ScotlandTranServ
A Balfour Beatty Mouchel Parkman Joint Venture

A83 Tarbet-Lochgilphead-Kennacraig Trunk Road

A83 Rest and Be Thankful

Debris Flow

Emergency Works

07/NW/0601/005

28 October – 20 November 2007

Produced for
Transport Scotland

Prepared by
ScotlandTranServ

Broxden House
Broxden Business Park
Lamberkine Drive
Perth
Perthshire
PH1 1RA

T 01738 - 455300
F 01738 - 455301
E martyn.spicer@scotland.transerv.co.uk

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Organisation	Contact	Copies
ScotlandTranServ	Martyn Spicer	1
ScotlandTranServ	John Malcolm	1
Transport Scotland	John Withers	1
Halcrow Group Limited	Graham McGregor	1

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1 Introduction

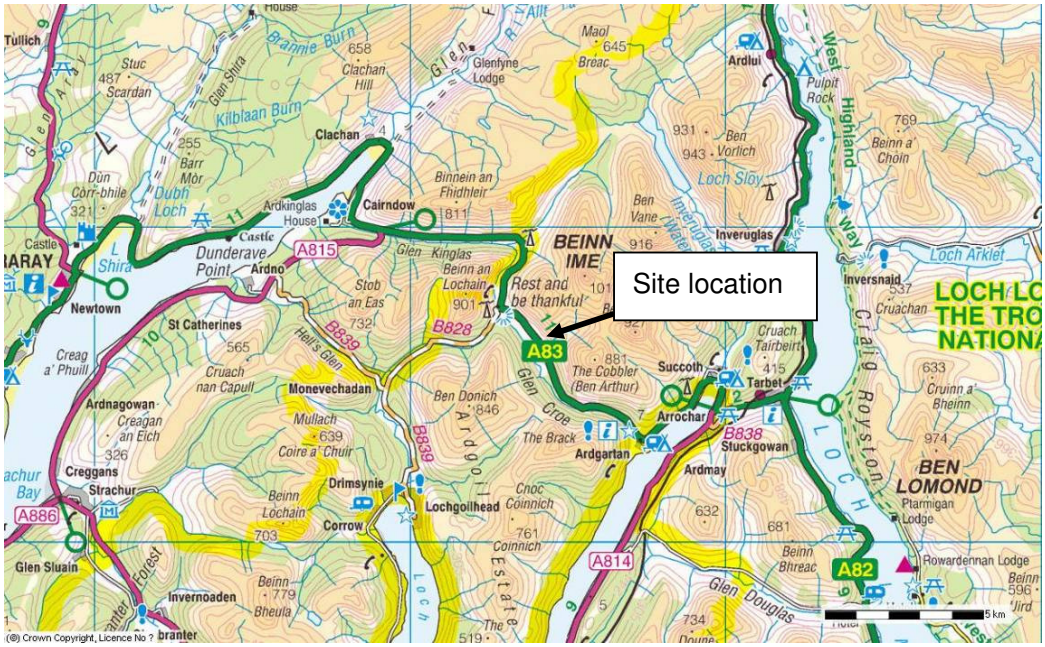
Scotland TranServ, as the appointed agents for Transport Scotland, acts as the Operating Company to supply emergency call out services on areas of network that require geotechnical remediation.

At approximately 03.00 hrs on 28th October 2007 a landslip occurred on the A83 trunk road near the Rest and Be Thankful summit (see Figure 1 and Photograph 1). Following the landslip, emergency services were provided at this location under Scheme No. 07/NW/0601/005 and OI No. 7301185. The landslip consisted of a debris flow which deposited saturated, boulder laden soils to a depth up to approximately 2.5m across the entire width of the road (see Photograph 2).

Above the road, a channel up to about 4m in depth, along which the flow occurred has been eroded. This channel extends approximately 200m up to the source area for the debris flow (see Photographs 3 and 4). Below the road, the embankment supporting the road was heavily eroded by scour from the flow debris and from surface water redirected onto the embankment (see Photograph 5). This erosion created a new channel, up to about 3m in depth, in the embankment removing materials which previously supported the verge and the safety barrier.

Following the completion of emergency remedial actions detailed in this report, the road was reopened on 15th November with traffic controlled by temporary traffic lights.

Figure 1 – Site Vicinity Map

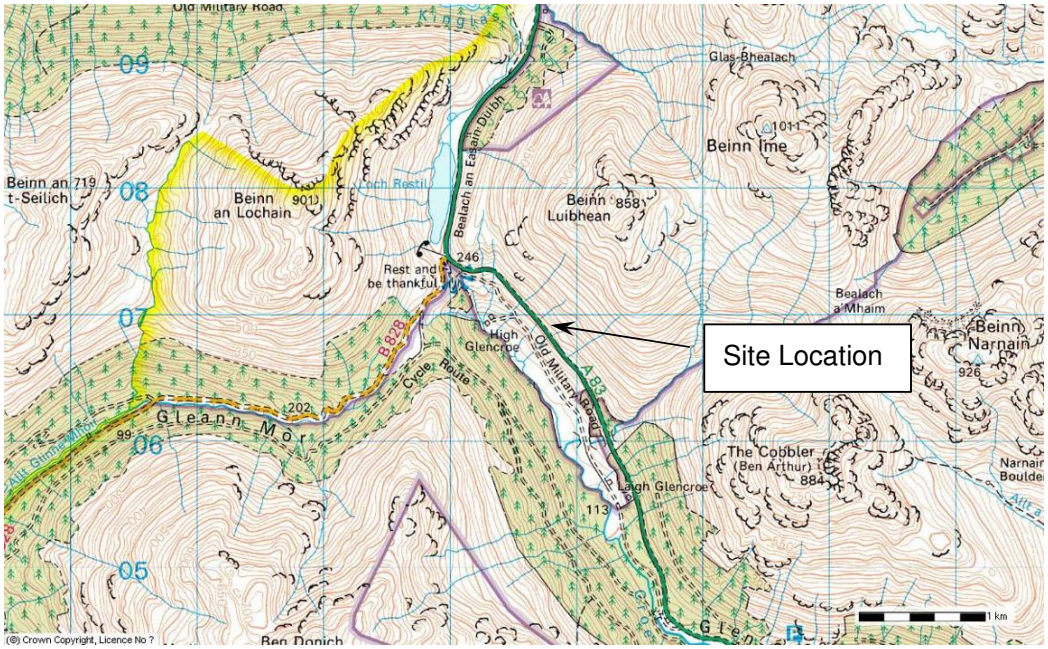


1.1 Site Location

The site is located approximately 800m east of the B828 Lochgoilhead junction near the Rest and Be Thankful summit (see Figure 2). Carriageway elevation at this location is approximately 220m AOD. The slope ascends from the road at an approximate gradient of 1:1.4 (V:H) to the head scarp of the source area located at approximately 346m AOD. The slope ascends above the head scarp to the summit of Beinn Luibhean at an elevation of 858m AOD. The slope descends below the road at a similar gradient to the Old Military Road at an elevation of about 165m AOD.

The slopes above and below the carriageway are vegetated with grasses, heather, reeds and occasional stunted small trees. Rock faces are exposed in the slope above the carriageway. The debris flow blocked a culvert located beneath the road just to the west of the site. The culvert discharge pipe is shown on Photograph 6. Emergency drainage measures are discussed in Section 3.1.

Figure 2 - Site Location Map



Debris flow crossed the A83 at National Grid Ref: NN23664,07000

2 Initial Geotechnical Assessment

2.1 Site Walkover: 28th October 2007

A site walkover was initially performed on 28th October shortly following the debris flow. Walkover surveys were also performed on subsequent days to further evaluate site conditions and develop recommendations for emergency remedial measures. Sketch plans of the flow site and a cross section along the alignment of the flow (Figures 3 and 4) are presented on pages 4 and 5.

The debris flow channel and source area have been subdivided into four sections as shown on Figures 3 and 4. The path of the debris flow followed an existing shallow channel. This channel, which was deepened and scoured by the debris flow to expose rock in the bottom of channel sections, comprises a lower meandering section located below an upper "straight" section. Figure 5 presents a more detailed sketch plan of the upper and lower source sections shortly following the slope failure. The lower source section, approximately 20m wide by 50m long, which formed the source of the debris flow, has lost its vegetative cover exposing remnant disturbed materials ranging in size from fine-grained soils to abundant gravel, cobbles and frequent boulders (see Photograph 7). The upper subsoils to a depth of up to about 2.5m were removed in this section by the flow. A lobe of grassy, waterlogged material is located immediately west of the lower source area and separated from it by a "finger" of rock extending south towards the road (see Figure 5). Following the debris flow a surface water channel was observed to flow into this lobe.

The debris flow head scarp is located immediately above the lower source section (see Photograph 8). Following the flow, the scarp varied between about 6 to 9m in height with sand/silt/clay mixtures containing frequent gravel and cobbles with scattered boulders observed in exposed sections of the scarp face. The upper source section located above the head scarp is about 25m by 40m in plan dimensions (see Photograph 9). Several tension cracks are located within this section which is bounded to the west and east by boulder "levees", (see Figure 5).

A water course discharges into the northwest corner of the upper source section feeding water into and across the source area. A smaller water course flows into the upper source section from its northeast corner.

The debris flow blocked Culvert No. 1 located beneath the road just west of the flow path which prior to the slope failure discharged water from Burn No. 1(see Figure 3). Following the slope failure, water from Burn No. 1, which previously flowed along the roadside ditch located along the north side of the road was diverted by the debris flow onto the road and discharged onto the downslope embankment.

A BT fibre optic cable is located within the verge on the downslope side of the road.

Figure 3 - Sketch Plan of Debris Flow Site

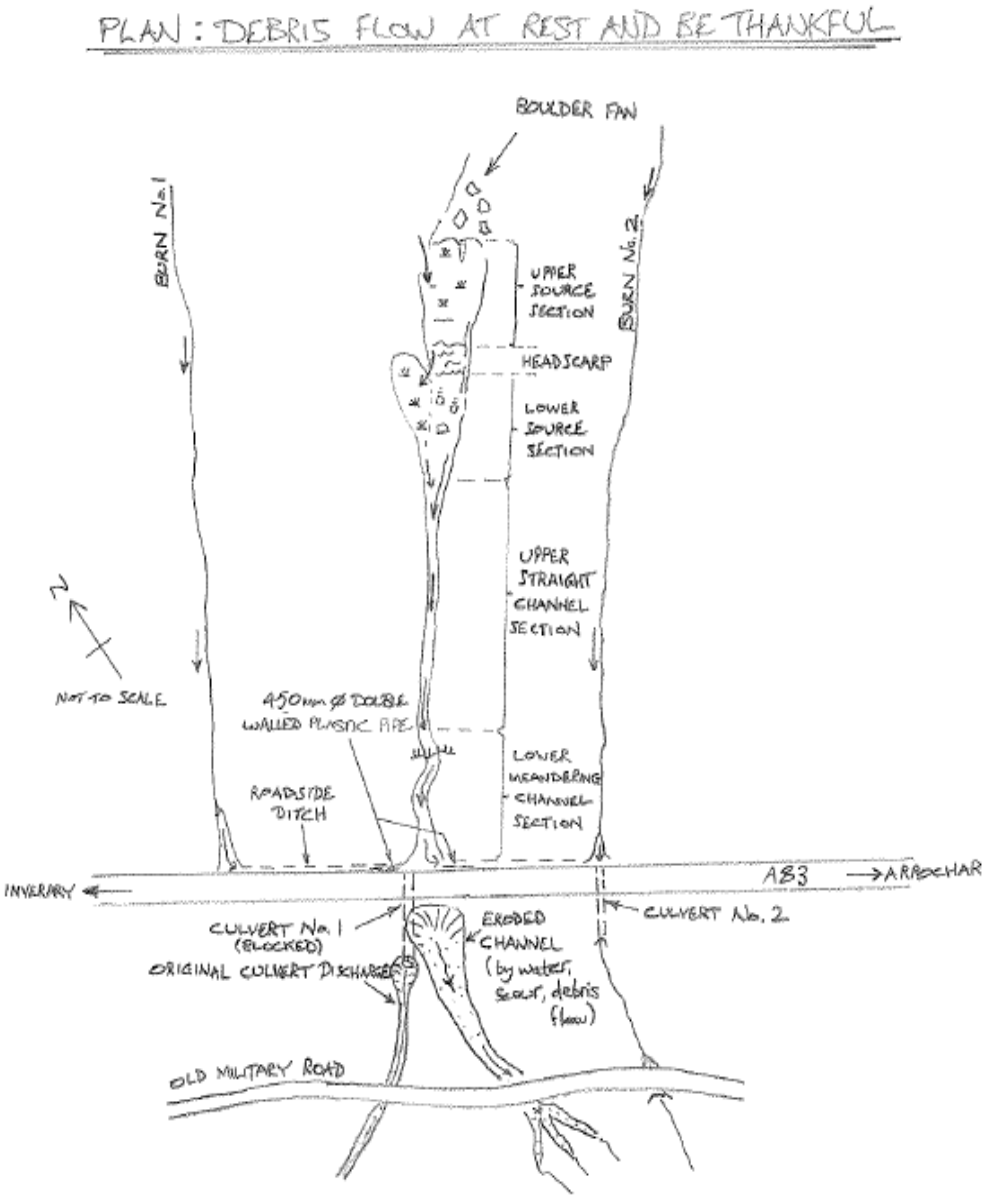


Figure 4 - Sketch Cross Section in region of Debris Flow

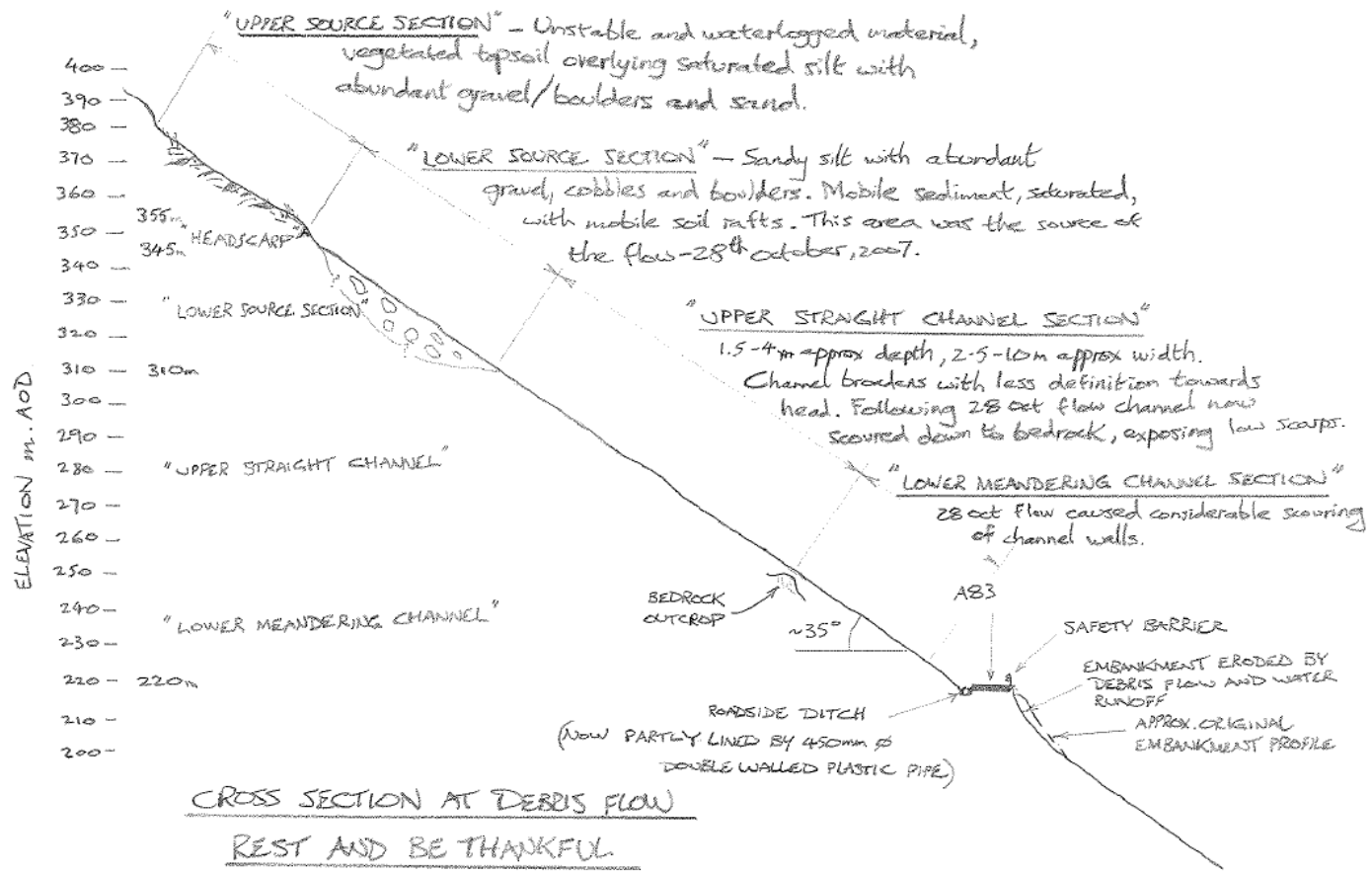
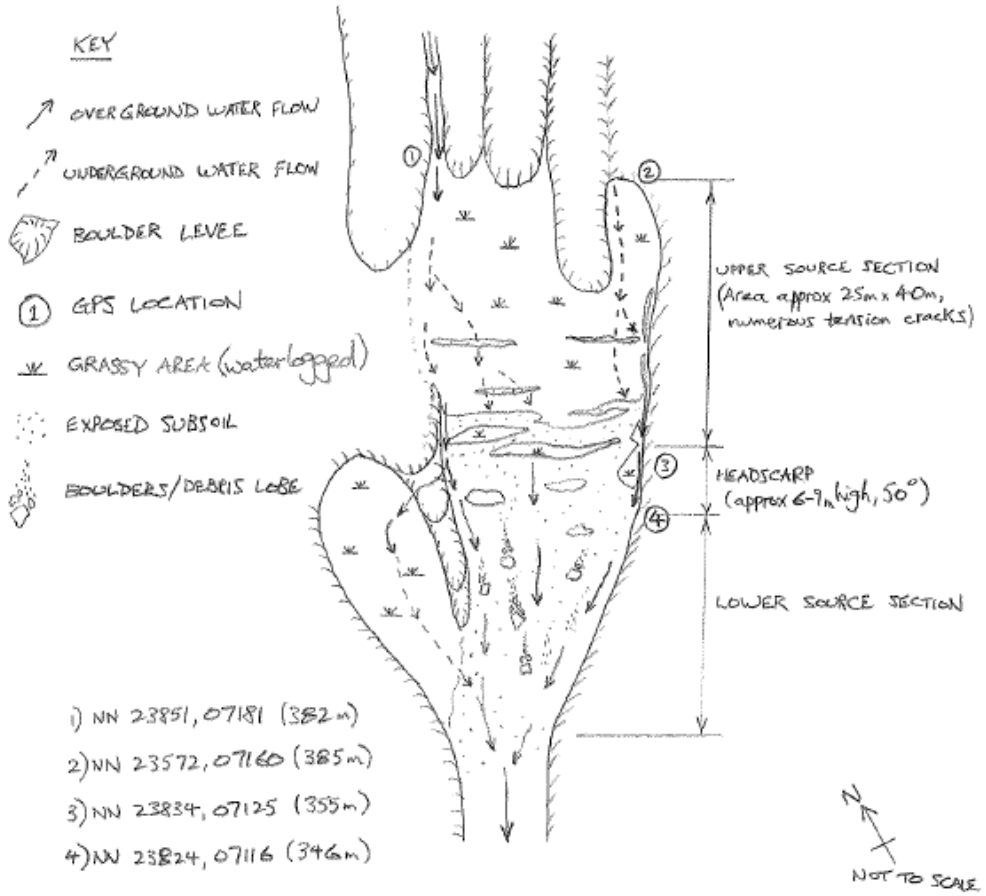


Figure 5 - Detailed Sketch Plan of Upper and Lower Source Sections



PLAN VIEW SHOWING UPPER & LOWER SOURCE SECTIONS AT REST AND BE THANKFUL

2.2 Assessment

Following detailed assessment of the slope area by geotechnical and geomorphological specialists, unstable, deformed and deteriorating materials remaining in the source areas immediately above the head scarp area were identified as still posing a considerable risk to the travelling public on the A83 below.

Surface water runoff and debris material had scoured out and incised a deep channel into the embankment below the road. The head scarp of this channel was slowly migrating upslope and undermining the road. As the road was being actively undermined there was a potential for partial road collapse if no remedial measures were taken. This potential was independent of the risk of road damage or destruction due to reactivation of unstable upslope material flowing down onto the road. If emergency protection of the downslope side of the road was not performed there was a risk that the road would become unusable due to the risk of collapse due to undermining.

Therefore, above the slope there was an imminent danger from the unstable material, while below the road there was a risk that the road may collapse due to undermining. The apparent instability of the material in the source area of the landslide suggested that it could flow and travel down the channel at some point in the future.

In addition, as the culvert and roadside ditch at this location had been blocked by the slope failure, surface runoff water was flowing uncontrolled across the road resulting in further erosion of the embankment.

As previously stated a BT fibre optic cable is located in the verge on the downslope side of the road. Undermining of this side of the road due to the upslope migration of the head scarp of the erosion channel could have impacted the integrity of this cable.

2.3 Conclusion

The walkover inspections indicated emergency remedial measures were required to address three main issues:

- Potentially unstable materials remaining in the source areas and flow channel above the road.
- Undermining of the road due to upslope migration of the erosion channel located in the embankment below the road.

- Surface water runoff flowing across the road, due to the blocked culvert and roadside ditch, and discharging onto the embankment.

3 Emergency Remediation Works

3.1 Remediation Works

Slope Area above the A83

During the site walkovers potentially unstable materials were identified as remaining on the slope above the road. To help stabilise the slope above the road, water was introduced onto selected sections of the source areas to dislodge loose and potentially unstable materials and to flush these materials down the flow channel in a controlled manner. This work commenced on 5th November and continued until 14th November as detailed below.

Initially, water was pumped onto sections of the source area using two 6-inch pumps secured adjacent to existing watercourses located immediately west and east of the slide area (Burn Nos. 1 and 2 respectively, see Figure 3). On 5th November a helicopter was used to transport the pumps, hose and associated equipment onto the slope (see Photograph 10). Hosing of water onto the source area commenced on 6th November and the hoses remained in place spraying water onto the source area overnight. On 7th November hosing continued combined with the manual removal of loose materials (see Photograph 11) from the source areas and the head scarp. The head scarp was reprofiled and overhanging soil rafts, debris and rock were removed. Water hoses were fixed in position with rebar on the 7th November but had stopped by the afternoon of 8th November. Adverse weather conditions (gales and heavy rain) precluded any personnel working on the hillside between 8th and 11th November. The pumps, hose and associated equipment were removed from the hillside by helicopter on 14th November.

Between the 8th and 12th November and following the water hosing operation, slope conditions were reassessed. Small areas of potentially unstable material were identified as remaining on the slope and the use of a helicopter to target selected areas with water drops was proposed. To deliver a greater volume of water over a shorter time period onto identified areas of potentially unstable soils, and to minimise personnel working on the slope due to safety considerations, a helicopter was used to drop water from variable heights onto the source areas using a 750-litre “Bambi” bucket (see Photograph 12). This technique was also used to help remove debris from vegetated areas of the side slopes of the flow channel. This work was carried out on 14th November. Approximately 15,000 litres in total were dropped onto the source area and the side slopes of the flow channel. Water was collected from Loch Restil located about 1km north of the site (see Figure 2).

A drainage channel was excavated by hand within the source area and lined with sand bags to direct surface water away from the lobe of grassy, waterlogged material located west of the source area. Existing channels were cleaned out and

additional channels were excavated to help direct water away from potentially unstable materials and minimise water flow into source areas.

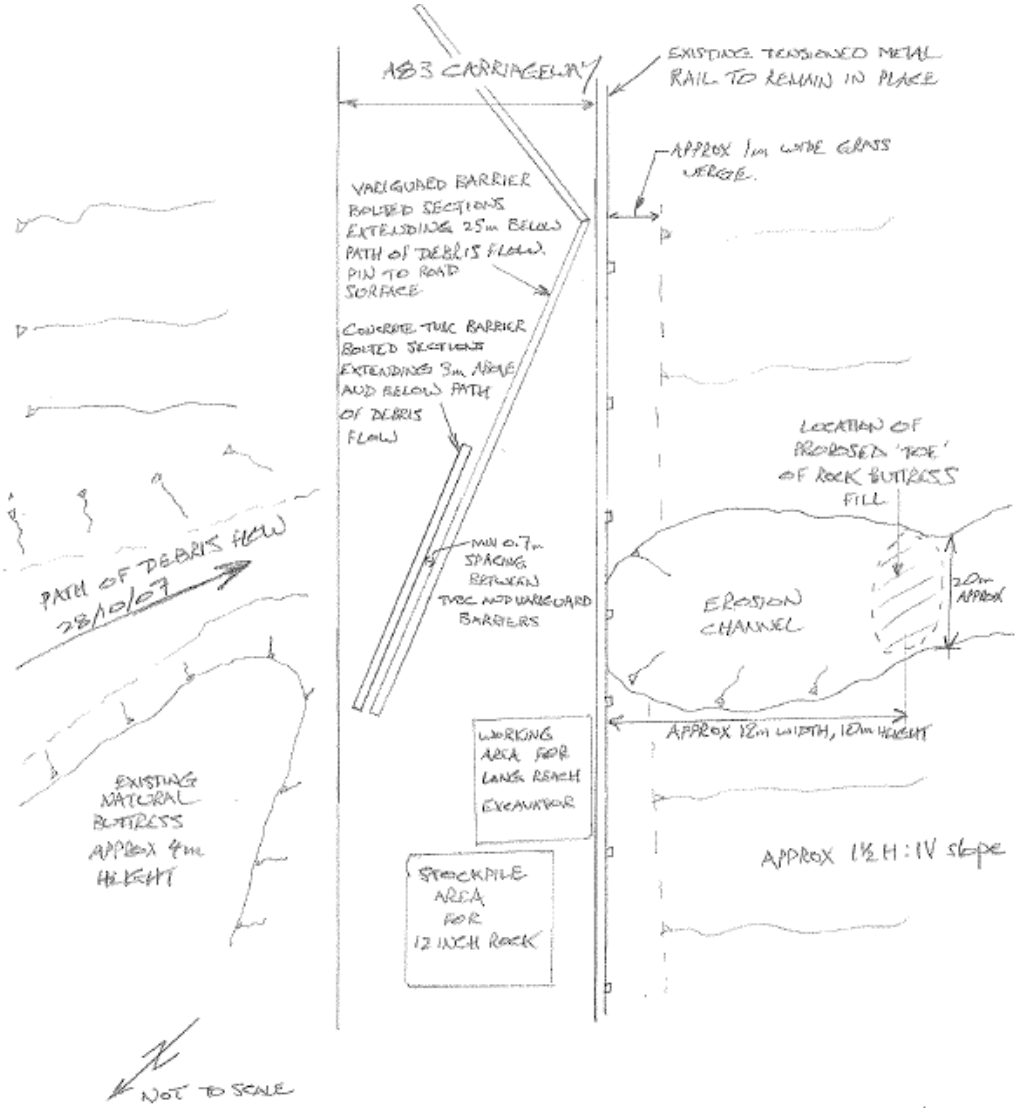
Following completion of the water drops, debris that had flowed down the flow channel into the roadside ditch adjacent to the A83 was removed and hauled offsite. On 15th November personnel inspected the flow channel and removed soil debris and loose rock from the side slopes and bottom of the channel.

Erosion Channel below the A83

Following the 28th October slope failure loosening of materials exposed in the headscarp of the erosion channel below the road and seepage of groundwater from the headscarp resulted in the active upslope migration of the erosion channel. This resulted in undermining of the grass verge and metal safety barrier adjacent to the carriageway. On 1st November the erosion channel had migrated upslope to within 0.7m of the carriageway.

To help mitigate the potential for additional undermining of the verge and carriageway, a buttress rock fill was placed on 3rd November in the upper portion of the erosion channel to help support exposed sections of the road embankment (see Photograph 13). An excavator was used to place approximately 200 tonnes of 300mm gabion rock in the upper section of the erosion channel. The section adjacent to the road was capped using Type 1 granular fill (see Photograph 14). A sketch plan used for construction of the emergency buttress fill is shown as Figure 6 overleaf.

Figure 6 - Sketch Plan for Emergency Buttress Fill Construction



Drainage Provisions due to blocked Culvert

As Culvert No. 1 beneath the road was blocked, a 450mm diameter pipe was installed in the roadside ditch along the upslope side of the A83 to ensure the free flow of water from Burn No. 1 through the site to the adjacent intact downslope culvert (Culvert No. 2, see Figure 3). This culvert (Culvert No. 2) currently discharges surface water from Burn No. 1, Burn No. 2, and the debris flow channel

to the watercourse in the valley floor. The capacity of the culvert appears adequate to carry the increased discharge during this emergency situation.

Prior to the slope failure these three water sources discharged to the watercourse in the valley floor as they do currently.

3.2 Traffic Management

The road reopened on 15th November with traffic controlled by lights. Two rows of concrete barriers were placed along the upslope side of the carriageway as a traffic protection measure. A Varioguard barrier, pinned to the road surface, was placed along the downslope side of the carriageway. In addition, sand bags were placed along the down slope edge of the carriageway to divert surface water runoff away from the buttress rock fill.

3.3 Quantities

The quantities listed below are approximations based on rough measurements taken during the initial and subsequent site walkovers and the site emergency remedial works carried out between 28th October and 15th November, 2007.

- Soil and rock debris cleared from the roadway and the roadside ditch following the 28th October debris flow totalled approximately 500 tonnes. This material was hauled offsite by Scotland TranServ to be temporarily stored at the Forestry Commission Tip near to Honeymoon Bridge, approx 1.5km south of the landslip site. The material was taken here as an interim measure. Due to its very “liquid” condition it was considered too unstable to move to an official tip due to the mess/hazard that would have been left on the carriageway between the site and the tip. The material was transported in Scotland TranServ lorries and two lorries owned by a subcontractor, D. A. MacDonald.

- Gabion rock fill (>300mm) used as buttress fill to support the road totalled about 200 tonnes. Approximately 20 tonnes Type 1 granular material was used as a capping material in the verge area.

- Approximately 15,000 litres of water were abstracted on 14th November by helicopter from Loch Restil during the emergency remedial works.

4 Post Emergency Remedial Works Assessment

4.1 Site Walkovers

Following completion of the emergency remedial works on 15th November 2007, post remediation walkovers of the site were conducted on the 20th and 29th November, the 6th and 18th December, 2007, and the 14th and 28th January, 2008 by geotechnical and geomorphological staff. This forms part of a rolling programme of inspections of the slope area.

The buttress fill on the down slope embankment is performing well with no observable deformation and no surface cracks visible in the vicinity of the road. No apparent soil movements were observed in the source areas above the road and no unstable rocks were observed within the flow channel. The surface of the carriageway appeared to be in good condition.

A topographic survey of the embankment below the road has recently been completed.

5 Proposed Permanent Works

5.1 Geotechnical Investigation

A desk study and design of the geotechnical investigation is in preparation.

The geotechnical investigation programme comprising field exploration (including cable percussion and rotary boreholes) and laboratory testing of samples recovered during the fieldwork will be performed to develop geotechnical recommendations for permanent repair of the embankment below the road, replacement of the blocked culvert and road pavement design.

The extent of the investigation, including the number and locations of boreholes will be finalised following additional consultations with the client, specialist geotechnical subcontractors and Halcrow Group Limited (Transport Scotland's geotechnical "checker").

Slope monitoring and inspection recommendations pertaining to the source area and surrounding hillside have been presented in the 2007 Annual Slope Monitoring Report, dated 7th December, 2007 and issued 21st January, 2008.

6 Appendix A - Photographs

Photograph 1: Site Location

Photograph 2: Debris flow across the A83 (Note: driver attempted to drive across flow debris)

Photograph 3: Debris flow channel

Photograph 4: Debris flow channel looking down slope

Photograph 5: Erosion channel below the road

Photograph 6: Culvert discharge pipe

Photograph 7: Debris flow lower source area

Photograph 8: Head scarp of debris flow

Photograph 9: Debris flow upper source area

Photograph 10: Helicopter transport of equipment onto hillside

Photograph 11: Hosing water onto the source area

Photograph 12: Helicopter water drop onto the source area

Photograph 13: Construction of buttress fill below the road

Photograph 14: Granular capping layer on buttress fill adjacent to carriageway