximately 87,000 native trees and shrubs.

The project has been well received by the Tarcutta community with landholders seeing both the productivity and environmental benefits of undertaking works on their property and in working with their neighbours.

One of the major successes of the project has been the innovative means in which it has attracted the majority of landholders with creek frontage, including landholders not previously involved in Landcare, to participate in the project.

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