appendix A

Alternative log structures

Additional disclaimer

Many of the structures shown here have not been fully evaluated under a range of flow conditions and the examples shown here are offered as a guide only of structure styles that may be suitable for your site. Care should be taken to ensure appropriate design standards are applied in the application of any of the structures shown here or derivates thereof.

Natural wood accumulation — Meander River, Tasmania. Photo T. Cohen.

STRUCTURE TYPE

Log sill +/- abutment jams (gravel bed version)

Description

- Multi log structure complex comprising a buried, multi-log sill, and two small abutment jams
- Generally built as a full channel spanning structure, or between the bank and a mid-channel bar

Purpose

- Bed stabilisation
- Initiation of pool downstream of structure
- Creation of hydraulic gradient to drive hyporheic exchange

Location trialled

Williams and Hunter Rivers, NSW (see photos)

River characteristics

- Medium to high energy gravel rivers
- Catchment area ~200 and 4000 km^2
- Mean annual flood ~170 and ~500 cumecs
- Channel full discharge ~800 and 4000 cumecs
- Gradient 0.0019 and 0.001

Pros or cons

In highly active gravel bed rivers, log sill structures are highly prone to failure by scour undercutting the structure or by outflanking of the structure. Abutment jams appear to reduce outflanking failure, and reduce the risk of losing the whole structure from scour beneath the logs.

Performance to date

Of the seven log sill structures built in the Williams and Hunter Rivers, the structures with abutment jams are generally still performing as designed, while those without abutment structures tended to fail through under cutting or outflanking. This is similar to the experience on the Nambucca River (northern NSW) in the mid 1990s where a series of log sill structures were built, virtually all of which failed via under-scour or outflanking within a couple of years (A. Raine, pers comm.).

Captions, top to bottom

1. As-built small log sill complex — Williams River, October 2004. Note log sill between the abutment jams consists of a stack of six logs buried ~1 m below the bed, arranged as a pyramid and secured with piles and abutment jams.
2. Same structure as (1) 12 months later.
3. Cross channel spanning structure under construction — Hunter River, NSW. Photo S. Mika.
4. Same structure as (3) 12 months later.

STRUCTURE TYPE

Bar apex jam

Description

- Multiple log structure — variation of the standard bank attached deflector jam
- Located on an existing mid-channel feature

Purpose

- Stabilising existing bar (transforming to stable island), with a view to creating hydraulic diversity within a reach
- Initiating stable mid-channel bar/island
- Replacing stabilising influence of exotic vegetation on existing vegetated island/bar, i.e. to allow for removal of the vegetation without losing the bar

Location trialled

Williams River, NSW (see photos)

River characteristics

- Med-high energy gravel river
- Catchment area ~200 km^2
- Mean annual flood ~170 cumecs
- Channel full discharge ~800 cumecs
- Gradient 0.0019

Pros or cons

If using on a existing vegetated bar as the core — significantly fewer logs are required than if you were building an equivalent sized structure from scratch. This is because less excavation is required to help stabilise the structure with deeply buried key logs and, as a result, less logs are required overall for an equivalent sized structure above the bed.

Performance to date

To date, only two structures like this have been built in Australia (to our knowledge). Both are performing well after five years.

Captions, top to bottom

1. Willow induced bar/island with riffle to right.
2. Constructing log structure around existing vegetated bar.
3. Constructed bar apex jam.
4. Same structure as (3) after series of flows.

1


2


3


4


STRUCTURE TYPE

Bank revetment structure

Description

- Small, single or multi log structure for application as bank toe protection and habitat
- Located along the bank toe, parallel to the bank at sites with low banks, i.e. not subject to mass failure

Purpose

- Stabilisation of the toe of low banks or inset benches
- Recreation of bank overhang habitat
- Initiation of small scour holes adjacent to the bank overhang, in association with the protruding root wads

Location trialled

Williams River, NSW (see photos)

River characteristics

- Med-high energy gravel river
- Catchment area ~200 km^2
- Mean annual flood ~170 cumecs
- Channel full discharge ~800 cumecs
- Gradient 0.0019

Pros or cons

Primarily a habitat augmentation structure — although can potentially be an effective erosion control structure in small streams. Undercut banks are extremely valuable fish habitat and due to stock trampling and vegetation removal of this type of habitat is common along degraded agricultural/urban streams. This is a cheap and effective way of recreating this critical habitat.

Performance to date

To date only a small number of these structures have been built in the gravel bed Williams River site. In general they appear to be performing well, although they have lost some of their habitat value due to excess sedimentation adjacent to the structure.

Captions, top to bottom

1. Revetment structure on the Williams River. Note how the upstream logs overlap on the inside the downstream logs along the toe of this inset bench.
2. Same structure as (1) after a series of floods.
3. Revetment structure under construction — Williams River.
4. Same structure as (3) after completion.

1

2

3

4

STRUCTURE TYPE

Log sill +/- abutment jams (sand bed type — version 1)

Description

- Multi log structure complex comprising a buried, multi-log sill, using logs without rootwads for the cross spanning logs to ensure a snug fit, keyed well into both banks. Geo-fabric used in sub surface portion of log sill to reduce undercutting risk
- Generally built as a full channel spanning structure across small sand-bed streams

Purpose

- Bed stabilisation
- Initiation of pool downstream of structure
- Sediment retention

Location trialled

Stockyard Creek, Hunter Valley, NSW (see photos)

River characteristics

- Low–medium energy sand-bed streams
- Catchment area ~50 km^2
- Mean annual flood ~10 cumecs
- Channel full discharge ~300 cumecs
- Gradient 0.001–0.002

Pros or cons

Any bed control structure is prone to under-cutting failure in a mobile sand-bed stream, particularly in streams like Stockyard Creek with a high index of flow variability (Iv). Outflanking failure is also a real risk, and it is necessary to excavate the structures well into the bed and banks to reduce the risk of failure. This means large numbers of logs are required, and that the structures are relatively expensive. It would also be difficult to build structures like this in larger streams with a substantial base-flow, because of the need to excavate the bed to a depth of 1.5 m or more and construct the structures before the hole in-filled. These structures also require substantial disturbance of the bed during construction which may not always be desirable.

Performance to date

To date, six of these structures have been built, however, as yet they have not been subjected to a substantial flows due to ongoing drought in this area since construction. It is too early to provide a definitive answer as to the efficacy of the structures.

Captions, top to bottom

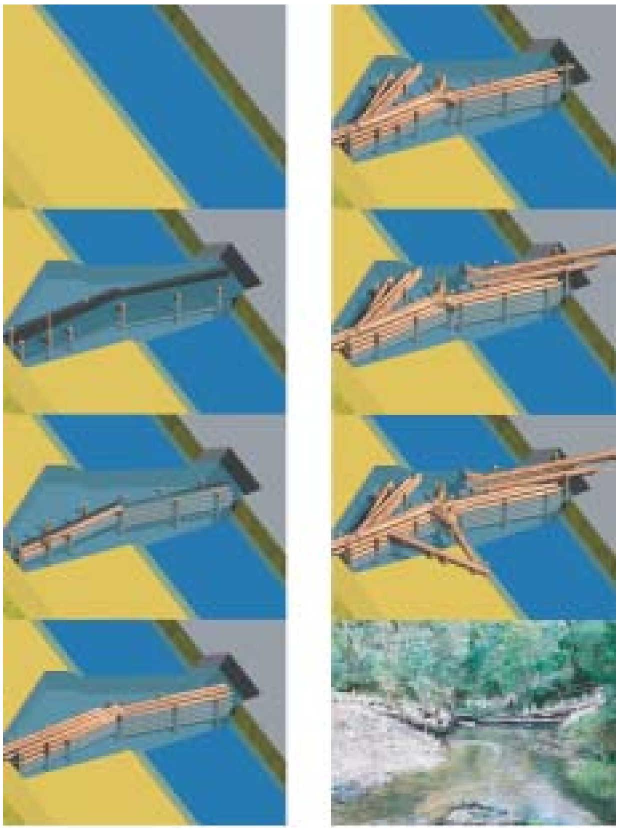
1. Log sill under construction on Stockyard Creek. Cross-spanning logs are stacked between driven piles.
2. Cross-spanning logs do not have roots to enable tight packing. Note also how the geo-fabric has been woven through the stacked logs.

3. Cross channel spanning structure with bank abutments nearing completion.

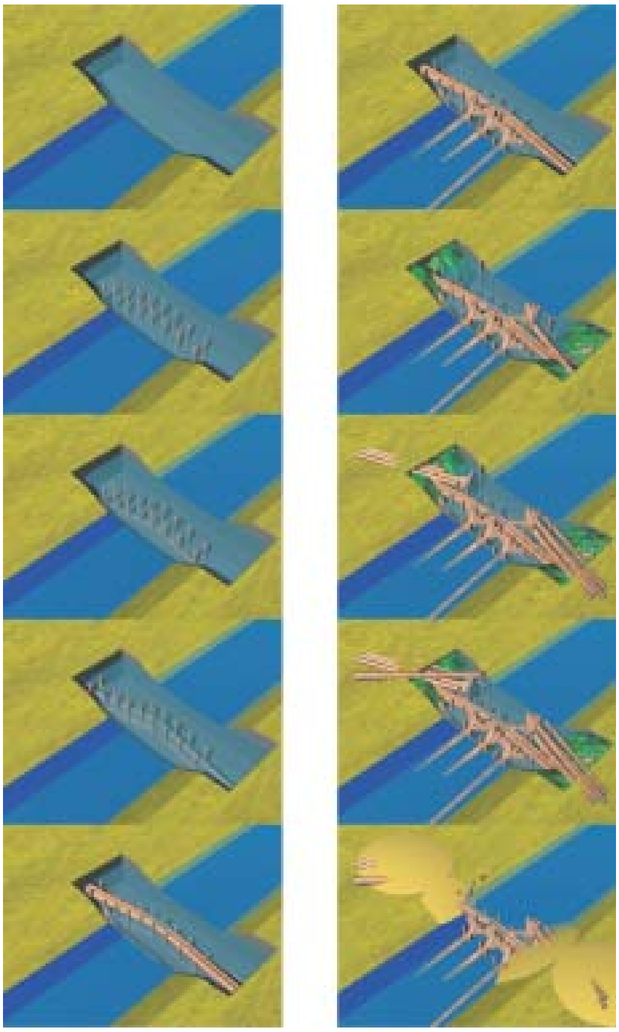
4. Completed structure looking upstream.

Schematic diagrams showing sequential construction procedure for sand-bed stream cross spanning log sill structures. The second variant uses green acacia foliage within the abutment structure instead of geo-fabric.

Sand-bed channel log bed-control structure, type 1.



Sand-bed channel log bed-control structure, type 2.



STRUCTURE TYPE

Pre-fabricated deep water fish habitat structures (fish hotels)

Description

- Pre-fabricated, coherent log structures consisting of small logs (regrowth timber) bolted together to form a rectangular log stack. These can be made more complex by the addition of branches and other small timber pieces to the centre of the structure
- Requires additional ballast where the structures can't be fixed to the bed with piles. Structure also required to be sufficiently sturdy to be picked up by crane and lowered into the water in one go

Purpose

- Fish habitat — where large logs not available, and where steep banks and deep water prevent in-stream access for construction
- Useful method of making functional habitat structures from small regrowth timber

Location trialled

Hunter River, NSW near Muswellbrook

River characteristics

- Low–medium energy gravel-bed river
- Catchment area ~4000 km^2
- Mean annual flood ~110 cumecs
- Channel full discharge ~1800 cumecs
- Gradient 0.0005

Pros or cons

On the downside, these structures are not particularly aesthetically pleasing, and they go against the philosophy of using nature as a guide for designing log structures. While the log structures themselves can be constructed fairly cheaply and easily, the size of crane required to lower a structure of this size into the river makes them very expensive. In this trial we also had to lower ballast blocks into the river, which added even more to the cost (in addition to the making of the ballast blocks themselves). In most cases it should be possible to use other means of securing the structures (either with driven piles or some sort of dual tether). On the upside, in many locations where large timber is scarce, this may be the only option available. Initial results also indicate they are very effective fish habitat, particularly when made more complex with added branches etc.

1


2


3

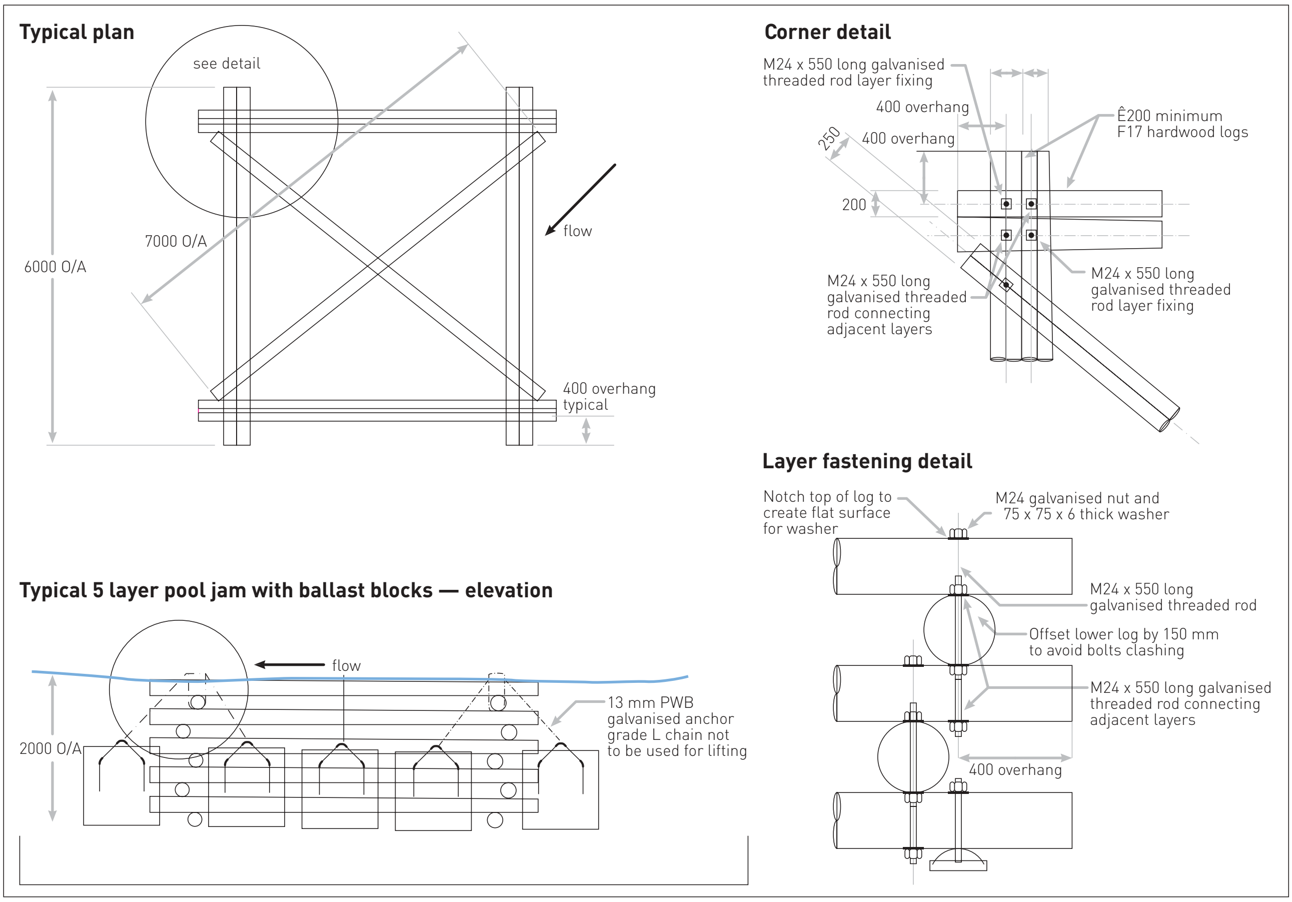

Captions, top to bottom

1. Completed fish hotel ready for deployment to river. Note the log offset between layers to allow for high tensile bolts between layers.
2. Logs being bolted together.
3. Completed structure ready for lifting into river.

4. Fish hotel being lowered into pool 1.

5. Fish hotel being positioned in pool 1.

Design for 5 m square fish hotel structure



STRUCTURE TYPE

Elevated log sill with log pin abutments (gravel bed rivers)

Tony Broderick and Peter Menzies, NSW Northern Rivers CMA

Background and description

Trees often fall across channels following bed incision. These can play an important role in raising upstream water levels during flood events, thereby decreasing hydraulic gradient upstream and promoting deposition. Observation of this natural process initiated the concept of the Elevated Log Sill (ELS).

- Cross spanning logs elevated above bed level with timber pins radiating either side to protect abutments.

Purpose

- Decrease upstream hydraulic gradient
- Upstream riffle stabilisation/aggradation
- Localised energy dissipation

Locations trialled

Bonville Creek (2), Orara (4) and Urumbilum (1) Rivers, northern NSW (see photos)

River characteristics

- Medium to high energy gravel rivers
- Catchment area ~55–135 km^2
- Mean annual flood ~25–42 cumecs
- Channel full discharge ~148 cumecs
- Gradient 0.004–0.0065

Pros or cons

ELS are cheap, do not require trenching into the bed, are effective in upstream riffle stabilisation and localised energy dissipation. Whilst water flows beneath the structure, downstream scour is minimised and low flow fish passage provided. Over time gravel aggradation behind and under the ELS can increase scour depth and reduce fish passage. Outflanking is a risk and needs to be considered in design.

ELS provide an alternative to LWD realignment; i.e. trees naturally fallen perpendicular to flow the low flow channel can be lowered to an appropriate height and anchored in situ.

Performance to date

Seven ELS structures have been constructed over the last seven years. Six have successfully influenced upstream hydraulic gradient and deposition. Bed level monitoring and flood observation has indicated the importance of design location and height. Radial pins have been successful in stabilising abutments in these gravel bed rivers.

1


2


3


Captions, top to bottom

1. Site One — Orara River. Left view of elevated log sill (ELS) with log pin radials to protect abutment.
2. Site One — Orara River right view during a fresh. Note the localised step in hydraulic gradient and energy dissipation immediately downstream of ELS.
3. Site Two — Orara River post March 2006 bankfull event (note height of debris). ELS constructed in meander cutoff with pin rows (in background) to reduce upstream hydraulic gradient.

4. Site Two — view from upstream. Elevation of upstream water levels has promoted gravel deposition and riffle formation upstream of ELS.

5. Site One — under low flow conditions.

STRUCTURE TYPE

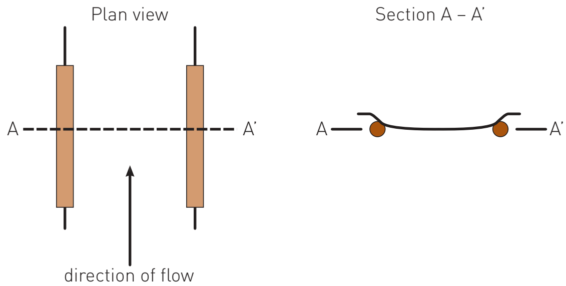
Elevated log sills with log pin abutments

Tony Broderick and Peter Menzies, NSW Northern Rivers CMA

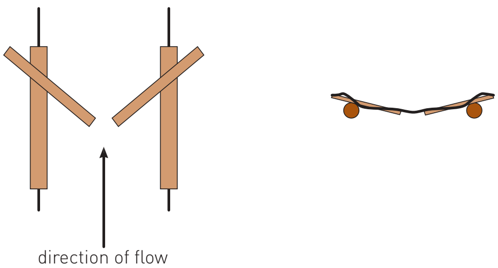
Generic ELS structure design and construction notes

- ELS are constructed between riffles.
- Objectives relating to hydraulic gradient and depositional patterns upstream of structure determine the exact height (<600 mm) and construction location.
- The higher the structure the greater the risk of trapping flood debris and outflanking due to flow deflection. Poorly armoured substrates may require more substantial abutments than timber pin radials detailed in this design.

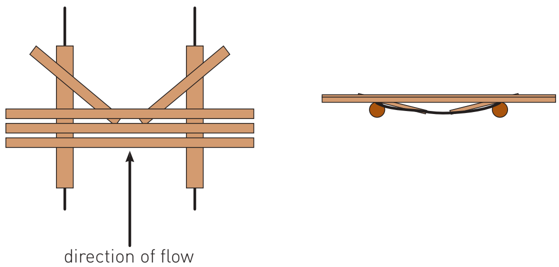
Step 1
Trench bed log into both sides of low flow channel. Depth determined by height of structure and diameter of bed and cross-spanning logs. Top of bed logs to be level.



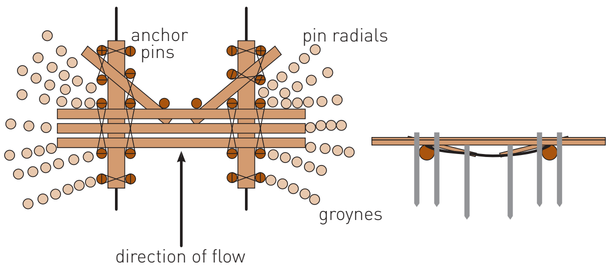
Step 2
Position diagonal logs over bed logs at appropriate angle, pointing upstream (i.e. into direction of flow). One end of diagonal log to key into bank, opposite end to key into bed.



Step 3
If necessary, cut billets out of cross-spanning logs to enable these to sit over diagonal logs. Position three cross-spanning logs on top of bed logs and over diagonal logs. Cross-spanning logs to be placed perpendicular to direction of flow, overlapping bed logs by at least 1.5 m to key into bank. Largest diameter log to be placed in middle, to raise sill to desired height.



Step 4
Place and drive anchoring pins with cable to suitably anchor structure to bed. Proceed to place and drive pin radials around flanks of structure and pin groynes on upstream side.



STRUCTURE TYPE

Bed control constriction structure

Tony Broderick and Peter Menzies, NSW Northern Rivers CMA

Description

- Log and rock channel constriction with complementary downstream groyne arrangement

Purpose

- Slowing flows upstream promoting deposition and raising bed levels
- Control bed incision
- Locally dissipate energy
- Increase diversity of geomorphic units (pools, riffles, bars) and habitat features

Location trialled

Blaxland Creek (3) Northern NSW (see photos)

River characteristics

- Medium energy sand and small gravel bed
- Catchment area ~125 km^2
- Mean annual flood ~35 cumecs
- Mid bank channel discharge ~53 cumecs
- Gradient 0.001–0.0017

Pros or cons

Relatively cheap and effective bed control structure which significantly increases upstream water levels with only a relatively minor change (100 mm single step) in bed gradient. A variety of flow velocities across the single step constriction combined with downstream eddying currents facilitates fish passage. These eddying currents, which are enhanced by downstream groynes to ensure hydraulic jump development, may cause bank erosion. Designs need to cater for these erosive forces.

Riffles are not disturbed as the structures are located in shallow pools. They are effective in upstream deposition, localised energy dissipation and scour pool development. Depth of scouring needs to be linked to girdle depth.

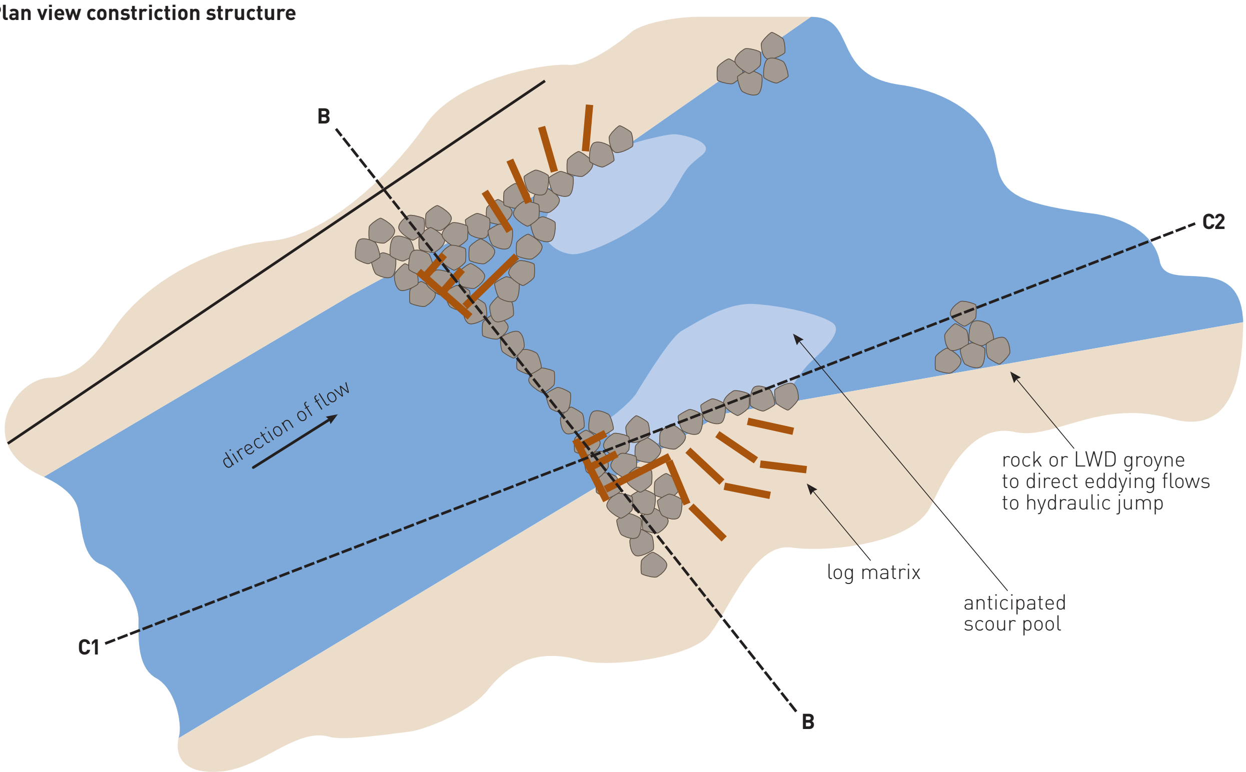
Performance to date

Constriction has elevated upstream water levels by an average of 0.3 m at each structure, depositing sands and small gravels. Scour pool development of >2 m has exceeded that predicted (1.5 m). Structures have created a diverse range of velocity profiles and habitats throughout the reach.

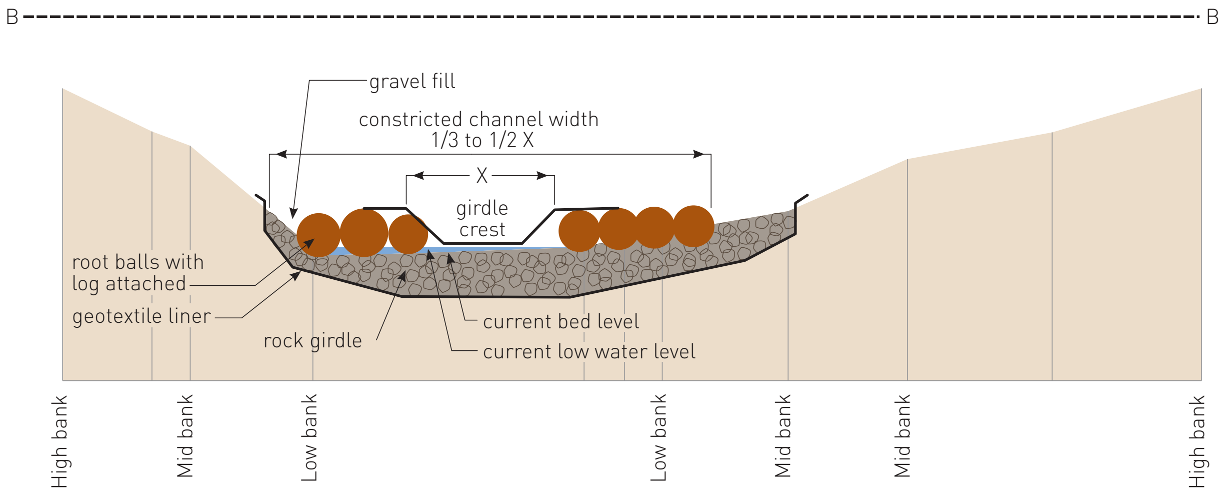
Captions, top to bottom

1. Site One — Blaxland Creek. One of three bed control constriction structures within a 500 m reach. LWD is anchored to the rock girdle beneath structure.
2. Site Two — Blaxland Creek, September 2005. Prior to works pools >0.3 m depth were almost absent throughout reach.
3. Site Two — Blaxland Creek, November 2006. Post works with approx. 8 cumecs of flow released from hydro power station. Groynes downstream of constriction direct eddying flows back upstream to enhance hydraulic jump. >2 m scour pool downstream and upstream water levels elevated by 0.37 m promoting deposition and raising bed levels.

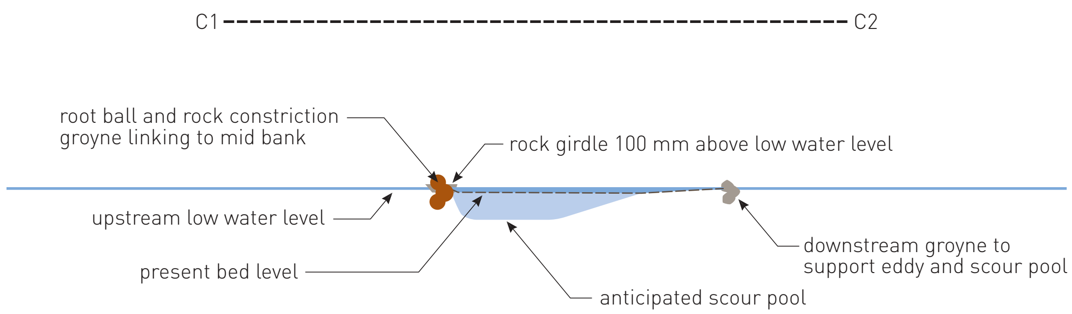
Plan view constriction structure



Long section B to B through constriction



Long section C1 to C2 through girdle crest



Designs by T. Boderick and P. Menzies. Redrawn from drawings by P. Menzies, NSW Northern Rivers CMA.