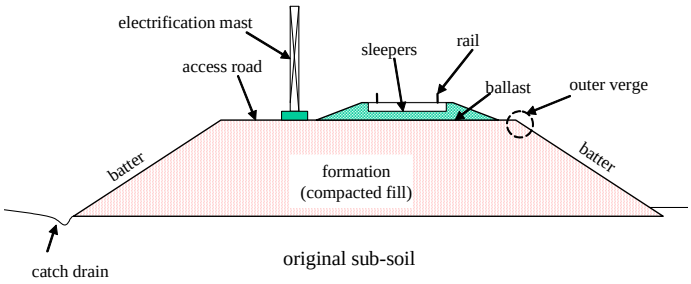
HEFRAIL PROJECT

RAILWAY BATTER (STEEP SLOPE) EROSION CONTROL

Erosion causes significant damage on the embankment and cutting steep slopes (batters) within the coal railway corridors in Central Queensland, Australia. The problems are manifested in one or more of the following forms:

- excessive scouring of rills on the batters;
- shallow seated slope failures;
- excessive tunnel erosion on the batters, access road and/or the property bordering the railway corridor;
- failure of ground-level railway signalling systems within railway cuttings due to inundation by eroded sediment from the batters, access road or the property bordering the railway corridor;
- fouling of ballast by eroded sediment and weeds, diminishing the effectiveness of the ballast in supporting the track structure;
- silting up of culverts rendering them incapable of transporting runoff and associated formation weakening due to flooding; and
- transport of sediment from railway corridors to nearby ponds, creeks, and rivers.



railway embankment features

As a consequence there is an increase in maintenance costs, risks of outages and derailments, interruptions of normal train operations and environmental degradation. It has been established that 60 % grass cover on railway embankment steep slopes reduces erosion by over 90 % compared with the bare scenario. Research into cost-effective strategies for erosion control (HEFRAIL Project) has been advanced on three fronts. Amelioration of the largely dispersive, sodic, saline and extreme pH in-situ or borrowed subsoil of the earthworks with lime/ gypsum and fertilisers to provide a conducive growth medium for grasses is the first front. Provision of a cheap mulch (waste ballast or erosion control blanket) to protect grass seeds/ seedlings and ameliorants from washout by high intensity and short duration rainfall events that characterise the semi-arid environment is another front. The final front involves development of a cost-effective drip irrigation system that sources water from either existing pressurised water main or temporary excavated pond/ dam (with solar pump) to supplement the unpredictable natural rainfall during the wet season. Pictures below demonstrate some of the problems, and before and after erosion control treatment.

Example of problems associated with erosion

rill and tunnel erosion on batter

cracks on surface sealed batter

tunnel erosion outlet sediment fans

culvert choked with sediment

tunnel erosion inlet undermining mast foundation

tunnel erosion inlet on access road

rill development on batter

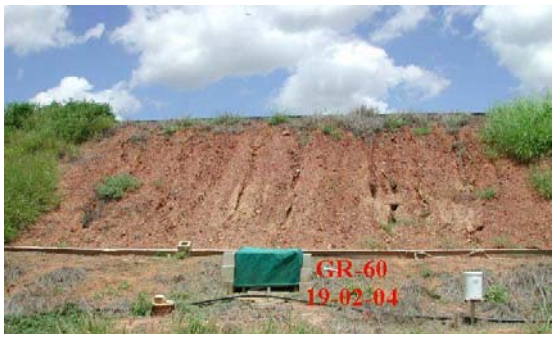
sheet and rill erosion on batter

1.1 PLOT SCALE FIELD TRIALS RESULTS

Strategies for erosion control on railway embankment batters (steep slopes) have been quantitatively evaluated using world class equipment consisting of dataloggers, pluviometers, runoff tipping buckets, and sediment filter troughs. Rainfall and runoff were monitored at one-minute intervals on 10-m wide embankment batter plots. Total bedload and suspended sediment eroded from the plots were also measured but only for a group of storm events within sampling intervals.

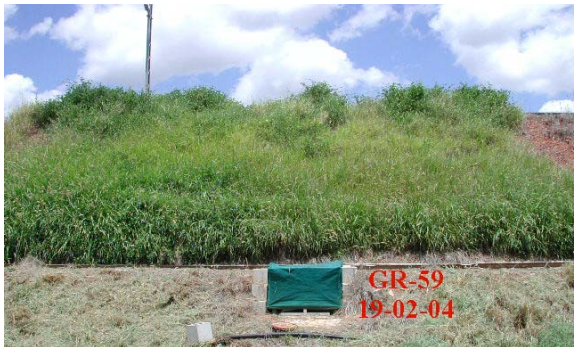
pluviometer

sediment filter busket

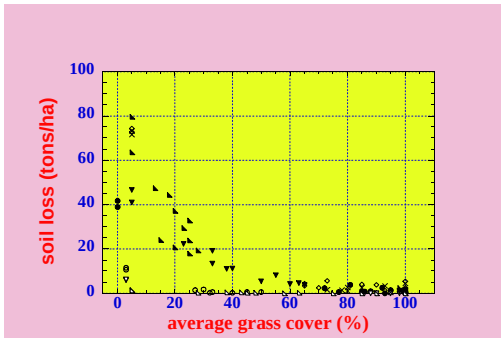


control plot – rill, inter-rill & tunnel erosion occurring

runoff tipping bucket



treated plot – 100% cover and no erosion

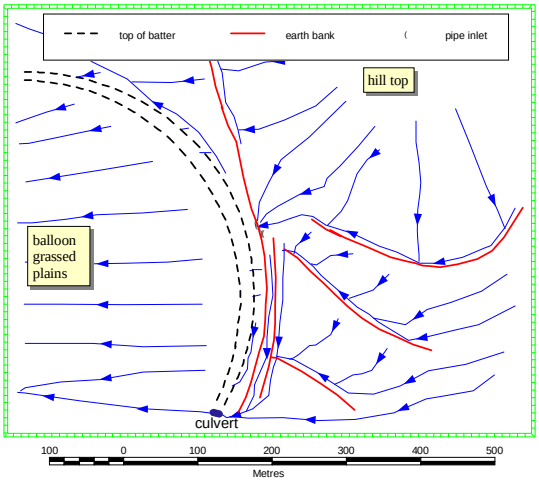


effect of grass cover on soil loss

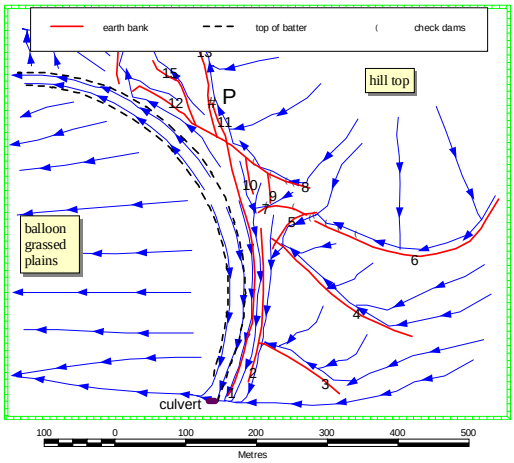
1.2 SELECTED LARGE SCALE FIELD TRIALS RESULTS

1.2.1 Boundary Hill Balloon Loop (1999)

The field trials site consisted of a 650 m long cutting located in the Boundary Hill coalmine railway balloon, approximately 40 km north-east of Biloela, in Central Queensland. A catchment-based approach was adopted in the mitigation of the erosion problems at the field trials site, viewing the cutting as an integral part of a drainage system that extends beyond the railway easement. Several earth banks and catch drains were constructed to divert runoff away from the railway cutting crest. A series of rock check dams were put in the catch drains to help control flow velocity, erosion, and trap sediment. All erosion pipe inlets and outlets were excavated and filled with basalt spoil material obtained from the nearby mine. The site was well graded to prevent ponding of runoff water on the disturbed areas. The batters were stabilised with Pioneer Rhodes grasses with the aid of sprinkler irrigation.



Layout of the site showing drainage paths (arrowed) before remediation works



Layout of drainage, erosion, and sediment control structures, with the new flow paths (arrowed)

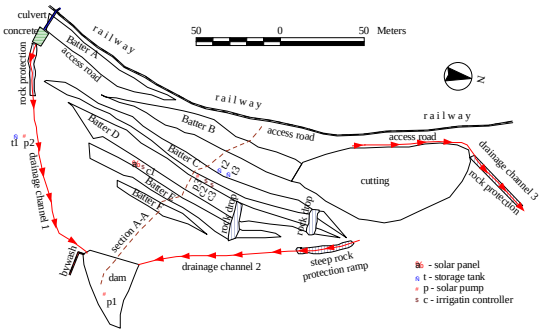
before treatment

two years after treatment

1.2.2 Black Mountain Derailment Site (2001)

An advanced technology cost-effective drip irrigation system design was set up on the environmentally sensitive elevated steep slopes (batters) of the coal train derailment site in Central Queensland, Australia. The final profile of the coal burial site consists of six batters and associated berms with an elevation drop of about 35 m. A small dam constructed downstream of the confluence of the two main drainage channels at the site supplied water for irrigation on the batters to aid grass establishment to control erosion. Water was periodically pumped from the small dam to three storage tanks using a petrol (gas) pump. Three solar pumps drew water from the storage tanks and dam to irrigate the top four batters. Contactors, pressure switches and irrigation controller valves shared a single solar power source between the solar pumps in turns. Level balls (floating switches) placed in the storage tanks cut the solar power supply to the associated pumps when the storage tanks were nearly empty. On the whole, the irrigation system worked very well and an excellent grass cover was established within 12 weeks. Given the environmental risks associated with the on-site coal burial, and the estimated cost of about AU$11.73/m^2 (1 in 10 years) in maintenance if the railway batters are not treated, the estimated total cost of AU$4.61/m^2 of batter area treated with irrigation, including AU$3.08/m^2 of irrigation costs, is justified.

soon after derailment



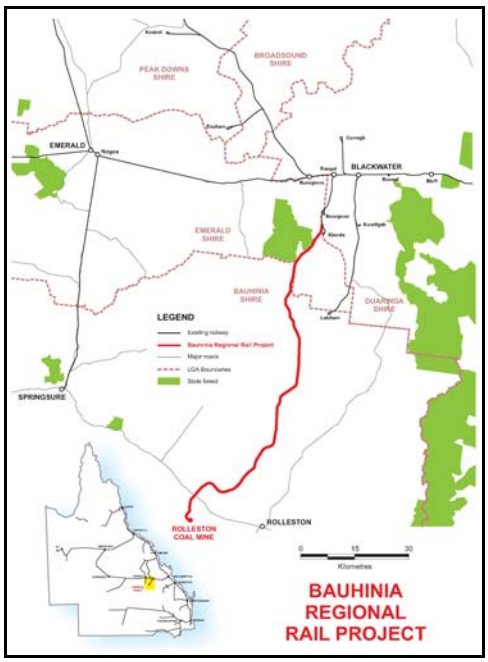
plan view of the derailment site after earthworks

before grass treatment

5 months after grass treatment

1.2.3 Bauhinia Regional Railway Project – BRRP (2004-2006)

The Bauhinia Regional Rail Project (BRRP) is the construction of a 110 km spur line linking the Rolleston Coal Mine to the Blackwater rail network in Central Queensland, Australia. It will generate rail traffic of 8Mt/year of coal from Rolleston mine by 2008. The new spur line includes several embankments that needed to be protected against erosion. In order to reduce the treatment costs, the embankment batters were categorised with different levels of treatment. The top 3 m of batters of all embankment sections exceeding 4 m in height and embankment batters on the downstream side of the two major flood plains received the full HEFRAIL erosion control treatment. There were 37 sites with full treatment embankment length ranging between 50 m and 2570 m. The full HEFRAIL treatment involves topsoiling, grass seeding and drip irrigation system set up to aid in the grass establishment. The remaining embankment batters received the full treatment except for the drip irrigation. Water from existing dams and creek water holes, from earthworks construction water tanks, and from road delivery to temporary tanks located within the rail corridor was used to supply the irrigation water. The slow germination process and low germination rate of the preferred drought resistance buffel grass impose a serious bottleneck for the rapid grass establishment required for erosion control. Therefore an attempt was made to increase the germination rate and accelerate the germination process by soaking seeds for 5 mins in water and pre-germinating in potting mix before spreading on the batter surface. Sulphuric acid treatment in the laboratory produced excellent results but has limitations for mass treatment, and it is being further investigated for improvement. Good emergence of buffel and Rhodes grass on the railway batters within a week of seeding with pre-germinated seeds has been observed where the irrigation water is secured. In general very good grass coverage was achieved within 8 weeks after seeding with irrigation. BRRP has demonstrated the success of HEFRAIL technologies at a project level, and for simultaneous multi-site treatments, in controlling batter erosion.



grasses establishing on batters

1.2.4 Holmes Cutting (2006-2007)

At this site QR eased the track curves, that is increased the curvature radii, at this section of the Toowoomba range. This activity resulted in fresh cuttings and the spoil material placed in embankment berms above the cuttings. The batters of the cuttings and embankments were progressively treated (three phases) between August 2006 and October 2007. Four rows of drip lines were laid at the top sections only. The two poly tanks located about 40 m above track level (Fig. 5) were periodically filled by a water truck. This site is an example of gravity driven irrigation system.