coffey geotechnics
SPECIALISTS MANAGING THE EARTH

# ANNUAL ROCK SLOPE INSPECTION - JUNE ~~2009~~ 2010

The Highland Council
A890 Stromeferry Bypass

454.1_R_001A_RMD-Annual10
July 2010

**Coffey Geotechnics Limited**
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coffey geotechnics
SPECIALISTS MANAGING THE EARTH

7th July 2010

The Highland Council
Technical Services
Council Offices
High Street
Dingwall
Ross-shire
IV15 3QN

**Attention: Mr B Stout**

Dear Bryan

**RE: A890 Stromeferry Bypass Annual Rock Slope Inspection, June ~~2009~~ 2010**

Please find enclosed two copies of the A890 Stromeferry Bypass Annual Rock Slope Inspection Report, June 2010.

The principal recommendations from the Annual Inspection are summarised in Tables 2 and 3.

"I" beam post and reinforced concrete panel retaining wall has a significant deflection has increased by 8mm and the offset has increased by 2mm since the tell tale was installed in 13/11/2006. We would recommend that an inclinometer should be installed behind the wall to monitor for any movements which may be affecting it.

Further erosion of the east gully wall between slopes AA19 and AA20 has occurred up and down stream of the erosion protection measures. Erosion has also occurred immediately below these measures. If this is allowed to continue, it could eventually lead to the undermining of the concrete beam and associated works above. We would recommend that additional erosion protection measures / training of stream within gully are undertaken during the next Phase (VI) of rock slope remedial works.

The natural slopes above the man-made (cut) slopes are increasingly demonstrating that they pose a significant hazard to the road and railway (due to aging trees, natural crags and soil slopes). Since 2007 there have been 3 serious rockfall incidents from the upper slopes that have landed on the road and railway. A review of the risk presented from the upper slopes should be undertaken to identify the current level of risk posed to the infrastructure users below.


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We would recommend a meeting with yourselves to discuss these and other issues raised in this report.

If you have any queries or we can be of any further assistance, please do not hesitate to contact the undersigned or Ian Nettleton.

For and on behalf of Coffey Geotechnics Ltd

**Richard Denney**

Project Engineer

cc C. Howell
The Highland Council
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# CONTENTS

# 1 INTRODUCTION

The Highland Council (THC) appointed Coffey Geotechnics Ltd (Coffey) as their Consultants for advice on and inspection of the A890 Stromeferry Bypass rock slopes, between Ardnarff and Attadale.

The maintenance management strategy developed in 2000, by the Transport Research Laboratory (TRL), for the A890 Stromeferry Bypass rock slopes requires the rock slopes to be inspected annually.

Mr Richard Denney and Mr Christian Houghton of Coffey undertook the annual inspection of the A890 Stromeferry Bypass Rock Slopes on the 7th till the 10th of June 2010.

The 2010 Annual Inspection included the following:

- Reviewing the monthly inspection reports
- Ground level inspection of slopes AA1 to AA24
- Rope access inspection of slopes AA12, AA15 and AA22b.
- Inspection of the landslide remedial works (September 2001) adjacent to rock slope AA20.
- Inspection of the debris flow scar and remedial works (October 2001) between rock slopes AA5 and AA6.
- Inspection of Frenchman's Burn stilling basins.
- Inspection of the crest above slopes AA5, AA6, AA11, AA12, AA15 and AA22b.
- Inspection of the source of the September 2009 rockfall west of AA5.

This report presents the findings and recommendations coming from the inspections, and provides a timescale in which the recommendations should be implemented. In addition, record sheets are presented for each rock slope (Appendix A).

This report is the tenth of the annual Stromeferry Bypass rock slope inspection reports. It presents only the findings and required actions of the June 2010 inspection, as the full management strategy and re-processed Road Rock Slope Hazard Index (RRHI) for the Stromeferry Bypass have been previously reported (Ref 19. April 2007 Inspection). The re-processed RRHI and full management strategy will be reported with any required updates as part the 2012 inspection (5 year review), or in the event of any significant change, which requires amendments to the strategy.

## 2 ANNUAL ROCK SLOPE INSPECTION (JULY 2009 TO JUNE 2010)

For the annual inspection, the Periodic Inspection reports filed during the year were reviewed to determine potentially active locations that should, in particular, be investigated during the rock slope inspection. Table 1 provides a summary of the significant observations noted during Periodic Inspections that were investigated during the Annual Inspection.

**Table 1: Periodic Inspection Summary.**

| Slope | Chainage | THC Comment | Action / Comment |
|---|---|---|---|
| **AA1** | **0023** | Small low level fall into ditch by passing place. (*6th August 2009*).<br>Small fall from 1m below crest into ditch half way between concealed access sign and Slope AA2.<br>3 loose stones visible but will also be contained by ditch. Slight scaling required. (*16th March 2010*) | Ditch containing these small ravelling failures. Light scale slope during next contract. |
| **AA4** | **0705** | Small boulder in ditch from rock outcrop near top of slope about midway along slope (*2nd February 2010*). | Remove vegetation, light scale slope and inspect during next contract. |
| **AA6** | **1390** | Very small fall – 3 stones into ditch from low level (*15th April 2010*). | Not a significant concern. |
| **AA8** | **1810** | Rock debris fall on 17th April to west of gulley at start of slope 8. Stones on road reported by police 9.30am. Cleared by DLO and inspected by Ian Hay10.30am.<br>Photos of fall sent to Coffey 30/4/10. Needs to be investigated at annual inspection. (*26th April 2010*). | Area of rockfall from slope AA7 where contractor "over scaled" area. Trap at toe would contain any larger failures. |
| **Frenchman's Burn** | **2200** | Small amount of small stones in top basin with lower fairly clear (*7th July 2009*).<br>Top basin about 1/3rd full but lower basin still fairly clear (*2nd February 2010*). | Clear out stilling basin during annual maintenance. |
| **AA15** | **2592** | *Approx 0.6 x 0.4 x 0.1 thick block of material from uplink side of nose, 3m up, 5m from start of slope. More loose to follow but all has been and will be contained by netting (May 2010)* | Inspected by rope access during annual inspection. Scale area during next contract. |
| **AA16** | **2770** | Large block in rock trap (*16th March 2010*). | Not a significant concern, due to trap and netting performing as intended. |

**Table 1: Periodic Inspection Summary (continued...).**

| Slope | Chainage | THC Comment | Action / Comment |
|---|---|---|---|
| Natural Crag above and between AA18 & AA19 | **N/A** | *New stones in pit at head of pipe. Mostly small but 3 No. approx 250 x 200 x 150. Probably brought down gully by2 No. dead tree branches. No sign of anything related to Crag (May 2010)* | Contained by adequate rock trap at toe of slope. |
| **AA22b** | **3328** | Scaled stones? in ditch at start of slope. Small falls at Ch 3372 and 3380 contained by netting and barrier. (*8th July 2009).* | #3372 and #3382 inspected by rope access and heavy scaled during annual inspection.<br>Additional areas worth scaling during next contract. |
| | | Approximately 1m$^3$ rockfall contained by netting and barrier. Location is a 6th post from West end of barrier. (*2nd February 2010*). | |
| | | Cobbles contained by netting at chainages 3227m and 3255m (*16th March 2010*). | |
| | | Another 3m$^3$ rockfall contained by netting and barrier adjacent to fall reported in February. Fall centred 5m further along slope. (*15th April 2010*). | |
| **AA24** | **3627** | Accident damage to East end of netting. Netting pulled West along slope about 2m. Slight damage to netting. Main bottom restraint wire needs retightened. Original old wire broken and securing bolt pulled out. (*2nd February 2010*). | Netting replaced / repaired during annual inspection. |

## 2.1 Significant Events

During the past year (July 2009– June 2010) the mean temperature and mean rainfall were above the 1961 to 1990 and the 1971 to 2000 regional averages during the summer and autumn of 2009, and below the means during winter and spring. The winter was the coldest winter in Scotland since 1962/63 with significant snowfalls (Ref. 12).

On Thursday the 10th of September 2009 at 3pm a rockfall was reported to have occurred west of slope AA5. The debris from the rockfall landed on the southern edge of a section of single track road with some material reaching the railway boundary fence. The weather the week prior to the rockfall had been very windy (gusting up to 70mph) with heavy rain.

Coffey undertook the inspection on the 14th September 2009. The inspection was carried out in order to identify the source of the rockfall and to identify any further potential failures from the source and

immediate (within 3m to 4m) area. Following the identification of the source of the rockfall, emergency remedial works were undertaken.

## 2.2 Findings of the 2009 - 2010 Annual Rock Slope Inspection

The rock slope inspections were initially undertaken from the base of the slopes to highlight areas of concern. These areas were then inspected from the most appropriate location. The observations and recommendations of the inspection are listed in the record sheet for each slope which can be found in Appendix A, along with a photograph of each slope (Appendix B).

The principal recommendations from the Annual Inspection of the Rock Slopes are summarised in Table 2. Particular observations are discussed below:

- Several of the slopes (AA4, AA13 and AA15) have become obscured by dense vegetation; this is impairing any monthly and annual inspections by covering potential failures and features. These slopes should be treated to remove the vegetation and where these slopes have not been netted (AA4), they should be light scaled to remove any detritus that has accumulated.
- At the base of the west end of slope AA20 the "I" beam post and reinforced concrete panel retaining wall has a significant deflection that appears to have been present for many years. The gap between the top of the 4$^{th}$ "I" beam post from the west and the concrete panel has continued to increase from the outside flange to the top of the concrete panel. Since the tell tale was installed in 13/11/2006 it has indicated that the gap has increased by 8mm and that the offset has increased by 2mm.

  The above measurements do not enable monitoring of the whole wall or the ground behind. Hence, additional tell tales should be installed to monitor any additional movements that may be occurring. We would recommend that tell tales are installed on either side (top and front) of the upper most concrete panel between the 3$^{rd}$ and 4$^{th}$ "I" beams. In conjunction with this an inclinometer should be installed behind the wall to monitor for any shallow and deep seated movements, which may be affecting the "I" beam wall.

  The "I" beams require maintenance to treat existing corrosion and to protect the steel work from further corrosion.
- Several (#3356, #3372 and #3382) of the noses of rock on slope AA22b appear to have deteriorated since the previous annual inspection in 2009. These noses where possible should be reduced in volume or removed by heavy scaling during the next phase (VI) of rock slope remedial works.

**Table 2. Principal Recommendations From The Annual Inspection of Rock Slopes – June 2010.**

| Slope | Recommendations | Action | Timescale |
|---|---|---|---|
| AA1 | #0023 to 0178 Remove vegetation and light scale slope. | THC | Next Phase (VI) of works |
| | Remove trees on edge of crest above the rock slope. | THC | **Outstanding** Next Phase (VI) of works |
| | Clear out ditch | THC | Annual maintenance |
| AA2 | Clear out ditch | THC | Annual maintenance |
| AA3 | Abandon the tell tale. The slope is performing satisfactorily, whilst the rock trap remains functioning | None | None |
| AA4 | #0705 to 0751 Remove vegetation and light scale slope. | THC | Next Phase (VI) of works |
| | #0712 Install dentition to base of undercut column. | THC | Next Phase (VI) of works |
| | Clear out ditch | THC | Annual maintenance |
| AA6 | #1420 Large fallen pine tree at crest of slope requires removal. | THC | Next Phase (VI) of works |
| AA7 | Clear Culverts | THC | Annual maintenance |
| AA9 | # 1906 heavy scaled area – keep under observation. | THC & Coffey | All inspections |
| | Clear out ditch | THC | Annual maintenance |
| AA10 | # 2053 large partially undercut block on small ridge – keep under observation - annual inspections. | Coffey | Annual Inspections |
| AA13 | #2404 to 2491 Remove vegetation from rock slope at crest area. | THC | Next Phase (VI) of works |
| AA14 West | #2500 to 2539 Remove vegetation from upper slope. | THC | Next Phase (VI) of works |
| | # 2543 Rock fall (<0.125m$^3$) material lying on top of buttress. Keep under particular observation during periodic inspections. | THC & Coffey | All inspections |
| | Rope access inspection of area above buttress. | Coffey | Next Phase (VI) of works |
| AA15 | #2592 to 2760 Remove vegetation from rock slope and crest area. | THC | Next Phase (VI) of works |

**Table 2. Principal Recommendations From The Annual Inspection of Rock Slopes – June 2009 (continued...).**

| Slope | Recommendations | Action | Timescale |
|---|---|---|---|
| AA17 | # 2860, column of fractured rock under existing netting by "Hughie MacKenzy" graffiti – keep under specific observation during periodic and annual inspections. | THC & Coffey | All inspections |
| AA18 | Clear out ditch. | THC | Annual Maintenance |
| AA20 | # 3080 "I" beam post - the measurements do not enable monitoring of the whole wall. Hence, additional tell tales and inclinometer should be installed. | THC & Coffey | Next Phase (VI) of works |
| | The "I" beams require maintenance to treat existing corrosion and to protect the steel work from further corrosion. | THC | **Outstanding** Next Phase (VI) of works |
| | Clear Culverts | THC | Annual maintenance |
| AA21 | #3271 Removal block next to buttress | THC | Next Phase (VI) of works |
| AA22b | # 3356, 3372 and 3382 – Potential failures keep under particular observation during periodic inspections. | THC & Coffey | All inspections |
| | #3356, 3372 and 3382 Noses should be heavy scaled / removed under supervision of Geotechnical Engineer / Engineering Geologist. | THC & Coffey | Next Phase (VI) of works |
| AA24 | # 3672 rope access inspection of area of rock fall. | Coffey | Next Phase (VI) of works |
| AA25, AA26N and AA26S | Slopes not considered a significant hazard. Hence, removed from slope inspection list. Recommend a visual inspection during the Annual Inspections, with reporting only if significant features observed. | Coffey | Annual Inspections (ongoing) |

## 2.3 Additional Features Inspected

The principal recommendations and timescales, from the Annual Inspection of the Additional Features are summarised in Table 3.

- **Debris flow scar and remedial works between rock slopes AA5 and AA6.**

  The slope drainage and erosion prevention works all appeared to be functioning as designed. The erosion control matting is well vegetated. The top drainage catch pit / debris trap was full with sediment to the height of the pipe and will require cleaning out within the next 12 months.

  The pipe extending from the drainage ditch down the slope has developed a leak in the upper most joint in the pipe. The restraining collar immediately below this joint is missing a galvanised eye for attaching to the ground anchorage. The cable has been temporally looped around the collar until the eye can be replaced.

  The area around the crest of the debris flow scar should be planted with appropriate trees to help further stabilise the area.

- **Frenchman's Gully.**

  The lower and upper stilling basins where clear of significant debris and the Phase V remedial works appeared to be performing satisfactorily.

  Based on previous debris flows in Frenchman's Burn the enlarged stilling basins (Ref. 23) should be able to contain "normal" routine debris flows (50 to 200m$^3$), but are likely to have their capacity exceeded by larger less frequent events with a return period of 5 to 15 years. The addition of a new source of approximately 100m$^3$ is likely to lead to a larger than "normal" scale debris flow during. Hence, it is vital that the stilling basins are kept clear of debris accumulations.

  The south west wall of the gully above the upper and lower stilling basin has been subject to erosion. This has resulted in over steep superficial material. This should be kept under observation during the monthly and annual inspections.

- **Gully between rock slopes AA19 and AA20.**

  Further erosion of the east gully wall has occurred up and down stream of the erosion protection measures. Erosion has also occurred immediately below these measures. If this is allowed to continue, it could eventually lead to the undermining of the concrete beam and associated works above.

  No significant debris dams were observed in the gully.

- **Landslide remedial works adjacent to rock slope AA20.**

  Concrete beam, cables and temporary catch fence all appeared to be functioning satisfactorily.

- **Natural Features**

  The natural crags and trees above the man made rock slopes AA5 to AA22 (Fig. 4) are representing a growing hazard to the road and railway. Recent examples that have seriously impacted on the road and railway are listed below:

  1. The rockfall from a natural crag above and between AA18 and AA19 which occurred on the 4th of May 2007. The material from which reached the road and the railway.
  2. On the afternoon of the 24th of August 2008 two blocks were found on the road beneath slope AA17. Upon inspection of the upper slopes, the blocks were found to have come from a natural crag, travelled down the upper vegetated slope and over the crest of the netted slope. The initial cause of the rockfall has not been identified, but may have been caused by the root action of the trees.
  3. During the 2008 Annual Inspection, a block (0.5m X 0.5m X 0.3m) from the upper slopes was observed to have been retained by the netting at the crest of slope AA18. The block appeared to have been funnelled in to a small gully feature, which the netting spans across.
  4. 10th September 2009 a rockfall from a natural crag west of slope AA5, the material from which reached the road.

  Above slopes AA11 to AA22 there are a large number of Larch trees that have fallen over and are lying across the slope. This is starting to act as a slide system for any new tree that falls over, sending the tree down slope towards the road. This is highlighted by the tree trunk leaning against the rock slope at AA14 east and the tree that landed on the road between slopes AA15 and AA16 during the Phase V remedial works contract. The trees are now presenting a growing significant hazard to the road and the railway.

  In addition, the root balls of several upturned trees contain blocks of rock which have the potential to become dislodged and roll down the slopes and over the crests of the slopes AA11 to AA22.

  The management of the standing and fallen trees is an issue that has been brought to the attention of Attadale Estate (Ref. 17).

- **Rockfall Signage**

  The rockfall signage between Ardnarff to Attadale covers the section slopes between AA1 to AA24. The first rockfall sign is between Ardnarff House and the car park above Ardnarff House, this sign is labelled to cover a distance of 2 miles. The second sign is located between AA2 and AA3 and is f labelled to cover a distance of 2 miles; this covers the distance to the road closure gate after slope AA24.

  The rockfall signage from Attadale to Ardnarff covers the slopes between AA24 to AA1. The first rockfall sign is prior to the road closure gate and states a distance of 2 miles. The following sign is between AA6 and AA7 with no distance marked and is located 1 mile from Ardnarff.

**Table 3. Principal Recommendations From The Annual Inspection of Additional Features – June 2009.**

| Feature | Recommendations | Action | Timescale |
|---|---|---|---|
| Debris flow scar between rock slopes AA5 and AA6 | Top drainage catch pit / debris trap requires clearing. | THC | Annual maintenance. |
| | The area around the crest of the debris flow scar requires planting with appropriate trees. | THC | **Outstanding** Next Phase (VI) of works |
| | 1st elbow joint down from the catch pit requires the leak fixing.<br>1st collar below the 1st elbow joint requires the missing galvanised eye replacing and the anchorage re-attaching. | THC | Next Phase (VI) of works |
| Slopes between AA6 and AA7 | No excavation or works on or in to the slopes between AA6 and AA7 without appropriate geotechnical advice. | THC | Immediate and continuous |
| Frenchman's Burn | Remove debris from culvert beneath road. | THC | Annual maintenance. |
| Upper slopes above AA11 to AA22b | Require inspection to identify features that could potentially affect the road and railway below. | Coffey | Prior to next annual inspection |
| | Devise management and remedial works strategy based on the above. | THC & Coffey | |
| | Removal of block above AA17 (Ref. 22) | THC | Next Phase (VI) of works |
| Natural Crag above and between slopes AA18 and AA19 | Keep under particular observation during periodic and annual inspections. | THC & Coffey | All inspections |
| | Remove tree rootball that is currently strapped. | THC | Next Phase (VI) of works |
| Gully between Slope AA19 and AA20 | *No excavation within 3m of northeast bank of the gully*. | THC | During any future clearance work. |
| | Installation of additional erosion protection measures / training of stream within gully. | THC | Next Phase (VI) of works |
| Landslide remedial works adjacent to Rock slope AA20 | Monitor and observe erosion of superficial materials within gully.<br>Observe and monitor for signs of further erosion. | THC & Coffey | All inspections. |

# 3 DISCUSSION

The recommendations from the Annual Inspection June 2009 are in Tables 2 and 3. The timescale categories are described below:

1. *Annual Maintenance (minor).*

   The Annual Maintenance consists of work that can be carried out by the local roads maintenance unit, e.g. clearing ditches and culverts, etc.

2. *Next Phase (VI) of Works.*

   The remedial works contract is for slopes and additional features that will require action in the next 2 to 5 years. For efficiency and effective use of budgets this should be carried out as a single contract (Phase VI).

3. *The Natural Slopes and Trees above the cut rock slopes.*

   The slopes above the man-made (cut) slopes on the A890 Stromeferry Bypass are increasingly demonstrating that they pose a growing significant hazard to the road and the railway due to:

   - Unstable trees and associated disturbance or crags and superficial deposits.
   - Over-steep superficial deposits with localised drainage problems, e.g. debris flow AA5/6.
   - Natural crags e.g. between slopes AA6 and AA7, above and between AA11 to AA22b.

   A series of stereo oblique aerial photographs have been obtained for the A890 Stromeferry Bypass under the Phase V contract to enable events on these slopes to be recorded and assessed. These shall enable investigation and management of future failures to be undertaken once they have occurred, and could be used for a pro-active management strategy for the slopes.

   The level of risk presented by the upper slopes to the road and railway should be assessed. The previous events from the last 10 years should be back analysed to determine the level of risk posed to the road and railway. An assessment of the natural hazards remaining should be undertaken following the analysis. This should then be reviewed by THC and Coffey. If the level of risk is deemed unacceptable, a list of practical management actions / remedial measures could be compiled that would manage / reduce the risk to an acceptable level.

# 4 CONCLUSIONS

From the findings and analyses of the annual rock slope inspection our conclusions are as follows:

1. The remedial / maintenance works in Tables 2 and 3 should be undertaken within the timescales given.
2. The natural slopes above the man-made (cut) slopes are increasingly demonstrating that they pose a significant hazard (due to trees, crags and soil slopes). A risk analysis of the upper slopes should be undertaken to determine the level of risk posed to the infrastructure users below.
3. Due to potential relict postglacial slope movements no excavation or works on or into the slopes between rock slopes AA6 and AA7 (Fig. 2) should be undertaken without appropriate geotechnical advice.
4. During the year (July 2009 to May 2010) there was one significant natural event (a rockfall originating from 30m west of slope AA5) that affected the road.
5. Phase V remedial works were undertaken between September to October 2008, with additional scaling work carried out in July 2009. All of the works appear to be functioning satisfactorily. Outstanding works that were not undertaken during the contract are highlighted in Tables 2 and 3.
6. The rockfall risks from the cut rock slopes on the A890 Stromeferry Bypass between Ardnarff and Attadale remain high but are suitably managed, as the traffic flow is relatively low (low exposure). If the traffic flows were to increase then the risk management of the Stromeferry Bypass would require proportionate future remedial works.
7. The risk reduction and maintenance management strategy has been implemented. The reduction in risk is largely due to remedial works that will require on-going maintenance. Despite this the possibility of unforeseeable events cannot be entirely ruled out.
8. The remedial works for the October 2001 landslide between slope AA5 and AA6 (at chainage 1335) and the August 2001 works adjacent to rock slope AA20 are functioning satisfactorily.
9. The 1999 sediment traps at the bases of Frenchman's Gully and the gully between rock slopes AA19 and AA20 have, as expected, functioned satisfactorily. The rock fall further up the gully has added to the supply of debris in Frenchman's Burn, hence it is vital that the stilling basins are kept clear of debris accumulations.
10. The 2010 Annual Inspection should be undertaken between the end of March and the end of June to enable any urgent remedial works required to be undertaken prior to the onset of the following winter.

For and on behalf of Coffey Geotechnics Ltd.

| Authorised Reviewer | Author |
|---|---|
| **I.M. NETTLETON** | **R.M. DENNEY** |
| Principal | Project Engineer |

## REFERENCES


1. McMillan P. 1995. Rock Slope Risk Assessment, Project Report PR/SC/22/95. Unpublished project report. Transport Research Laboratory, Crowthorne, Berkshire, UK.
2. McMillan, P., Butler, T., Harber, A. J. & Nettleton, I. M. 1998. A890 Stromeferry Bypass Ardnarff to Attadale Rock Slope Hazard Index and Rating Survey. *TRL Project Report* PR/SC/02/98, Transport Research Laboratory, Edinburgh.
3. Harber, A. J. & Nettleton, I. M. 2000. A890 Stromeferry Bypass Ardnarff to Attadale Rock Slope Management Stategy and Emergency Procedure. *TRL Project Report* PR/SC/32/98, Transport Research Laboratory, Edinburgh.
4. Terente, V. A., Harber, A. J. & Nettleton, I. M. 2000. A890 Stromeferry Bypass Ardnarff to Attadale Rock Slope Hazard Rating Surveys (Phase II). *TRL Project Report* PR/ISS/22/00, Transport Research Laboratory, Edinburgh.
5. Nettleton, I. M. & Butler, A. J. 2000. Inspection of the A890 Stromeferry Bypass Rock Slopes and Gullies. *Short Letter Report*, Transport Research Laboratory, Edinburgh.
6. EDGE Consultants UK Ltd. 2001. A890 Stromeferry Bypass. Annual Rock Slope Inspection 2001.
7. EDGE Consultants UK Ltd. 2001. Emergency Inspection of Landslide Site and Major Stream Courses – November 2001.
8. EDGE Consultants UK Ltd. 2002. A890 Stromeferry Bypass. Annual Rock Slope Inspection July 2002.
9. EDGE Consultants UK Ltd. 2002. A890 Stromeferry Bypass. Phase II Remedial Works Completion Notes. October 2002.
10. EDGE Consultants UK Ltd. 2003. A890 Stromeferry Bypass. Annual Rock Slope Inspection May 2003.
11. EDGE Consultants UK Ltd. 2004. A890 Stromeferry Bypass. Annual Rock Slope Inspection June 2004.
12. Met Office. 2009. http://www.metoffice.gov.uk/climate/uk.
13. EDGE Consultants UK Ltd. 2005. A890 Stromeferry Bypass. Annual Rock Slope Inspection April 2005.
14. EDGE Consultants UK Ltd. 2006. A890 Stromeferry Bypass. Phase III Remedial Works Completion Report.
15. EDGE Consultants UK Ltd. 2006. A890 Stromeferry Bypass. Roped Access Inspection Report.
16. EDGE Consultants UK Ltd. 2006. A890 Stromeferry Bypass. Annual Rock Slope Inspection April 2006.
17. The Highland Council. 2007. Letter to Attadale Estates about trees posing road safety risk.
18. EDGE Consultants UK Ltd. 2007. Inspection Report of Rockfall Between Slopes AA18 and AA19 – May 2007.
19. EDGE Consultants UK Ltd. 2007. A890 Stromeferry Bypass. Annual Rock Slope Inspection – 5 Year Review, April 2007.
20. Coffey Geotechnics Ltd. 2008. A890 Stromeferry Bypass Rock Works 2008 Completion Report. May 2008.
21. Coffey Geotechnics Ltd. 2008. A890 Stromeferry Bypass. Annual Rock Slope Inspection - April 2008.
22. Coffey Geotechnics Ltd. 2008. A890 Stromeferry Bypass, August 2008 Rock Fall Assessment.
23. Coffey Geotechnics Ltd. 2009. A890 Stromeferry Bypass, Phase V Remedial Works Completion Report.
24. Coffey Geotechnics Ltd. 2009. A890 Stromeferry Bypass. Annual Rock Slope Inspection - June 2009.
25. Coffey Geotechnics Ltd. 2009. A890 Stromeferry Bypass, September 2009 Rockfall Inspection Report.

# Appendix A

**Annual Rock Slope Inspection June 2009**

| AA1 | Chainage: 0023 - 0178 | Length: 155m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 89054 35683 | Finish: NG 89161 35810 | |

**Description of Slope:**

# 0000 starts opposite entrance to Ardnarff House.

Natural and excavated rock slope.

Forest and forestry track above slope.

Ditch (0.5m wide x 0.25m deep).

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

**2004:** Ditch and culvert cleared.

**June 2010:** Trees removed at # 0018 and 0024 by CAN.

**Inspection Findings:**

Ravelling continues, no significant potential failures observed.

# 0038 Area of ravelling on face, 4m up, not significant.

# 0042 2 No. trees on the edge of the crest with small pod of material 1m below.

# 0063 Small block 200mm x 200mm x 100mm, 8m up – fallen and contained by ditch.

# 0068 Tree at crest of slope with yellow spray paint on trunk on edge of crest.

# 0082 Heavy water flow – minor root mass (grass) stripped off face. Possibly due to movements (vehicle) on forestry track above.

# 0093 Tree at crest of slope with yellow spray paint on trunk on edge of crest.

# 0127 Tree on edge of crest above rock slope.

# 0130 Undercut at crest of slope, no signs of deterioration - not significant.

# 0139 Pod of material (1m3) below crest of slope with sapling growing out of the middle.

# 0143 Small failure reported previously by The Highland Council.

# 0165 Wedge of weathering schist – deteriorating, but would be contained by ditch.

# 0168 Culvert clear.

Build up of debris in ditch along length of slope.

**Current Hazard Index Value:** 4

**Remedial / Maintenance Works Required:**

Remove trees on edge of crest above the rock slope (# 0042, 0068, 0093 and 0124).

Remove vegetation and light scale rock face.

Clear ditch (Annual Maintenance).

| AA2 | Chainage: 0178 - 0297 | Length: 119m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 89163 35809 | Finish: NG 89277 35890 | |

**Description of Slope:**

Natural and excavated rock slope.

Forest and forestry track above slope.

Ditch (0.5m wide x 0.3m deep).

**Failure Characteristics:**

General ravelling.

Potential plane failures.

**Existing Remedial Works:**

Localised (# 0178 to 0199 and # 0230 to 0277) draped chain link netting in poor condition, with some double twist rockfall netting patches.

**2002:**

# 0184 Potential failing column scaled (removed) by CAN.

**2004:**

Ditch cleared.

**January 2006:**

# 0199 to 0228 Un-netted area, light scaled by TRAC.

# 0255 Potential failing column (2m high x 1.5m wide x 0.25m thick) - heavy scaled by TRAC.

# 0257 Potential blockfall (1.5m high x 1m wide x 0.25m thick) - heavy scaled by TRAC.

# 0178 to 0199 and 0228 to 0277 slope re-netted by TRAC.

**Inspection Findings:**

Trees at crest appear to be generally in a satisfactory condition.

# 0197 Culvert is clear.

# 0220 Pod of material ($0.25m^3$) scaled during inspection.

# 0247 Galvanised shackle on netting at toe of slope.

# 0259 Culvert clear.

# 0276 Build up of debris behind netting from ongoing ravelling and galvanised shackle on netting bottom cable.

# 0297 Culvert is one quarter silted – generally clear.

Bottom cable on netting installed in 2006 is showing signs of corrosion.

Ditch partially blocked in places.

**Current Hazard Index Value:** 4

**Remedial / Maintenance Works Required:**

All shackles require threads smearing with adhesive resin (Annual Maintenance).

Clear ditch (Annual Maintenance).

| AA3 | Chainage: 0516 - 0630 | Length: 114m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 89054 35683 | Finish: NG 89161 35810 | |

**Description of Slope:**

# 0516 is at northeast end of Armco barrier.

Excavated slope set back from road.

Shrubs and mixed forest above slope.

From the toe of the rock slope a 40 to 45 talus slope leads down (3m to 5m) to a rock trap (see Existing Remedial Works). From this a talus slope with deer fencing, leads down (3m to 5m) to the ditch at the edge of the road.

Ditch 0.5m wide x 0.3m deep at roadside.

**Failure Characteristics:**

General ravelling.

Potential large plane and toppling failures.

**Existing Remedial Works:**

Rock trap created 3m wide with a 1.25m to 1.5m high 1m wide bund.

**January 2006:**

# 0560 Potential toppling failures upper driving blocks removed by TRAC. No blocks escaped during removal.

# 0573 Undercut of blocks removed by TRAC. During removal no blocks escaped when the ditch was clear. 1 block escaped when ditch was full.

**Inspection Findings:**

Old track forms rock trap 2.5m wide x 1m deep at toe of rock slope with well-established shrubs and sapling trees on outer bund. Trap was still clear following January 2006 remedial works.

Deer fencing installed from start of slope, running along whole length at road level.

# 0560 Tell tale installed 06/06/2006 by THC. Currently measuring +1.0mm horizontal, +1.0mm vertical (Appendix B – Figure 3).

# 0573 Back of scar is eroding back releasing small blocks (100mm X 50mm X 50mm). Area of erosion currently not undercutting any other areas and material will be contained by the ditch.

Several wooden crash barrier posts on railway side of road have failed and are rotten.

**Current Hazard Index Value:** <1

**Remedial / Maintenance Works Required:**

Tell tale no longer requires monthly recording of measurement, due to satisfactory performance of slope.

| AA4 | Chainage: 0705 -0800 | Length: 95m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 89511 36265 | Finish: NG 89567 36340 | |

**Description of Slope:**

Natural and excavated rock slope.

Shrubs and mixed forest above slope.

Ditch (0.5m to 1m wide x 0.5m to 1m deep).

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**2002:**

# 0728 Heavy scaling of a plane failure block, some material in ditch, small overhang of remaining material solid, keep under observation.

**January 2008:**

# 0725 Vegetation removed and light scaling of small overhanging block by Skye Rope Access.

**Inspection Findings:**

# 0705 to 0751 Vegetation almost entirely obscuring the slope.

# 0712 undercut column. Base of column is fractured and deteriorating.

# 0728 2No. overhangs have deteriorated (rockfall reported).

# 0740 Overhanging superficial (2m long by 0.5m high by 0.5m deep) 5m above the road level (Appendix B - photograph 6).

# 0774 Culvert is clear.

# 0795 Superficials washed away during debris flow on 4/10/2004.

Ditch is partially blocked in places.

**Current Hazard Index Value:** 2

**Remedial / Maintenance Works Required:**

# 0712 Install dentition to base of undercut column.

# 0705 to 0751 Remove vegetation and light scale.

# 0728 Heavy scale overhangs.

# 0740 Remove overhanging superficials.

Clear ditch (Annual Maintenance).

| AA5 | Chainage: 1310 - 1330 | Length: 20m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 89839 36749 | Finish: NG 89956 36756 | |

**Description of Slope:**

Natural bluff of rock in a grass, shrub and tree covered hillside.

Ditch (0.5m wide x 0.3m deep).

Deer fencing along toe of slope.

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

None.

**Inspection Findings:**

Ditch appears to adequately control the ravelling failures, some small ravelling failures in ditch.

Slope has re-vegetated well with no apparent signs of ongoing erosion.

Deer fencing installed from start of slope, running along whole length at road level.

# 1330 Culvert clear.

# 1333 Block (0.25m$^3$) 1m above road level has become dilated – keep under observation.

# 1335 Minor erosion of side of gully at the toe of the slope. Material is contained in the ditch

**Current Hazard Index Value:** 5

**Remedial / Maintenance Works Required:**

None.

| AA6 | Chainage: 1390 -1450 | Length: 60m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 89903 36816 | Finish: NG 89932 36865 | |

**Description of Slope:**

Natural and excavated rock slope.

Grass, shrub and tree covered hillside above slope.

Ditch (0.5m to 1m wide x 0.5m to 0.75m deep).

To the north east of the slope there is a natural gully with rock walls.

Deer fencing along toe of slope.

**Failure Characteristics:**

General ravelling.

Potential plane failures.

**Existing Remedial Works:**

**2002**

300m$^2$ Scaling on slope.

5m$^3$ Heavy scaling / controlled removal on slope.

700m$^2$ Reinforced netting (# 1390-1417).

In the gully to the north east there are:

New catch fence across gully.

2 No. Gabion walls with double twist rockfall netting and wooden posts acting as catch fences, repaired during Phase II remedial works.

**Inspection Findings:**

# 1420 Large pine tree at crest of slope has fallen over.

# 1426 Rock scar on face from 2002 remedial works. Not significant.

# 1448 Small rockfall scar on face (1m wide by 1m high).

Fallen tree above crest, south west of gully, currently lodged on slope.

**Current Hazard Index Value:** 5

**Remedial Works Required:**

# 1420 Remove fallen pine tree.

| AA7 | Chainage: 1706 - 1810 | Length: 104m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 90146 37002 | Finish: NG 90242 37024 | |

**Description of Slope:**

Natural rock slope.

Grass, shrub and tree covered hillside above slope.

Slope is heavily wooded.

Deer fencing installed on talus slope below rock slope.

Ditch: # 1706 – 1720 rock slope is set back >10m, with a ditch 2m wide by the road. Densely vegetated.

# 1720 – 1810 French drain has replaced ditch.

**Failure Characteristics:**

General ravelling.

Potential wedge failures.

**Existing Remedial Works:**

**January 2006:**

# 1802 Tree toppled off the face pulling with it the root mat and some superficial materials. Removed by TRAC.

**February 2008:**

# 1706 – 1810 Vegetation removed, light scaling, targeted heavy scaling and tree removal by Skye Rope Access.

# 1717 Trap and bench (4m wide) created at toe of slope from scaled material by Skye Rope Access.

# 1810 Installation of 5 No. 4m long stainless steel dowels into potential plane failure near the crest by Skye Rope Access.

**Inspection Findings:**

# 1706 Culvert clear.

# 1717 Mass to right of scar may deteriorate but will fail into the gully and debris cone at the toe.

# 1755 Culvert clear.

# 1766 Culvert partially blocked.

# 1766 Rock buttress – fractured but above low angle slope covered in vegetation and tree stumps, should be retained on slope and is >20m from road.

# 1796 Culvert – minor debris present.

Ditch is no longer present, has been replaced by a French drain.

**Current Hazard Index Value:** 12

**Remedial / Maintenance Works Required:**

Clear culverts (Annual Maintenance).

| AA8 | Chainage: 1810 - 1873 | Length: 63m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 90242 37024 | Finish: NG 90301 37052 | |

**Description of Slope:**

Natural rock slope.

Grass, shrub and tree covered hillside above slope.

Slope is heavily wooded (vegetation cleared in area of Phase II remedial works has now re-established well).

Ditch: # 1810 – 1846 (1.0m wide, 0.5 – 1.0m deep).

# 1860 – 1846 rock slope is set back 4.0 – 6.0m from the road.

**Failure Characteristics:**

General ravelling failures.

Potential wedge and toppling failures.

**Existing Remedial Works:**

**2002:**

200m$^2$ Scaling over top half of slope.

10m$^3$ Heavy scaling / controlled removal at crest of slope.

1400m$^2$ Draped double twist rockfall netting (# 1823 – 1860).

**January 2006:**

# 1822 Toppled tree removed along with a tree it supported, by TRAC.

**Inspection Findings:**

# 1822 Tree trunk removed, stump and roots left to allow coppice to develop as these hide rock slope remedial works and help to dissipate rockfall energy

# 1848 Post shaped block at approx. 30m height behind rock fall netting, if fails should be contained by netting - keep under observation, now difficult / impossible to see in summer.

# 1854 Culvert ¼ full.

# 1873 Column 4m above toe of slope, on gully side with tree growing out of area above. Should be retained on slope, >3m from road.

**Current Hazard Index Value:** 7

**Remedial Works Required:**

None.

| AA9 | Chainage: 1873 - 1953 | Length: 80m | Height: >40m |
|---|---|---|---|
| | Grid Ref Start: NG 90301 37052 | Finish: NG 90368 37079 | |

**Description of Slope:**

Natural rock slope.

Grass, shrub and tree covered hillside above slope.

Slope is heavily wooded.

Deer fencing installed on talus slope below rock slope.

Ditch: # 1873 – 1886 1.0m grass verge, no ditch.

# 1886 – 1913 (2.0 - 4.0m wide, 0.5 – 1.0m deep)

# 1913 – 1953 (4.0 – 6.0m wide, 0.5 – 1.0m deep)

**Failure Characteristics:**

General ravelling.

Potential wedge failures.

**Existing Remedial Works:**

**2002:**

# 1886 Heavy scaling of two small blocks approximately 25m above the road on the rock slope and installation of 150m$^2$ of rock fall netting.

**January 2006:**

# 1899 Attempts to scale off block at north east of netting made – only some small blocks were removed. Netting extended across this area, by TRAC.

EDGE Rope access inspection February 2006 (Ref. 15).

**February 2008:**

# 1873 – 1953 Vegetation removed, slope light scaled by Skye Rope Access.

# 1930, 1970 & 2010 Targeted heavy scaling undertaken by Skye Rope Access.

# 1906 Heavy scaled area 25m up – scaled rock contained in ditch / verge by Skye Rope Access.

# 1970 Vegetation removed, 4 No. mature trees removed and light scaled by Skye Rope Access.

# 1970 – 2000 Targeted removal of dense vegetation and mature trees along crest line by Skye Rope Access.

**Inspection Findings:**

# 1906 – No change to heavy scaled area since 2008 contract.

Ditch partially blocked.

Deer fencing installed.

**Current Hazard Index Value:** 10

**Remedial / Maintenance Works Required:**

Keep heavy scaled area (# 1906) under observation.

Clear ditch (Annual Maintenance).

| AA10 | Chainage: 1953 - 2100 | Length: 147m | Height: >40m |
|---|---|---|---|
| | Grid Ref Start: NG 90368 37079 | Finish: NG 90603 37205 | |

**Description of Slope:**

Natural rock slope set >10m back from the road.

Grass, shrub and tree covered hillside above slope.

Slope is heavily wooded.

Talus slope 10 m high 40° to 45° slope angle.

Deer fencing installed on talus slope below rock slope.

Ditch replaced by French drain.

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

**February 2008:**

# 2056 – 2137 Targeted tree removal, light scaling and heavy scaling by Skye Rope Access.

# 2218 Mature tree removed from above large boulder to prevent wind loading on roots within mass, by Skye Rope Access.

**Inspection Findings:**

# 1968 Culvert clear.

# 2014 Culvert clear.

# 2042 Culvert clear.

# 2053 Large partially undercut block on small ridge – keep under observation during annual inspections.

# 2080 Culver clear.

Ditches have been infilled and turned in to French Drains

**Current Hazard Index Value:** RHI not applicable to this slope

**Remedial / Maintenance Works Required:**

# 2053 Large partially undercut block on small ridge – keep under observation during annual inspections.

| AA11 | Chainage: 2285 - 2325 | Length: 40m | Height: 10 - 25m |
|---|---|---|---|
| | Grid Ref Start: NG 90655 37253 | Finish: NG 90689 37271 | |

**Description of Slope:**

Excavated rock slope.

Grass and shrub covered hillside with woodland above slope.

Ditch at # 2309 to 2325 (<0.5m wide x <0.5m deep).

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

Draped chain link netting. This was repaired with double twist rockfall netting in 1992. In addition an extra bottom anchor was added.

# 2298 – 2309 masonry toe buttress.

**January 2006:**

Netting between # 2285 to 2298 and # 2310 to 2323 replaced by TRAC.

Top cable installed in existing netting between #2298 to 2310 by TRAC.

**February 2008:**

# 2298 – 2309 Re-pointing of buttress masonry work, by Skye Rope Access.

**Inspection Findings:**

#2275 Boulder from upper slope perched against tree.

Note poor condition of trees on slopes above rock slopes.

Bottom cable of netting replaced during 2006 shows signs of corrosion.

**Current Hazard Index Value:** <1

**Remedial / Maintenance Works Required:**

None

| AA12 | Chainage: 2329 - 2404 | Length: 75m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 90688 37272 | Finish: NG 90739 37331 | |

**Description of Slope:**

Natural and excavated rock slope.

Grass and shrub covered hillside with woodland above slope.

Ditch: # 2329 to 2375 ditch has been infilled with a French drain.

# 2375 – 2383 (1.0 – 2.0m wide, 0.5 - 1.0m deep)

# 2383 – 2404 (<0.5m wide, <0.5m deep).

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

**January 2006:**

# 2350 Potential small plane / ravelling area scaled and vegetation removal by TRAC (Photograph 16).

# 2367 Removal of holly bush, undertaken by TRAC.

**February 2008:**

# 2350 Heavy scaling of block by Skye Rope Access.

# 2367 Holy bush re-poisoned by Skye Rope Access.

**Inspection Findings:**

# 2378 Culvert beneath waterfall clear.

# 2395 Tree (300 to 500mm girth) has died on the talus slope between the rock slope and the road.

The ditch is no longer present due to the widening of the road. Replaced with a French drain.

**Current Hazard Index Value:** 8

**Remedial / Maintenance Works Required:**

None

| AA13 | **Chainage:** 2404 - 2500 | **Length:** 96m | **Height:** 20 - 40m |
|---|---|---|---|
| | **Grid Ref** **Start:** NG 90146 37002 | | **Finish:** NG 90242 37024 |

**Description of Slope:**

Natural and excavated rock slope.

Grass and shrub covered hillside with woodland above slope.

Ditch: # 2404 – 2431 (0.5 – 1.0m wide, 0.5m deep)

# 2431 to 2458 ditch has been infilled by French drain.

# 2458 – 2500 (0.5 – 1.0m wide, 0.5m deep, with a 2.0 – 4.0m wide verge)

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**1998:**

100m$^2$ Light scaling.

30m$^3$ Heavy scaling.

# 2404-2492 3740m$^2$ Draped double twist rockfall netting. Reinforced with vertical 10mm diameter galvanised steel cables at 1m *c/c* at the nose.

# 2439 Doweling of "Nose" with stainless steel dowels (2 No).

**2002:**

Cleared and poisoned gorse bushes at top of nose.

**February 2008:**

# 2439 Vegetation removed from "Nose" and crest. 2 No. 5m long stainless steel dowels installed into block, by Skye Rope Access.

**Inspection Findings:**

# 2447 Pod of loose material approximately 5m above the road, will be controlled by the netting.

# 2491 Scar from superficial slip (January 2007) continues to re-vegetate.

**Current Hazard Index Value:** 8

**Remedial / Maintenance Works Required:**

None

| **AA14 West** | **Chainage:** 2500 - 2560 | **Length:** 60m | **Height:** 10 - 20m |
|---|---|---|---|
| | **Grid Ref** **Start:** NG 90792 37401 | | **Finish:** NG 90871 37458 |

**Description of Slope:**

Excavated rock slope.

Grass and shrub covered hillside with woodland above slope.

No / limited ditch.

**Failure Characteristics:**

General ravelling.

Potential plane and wedge failures.

**Existing Remedial Works:**

**1992:**

# 2514 – 2562 Area scaled and re-netted with localised draped chain link netting.

# 2550 - 2556 Masonry toe buttress.

**2002:**

50m$^2$ Light Scaling (particularly # 2552 and 2543).

# 2526 2 No Dowels installed.

# 2500 - 2515 and # 2515 – 2562 300m$^2$ Draped double twist rockfall netting.

# 2539 – 2549 Anchored concrete buttress 4m high at base.

**February 2008:**

# 2559 Missing Shackle replaced, by Coffey.

**Inspection Findings:**

# 2515 Undercut blocks on slope, no significant change. Keep under observation.

# 2539 - 2549 Material above toe buttress - # 2543 rock fall (<0.125m$^3$) material lying on top of buttress.

# 2550 - 2556 Masonry toe buttress has a minor amount of vegetation growth from between the mortar joints.

**Current Hazard Index Value:** 8

**Remedial / Maintenance Works Required:**

# 2543 rock fall (<0.125m$^3$) material lying on top of buttress. Keep under particular observation.

| AA14 East | Chainage: 2560 - 2585 | Length: 25m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 90792 37401 | Finish: NG 90871 37458 | |

**Description of Slope:**

Natural rock slope.

Grass and shrub covered hillside with woodland above slope.

A talus slope (35 +/- 5 ) runs down from the toe of the slope to the ditch at the edge of the road.

Ditch (0.5m wide x 0.5m deep).

**Failure Characteristics:**

General ravelling.

Potential plane and wedge failures.

**Existing Remedial Works:**

**2002:**

75m$^3$ Heavy scaling / controlled removal.

# 2555 – 2562 200m$^2$ Draped double twist rockfall netting.

# 2560 – 2585 Rockfall catch fence.

**Inspection Findings:**

Tree has fallen from above crest of slope and is leaning against the rock slope next to the waterfall.

# 2578 Culvert clear.

**Current Hazard Index Value:** 8

**Remedial / Maintenance Works Required:**

Trees on upper slope between slopes AA11 and AA22 are becoming a significant hazard. Plans need to be developed for managing / removing them.

| AA15 | Chainage: 2592 - 2760 | Length: 168m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 90792 37401 | Finish: NG 90871 37458 | |

**Description of Slope:**

Natural and excavated rock slope.

Grass and shrub covered hillside with woodland above slope.

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**1998:**

500m$^2$ Light scaling.

50m$^3$ Heavy scaling.

# 2597-2707 6,050m$^2$ Draped double twist rockfall netting. Reinforced with vertical 10mm diameter galvanised steel cables at 1m c/c at the nose.

**2006:**

Tree perched above the crest of the slope removed by Skye Rope Access Ltd. Root ball left in place and secured to tree stumps.

**February 2008:**

Tree root ball removed from above crest line, by Skye Rope Access.

**Inspection Findings:**

#2605 0.25m$^3$ of debris in ditch / contained behind the netting – source 3m up from toe.

# 2605 Scaled area, could undermine other blocks – keep under observation.

# 2619 Area of ravelling and blocks just below crest – keep under observation.

# 2640 Buttress of rock approximately 15m above the road on the rock slope, no current rockfall activity – keep under observation.

# 2679 Culvert clear.

Ditch has been partially replaced by road widening, this has resulted in a reduction of the rock trap.

**Current Hazard Index Value:** 9

**Remedial / Maintenance Works Required:**

Trees on upper slope between slopes AA11 and AA22 are becoming a significant hazard. Plans need to be developed for managing / removing them.

| AA16 | Chainage: 2770 - 2838 | Length: 68m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 91001 37563 | Finish: NG 91065 37609 | |

**Description of Slope:**

Natural and excavated slope, probably a section of relict-sea cliff with a cave.

Grass and shrub covered hillside with woodland above slope.

Ditch: # 2770 – 2782 (2.0m wide, 0.5m deep)

# 2782 – 2875 no ditch

# 2875 – 2838 (1.0m wide, 0.5m deep)

**Failure Characteristics:**

General ravelling.

Potential plane and wedge failures.

**Existing Remedial Works:**

**February 2008:**

# 2800 – 2820 Vegetation removed from face and directly above crest of slope and light scaled with targeted heavy scale. Rope access inspection undertaken by Coffey. Drill steel stuck in face while attempting to drill dowel, steel left in face. Skye Rope Access.

**October 2008:**

# 2792 – 2814 Slope reprofiled to remove large mass., by RJ McLeod.

# 2790 – 2818 Slope netted, by Geo-Rope Ltd.

# 2800 6 No. rock bolts and 6 No. rock dowels installed by Geo-Rope Ltd.

# 2804 – 2811 Large wedge failure bolted and sprayed with shotcrete, and drainage holes installed, by Geo-Rope Ltd.

**Inspection Findings:**

Ditch clear.

Bottom cable of netting replaced since Annual Inspection 2009.

**Current Hazard Index Value:** 9

**Remedial / Maintenance Works Required:**

None

| AA17 | Chainage: 2838 - 2908 | Length: 70m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 91066 37609 | Finish: NG 91118 37637 | |

**Description of Slope:**

Excavated rock slope.

Ditch (0.5 – 1.0m wide x 0.5m deep).

Grass and shrub covered hillside with mixed woodland above slope.

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**September 1990:**

Reprofiling removed 1000t of rock.

Fixed double twist rockfall netting with tensioned cables and erosion protection at crest.

91 No. reinforcing elements (comprising 4m & 6m stainless steel bolts tensioned to 100kN, 6m corrosion protected anchors tensioned to 200kN and un-tensioned dowels).

Drain holes

The newly reprofiled slope was reported as being unstable. No additional explanation, has been reviewed by EDGE.

Drainage installed above the slope.

**2002:**

10m$^2$ Light Scaling at # 2860, under existing netting – keep under observation.

450m$^2$ Draped double twist rockfall netting over the previous netting (#2845-2865).

**February 2008:**

# 2897 Lift off tests performed on the 4 anchors present on the slope, by Skye Rope Access.

**Inspection Findings:**

No significant change.

# 2860 Column of fractured rock under existing netting by "Hughie MacKenzy" graffiti, no significant change - keep under observation.

**Current Hazard Index Value:** 13

**Remedial / Maintenance Works Required:**

# 2860 Column of fractured rock, keep under observation during periodic and annual inspections.

| AA18 | Chainage: 2908 - 2978 | Length: 70m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 91119 37635 | Finish: NG 91186 37657 | |

**Description of Slope:**

Excavated rock slope.

Ditch 0.5 – 1.0m wide x 0.5m deep.

Grass and shrub covered hillside with mixed woodland above slope.

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**1990:**

Slope treated with rock bolts.

**1991/92:**

Some areas were scaled and re-netted, with a bottom anchor cable.

**1994:**

Clearance of debris from behind netting.

Draped chain link and some double twist rockfall netting.

Drainage installed above the slope.

**1998:**

Replaced chain link net with 600m$^2$ double twist rockfall netting (# 2908-2919, 2949-2953).

Reinforced netting with 10mm diameter vertical cables (# 2912-2930, 2942-2949, 2960-2965).

Reinforced bottom netting with 10mm diameter horizontal cables (# 2908-2972).

Improved and strengthened top anchorage system (new stainless steel dowels added).

**February 2008:**

# 2927 Installation of 1 No. 3m long, 3 No. 4m long and 3 No. 5m long stainless steel dowels, by Skye Rope Access. Rope access inspection undertaken by Coffey.

# 2950 Missing shackle replaced, by Skye Rope Access.

**Inspection Findings:**

# 2911 Hole between sections of netting from the toe to 2m up. Not significant, old netting underneath and low down on face.

# 2916 Culvert clear.

# 2927 Recently installed dowels require packing washers, ends of bar cutting down and nuts tightening.

# 2935 Unstable blocks at crest, will be controlled by the netting.

# 2949 Gully catch fence (incorporated part of netting system) has caught a boulder (Appendix B - photograph 21)

# 2950 Small nose of rock has dilated along several joints 5m above road level – Keep under observation.

# 2955 Blocks failed from approx. 8m height. No fresh falls - Keep area under observation.

**Current Hazard Index Value:** 11

**Remedial / Maintenance Works Required:**

Clear out ditch (Annual Maintenance).

| AA19 | Chainage: 2990 - 3052 | Length: 62m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 91201 37664 | Finish: NG 91244 37686 | |

**Description of Slope:**

Excavated rock slope (# 2990 to 3035).

Gabion wall retaining feature and rock trap (# 3035 to 3052).

Grass and shrub covered hillside with mixed woodland above slope.

Ditch (0.5m wide x 0.5m deep) at the toe the slope.

**Failure Characteristics:**

General ravelling.

Potential wedge failures.

**Existing Remedial Works:**

**Pre 1972:**

# 3035 – 3052 3 tier high stepped gabion wall

**Pre 1995:**

# 3000 – 3027 Slope netted

**1992 to 1993:**

Draped double twist rockfall netting replacing previous Chain link (still present).

Some areas of chain link only.

**2002:**

Replaced 25m length of the netting bottom cable with 16mm diameter galvanised steel cable.

**February 2008:**

# 3032 Nose of material heavy scaled, tree on the face removed and 1 No. 3m long and 2 No. 4m long stainless steel dowels installed, by Skye Rope Access.

# 3052 Corner of gabion basket wall repaired, by Skye Rope Access

**October 2008**

Culvert reinstated and road edge markers installed, by RJ McLeod.

**Inspection Findings:**

# 2980 (boundary between AA18 and AA19) Culvert reinstated during recent contract.

# 2998 Overhanging block (<0.25m$^3$) 2m above road level. Side releases have begun to dilate, likely to be contained by the ditch.

# 3017 Column beginning to dilate 1m above road level – keep under observation.

# 3032 Minor ravelling around the dowels installed in 2008.

**Current Hazard Index Value:** <1

**Remedial / Maintenance Works Required:**

# 2980 (boundary between AA18 and AA19) keep erosion of stream bank under observation during annual inspections.

| AA20 | Chainage: 3072 - 3132 | Length: 60m | Height: 5 - 10m |
|---|---|---|---|
| | Grid Ref Start: NG 91270 37696 | Finish: NG 91322 37729 | |

**Description of Slope:**

Excavated rock slope on north east side of major gully.

"I" beam wall in front of gully acting as a deflection barrier and extending east in front of slope as a retaining wall.

The rock slope is vegetated with trees at the crest.

Grass, shrub and mixed tree covered hillside above slope.

Verge (<0.5m wide) at the toe of the slope (# 3104 no verge). No ditch.

**Failure Characteristics:**

General ravelling.

Potential wedge and toppling failures.

**Existing Remedial Works:**

**Pre 1972:**

# 3072 to 3104 "I" Beam and segmental Concrete retaining wall.

# 3095 Small concrete buttress / block above "I" beam wall supporting rock slope above.

# 3103 Very wide joint infilled with cement mortar.

**September 2001:**

Concrete toe buttress secured with Ischebeck 40/16 anchorages; wire rope slings; and erosion protection installed September 2001. To secure blocks on northeast flank of gully at # 3072.

**April 2002:**

# 3123 10m$^2$ Light scaling.
4.5m$^3$ Heavy scaling / controlled removal (# 3094, 3097, 3115, 3129).

Doweling (2 No. at # 3131, 2 No. at # 3129).

**October 2008**

2 No. damaged concrete panels in "I" beam wall replaced with "I" beams. 4$^{th}$ "I" beam from the west end has had a metal flange installed to retain concrete panels, by RJ McLeod.

**Inspection Findings:**

Top tell tale: hor = -7.0mm, vert = -2.0mm (Appendix B). Ongoing movement of end "I" beam.

Trees immediately above "I" beam wall have been cut down.

# 3079 Culvert clear.

# 3130 Culvert partially blocked by material behind wall next to avalanche shelter.

**Current Hazard Index Value:** 5

**Remedial / Maintenance Works Required:**

The "I" beams require maintenance to treat existing corrosion and to protect the steel work from further corrosion (Annual Maintenance) **Outstanding**.
Clear culverts (Annual Maintenance).
The above measurements do not enable monitoring of the wall in the plane perpendicular to the wall. Hence, a monitoring / recording system should be put in place which can be used to monitor such movements.
In conjunction with a monitoring / recording system the wall should be re-laser surveyed immediately prior to the 2012 inspection (5 year review).

| AA21 | Chainage: 3196 - 3304 | Length: 108m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 91340 37746 | Finish: NG 91427 37820 | |

**Description of Slope:**

Excavated rock slope.

Grass and shrub covered hillside with mixed woodland above slope.

Verge (<0.5m wide) at the toe the slope. No ditch.

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**1998:**

New bottom cable and additional bottom anchors installed.

# 3272-3277 Masonry toe buttress.

Draped chain link netting (poor condition). Patched with double twist rockfall netting.

**2001:**

# 3260 Bottom cable anchor eye and shackle replaced.

**2002:**

116m$^3$ Heavy scaling / controlled removal (# 3206, 3209, 3216, 3217, 3219, 3220, 3222, 3229, 3239, 3244, 3258, 3261, 3268, 3274, 3281).

2700m$^2$ Cable reinforced double twist rockfall netting over previous netting.

Doweling (4 No. at # 3198, 2 No. at # 3202, 3 No. at # 3206, 3 No. at # 3217, 2 No. at # 3218, 12 No. at # 3229, 3 No. at # 3244, 1 No. at # 3249, 4 No. at # 3261, 9 No. at # 3268, 5 No. at # 3274).

**2004:**

# 3206 and 3217 – shackle and eye threads smeared with epoxy resin by EDGE, to deter theft.

# 3248 Shackle replaced and threads smeared with epoxy resin by EDGE.

**2005:**

# 3269 Eye replaced with spare eye from slope AA19.

**2006:**

# 3233 and 3269 shackles replaced and threads smeared with epoxy resin by EDGE.

# 3232 Hole in netting by dowel – repaired by TRAC January 2006.

**February 2008:**

# 3272 – 3277 Vegetation removed from buttress and poisoned, by Skye Rope Access.

Continued...

**AA21** (Continued...)

**Inspection Findings:**

# 3199 Culvert clear

# 3216 6m high column of material – no change since last year– keep under observation for deterioration.

#3220 Block (400 X 150 X 300mm) 6 to 7m up on slope. Would be contained by rockfall netting.

#3230 Block at toe of netting 700 X 300 X 300mm). From area to left of dowels. Hole in single twist netting in front of a scar on the rock face.

# 3271 Deterioration of block next to buttress due to growth of small tree.

# 3272-3277 Masonry toe buttress in satisfactory condition, plants are still growing on the buttress.

# 3270 Column of material. Keep under observation.

# 3276 Block from superficials on top of buttress.

# 3282 Block (300 X 300 X 150mm) 3m up on slope likely to fail but will be retained by the verge / ditch / netting.

**Current Hazard Index Value:** 8

**Remedial / Maintenance Works Required:**

# 3271 Remove block during next contract.

| AA22a | Chainage: 3294 - 3346 | Length: 52m | Height: >40m |
|---|---|---|---|
| | Grid Ref Start: NG 91427 37820 | Finish: NG 91461 37863 | |

**Description of Slope:**

Excavated rock slope.

Grass and shrub covered hillside with mixed woodland above slope.

Verge at the toe of the slope: # 3294 – 3312 (1.0 – 2.0m wide)
# 3312 – 3338 (2.0 – 4.0m wide)

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**1998:**

500m$^2$ Light scaling.

50m$^3$ Heavy scaling.

150m$^3$ Controlled removal (# 3316, 3338).

2860m$^2$ Draped Double twist rockfall netting (# 3304-3346), reinforced with 10mm diameter vertical cables (# 3315-3346).

**January 2006:**

# 3294 Tree trunk and root ball removed from crest netting cable by TRAC.

#3296 Block heavy scaled by TRAC.

**Inspection Findings:**

# 3298 Minor ravelling from waterfall, material present at the toe.

# 3303 Culvert clear

# 3338 Observe area 20m above the road on the rock slope for deterioration. No significant change since previous annual inspection.

**Current Hazard Index Value:** 11

**Remedial / Maintenance Works Required:**

None.

| AA22b | Chainage: 3346 - 3550 | Length: 204m | Height: 20 - 40m |
|---|---|---|---|
| | Grid Ref Start: NG 91461 37863 | Finish: NG 91551 37982 | |

**Description of Slope:**

Excavated rock slope.

Grass and shrub covered hillside with mixed woodland above slope.

Verge (0.5m to 4m wide) at the toe of the slope with a double height "Armco" safety barrier for some of the slope length.

**Failure Characteristics:**

General ravelling.

Potential plane, wedge and toppling failures.

**Existing Remedial Works:**

**1995:**

Area was scaled and re-netted with Draped Double twist rockfall netting (with poor top anchorage system).

# 3445 – 3450 Masonry toe buttress.

Double height "Armco" safety barrier along base of highest section of slope (up to # 3437).

**1998:**

Reinforced existing netting with vertical cables (# 3346-3355, 3368-3373, 3379-3383, 3388-3401, 3405-3418).

Reinforced existing netting with horizontal cables (# 3346-3373, 3378-3418).

Improved and strengthened top anchorage system (new stainless steel anchorage dowels).

# 3456 Shackle removed to render netting more flexible.

**2004:**

Eastern end of slope reprofiled to improve visibility.

**2005:**

Further reprofiling of eastern end of slope.

**February 2008:**

# 3445 – 3450 Vegetation removed from buttress and poisoned, by Skye Rope Access.

# 3480 – 3495 Superficial material above the slope reprofiled and face light scaled, by Skye Rope Access.

**June 2010:**

# 3376 Source of rockfall in February & April 2010, approx 6m up, heavy scaled by CAN.

# 3390 Nose of material approx 4m below crest, removed by CAN.

Continued...

**AA22b** (Continued...)

**Inspection Findings:**

# 3352 to 3356 Area on face undercut rock 25m up. Material is likely to fail at this location, but should be controlled by the reinforced rockfall netting. Keep under observation.

# 3362 Block (2m high x 1.5m wide x 1m deep) approx 1.5m up, will continue to break up and fail with time. The debris should be contained and controlled by the rockfall netting. No signs of further deterioration.

# 3372 Deterioration of nose of material approx. 10m up. Failures may occur at this location, but should be controlled by the reinforced rockfall netting. Keep under observation.

# 3382 Failure scar from 20t rockfall in December 2001. More material is likely to fail at this location, but should be controlled by the reinforced rockfall netting. Keep under observation.

# 3383 Deterioration of nose of material approx 8m up. Nose is undermined.

# 3438 Culvert clear.

# 3445 – 3450 Small rocks behind netting, not significant.

# 3477 Small block removed during inspection.

# 3480 New / reinstated culvert – clear.

**Current Hazard Index Value:** 11

**Remedial / Maintenance Works Required:**

# 3356, 3372 and 3382 – Potential failures keep under particular observation during periodic inspections.

#3372 & 3382 – Noses should be heavy scaled / removed during the next remedial work contract.

| AA23N | Chainage: 3553 - 3607 | Length: 54m | Height: 2 - 5m |
|---|---|---|---|
| | Grid Ref Start: NG 91551 37982 | Finish: NG 91577 38011 | |

**Description of Slope:**

Excavated rock slope forming Northbound side of a "box cutting".

Grass and shrub covered hillside above slope.

Verge (2m wide).

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

**1995:**

Verge built up and ditch deepened.

**February 2008:**

# 3579 Blast damaged area heavy scaled by Skye Rope Access.

**October 2008:**

#3565 – 3585 Slope reprofiled and dense gorse removed by RJ McLeod and Geo-Rope.

**July 2009:**

# 3570 – 3580 Slope scaled by CAN.

**Inspection Findings:**

Ditch has been partially infilled during previous reprofiling and is no longer acting as an effective rock trap.

**Current Hazard Index Value:** 1

**Remedial / Maintenance Works Required:**

Clear out and reform ditch (Annual Maintenance).

| AA23S | Chainage: 3541 - 3624 | Length: 83m | Height: 5 - 10m |
|---|---|---|---|
| | Grid Ref Start: NG 91551 37982 | Finish: NG 91577 38011 | |

**Description of Slope:**

Excavated rock slope forming Southbound side of a "box cutting".

Grass and shrub covered hillside above slope.

Verge (2m wide) that includes a ditch (0.5m to 1m wide x 0.5m deep).

# 3541 – 3580 French drain at toe of slope.

**Failure Characteristics:**

General ravelling.

**Existing Remedial Works:**

**1995:**

Verge built up and ditch deepened.

**February 2008:**

# 3608 Blast dilated mass removed by heavy scaling by Skye Rope Access.

**October 2008**

Slope has been partially reprofiled and the dense gorse removed by RJ McLeod and Geo-Rope.

**July 2009:**

# 3585 Potential wedge failure and surrounding area scaled by CAN.

**Inspection Findings:**

# 3569 Block 3m above road level. Discontinuity (joint) not through going at present.

**Current Hazard Index Value:** 4

**Remedial / Maintenance Works Required:**

None

| AA24 | Chainage: 3640 -3723 | Length: 83m | Height: 10 - 20m |
|---|---|---|---|
| | Grid Ref Start: NG 91632 38067 | Finish: NG 91735 38104 | |

**Description of Slope:**

Excavated rock slope.

Grass and shrub covered hillside above slope.

Ditch at toe of some of the slope (0.5 - 1.0mwide x 0.5m deep).

**Failure Characteristics:**

General ravelling.

Potential plane and wedge failures.

**Existing Remedial Works:**

**2002:**

65m$^3$ Heavy scaling / controlled removal (# 3650, 3653, 3657, 3675).

150m$^2$ Draped double twist rockfall netting (# 3640-3646).

Repair of existing netting damaged during heavy scaling / controlled removal.

Dowelling (1 No. at # 3650, 1 No. at # 3653, 3 No. at # 3655, 1 No. at # 3657, 2 No. at # 3669, 2 No. at # 3671, 2 No. at # 3673).

Draped double twist rockfall netting, not full coverage.

**June 2010:**

# 3672 – 3679 Damaged netting replaced, new termination anchorage installed and intermediate anchorage at # 3672 replaced.

**Inspection Findings:**

# 3662 Wedge approx 2m below crest should be contained by netting.

# 3672 Small rockfall (<0.25m3). Scar is 4m above road level behind netting, debris contained at the toe. Dilated blocks immediately next to the scar, likely to be contained by the netting. Small sapling growing out from between the blocks.

**Current Hazard Index Value:** 4

**Remedial / Maintenance Works Required:**

Rope access inspection by Coffey of rockfall at # 3672 during next phase of remedial works.

| **Frenchman's Burn (Allt an Fhrangaich)** | **Chainage:** 2200 |
|---|---|
| | **Grid Ref:** NG 90609 37219 |

**Description:**

Large deeply incised gully with a stream.

The stream flows in most weather conditions and flows in spate during / following heavy rainfall / snowmelt.

The stream carries significant quantities of rock debris during spate events.

**Existing Remedial Works:**

**1999:**

2 No stilling basins located just upstream from culvert under road and railway.

**2002:**

Removal of 2 No. tree trunk dams.

**October 2008:**

Repair to gabion wall of lower stilling basin. Raising and installation of new wing walls. Reprofiling of east bank of gully above upper stilling basin.

**Inspection Findings:**

The lower and upper stilling basins have a quantity of debris accumulation within them (Appendix B).

Further minor erosion has occurred on the South west gully wall above upper and lower stilling basins since previous Annual Inspection.

There has been a significant number of large rock falls (totalling approximately 100m$^3$) into the gully bed approximately 200m upstream of the stilling basins. The area of the rock falls is likely to suffer ongoing rock falls, particularly during / post adverse weather.

Deer gates and fencing installed around the lower stilling basin.

**Remedial / Maintenance Works Required:**

Remove half the stone from the two central baskets – if flow becomes obstructed.

The debris source is likely to lead to a larger than "normal" scale debris flow during / post adverse weather. Hence, it is vital that the stilling basins are kept clear of debris accumulations. Further means of increasing their capacity or retention capacity may be required in future.

The debris in the culvert requires removal (Annual Maintenance).

| **Stream Gully Between Slope AA19 and AA20** | **Chainage:** 3072 |
|---|---|
| | **Grid Ref:** NG 91270 37696 |

**Description:**

Large deeply incised gully with a small stream.

The stream flows in wet weather conditions and flows in spate during / following heavy rainfall / snowmelt.

The stream carries significant quantities of rock debris during spate events.

**Existing Remedial Works:**

# 3072 to 3104 "I" Beam and segmental Concrete retaining wall at base of gully installed pre-1972.

In November 1994 a significant rockfall damaged the retaining wall.

**September 2001:**

Beam installed approximately 40m above road level following landslide with blockfall in October 2000. Coir matting and rockfall netting installed in gully as erosion protection measures.

**Inspection Findings:**

The concrete beam and associated works show no observable signs of deterioration.

Vegetation is well established on the coir mat. Erosion of the gully wall (observed in 2005) has increased, now occurring up and down stream of the erosion protection measures and immediately below them. If allowed to continue will eventually undermine the concrete beam and associated works.

**Remedial / Maintenance Works Required:**

Monitor and observe eroded area within the gully during monthly inspections until next remedial works contract when measures can be taken to reduce / stop further erosion of the gully wall.

| **Debris Flow within gully between Slope AA5 and AA6** | **Chainage:** 1330 - 1350 |
|---|---|
| | **Grid Ref:** NG 89956 36756 – NG 89903 36816 |

**Description:**

The debris flow occurred in October 2001

The debris flow has eroded the superficial deposits down to rock head.

The debris flow occurred within an infilled gully.

**Existing Remedial Works:**

**October 2001:**

Interceptor drain to collect water from behind the crest of the soil slope and redirect to discharge on the exposed rock at the toe of the slope.

Erosion protection on the upper scar of the debris flow.

Deflection wall comprising concrete traffic protection blocks installed on the verge to act as a rock / debris trap.

**February 2008:**

# 1330 – 1350 Leaking interceptor pipe repaired and new sections installed. Large snapped branch in drainage ditch removed and large mature fallen tree stabilised, by Skye Rope Access.
# 1350 Breeze block tank re-pointed, by Skye Rope Access.

**Inspection Findings:**

The drainage works appear to be working satisfactorily. The catch pit is partially filled (material cleaned out within catch pit to contain material again) and requires further cleaning out.

The coir mat forming part of the erosion protection is continuing to vegetate (Appendix B).

No significant erosion below discharge point of pipe. Minor erosion of gully wall on the west side at road level.

Still some flow of water from superficials in the ditch on the south side of the gully.

Large tree that had fallen in to crest drainage ditch has been cleared from the ditch, but still remains on the slope.

Branch from tree opposite fallen tree on crest of slope has been cut up and stacked above the drainage ditch.

The pipe is leaking at the 1st elbow joint down from the catch pit (Appendix B).

A galvanised eye from the 1st collar below the above elbow joint is missing. The anchorage wire was not connected to the pipe or collar. The wire has been looped around the collar during the inspection until the eye can be replaced (Appendix B).

**Remedial / Maintenance Works Required:**

The leaking elbow joint requires repairing and the missing eye replacing with the anchorage re-attaching during the next phase of remedial works.

The area around the crest of the debris flow scar requires planting with appropriate trees –outstanding from 2003 inspection.

Top drainage catch pit / debris trap requires clearing (**Annual Maintenance**).

| **Natural slope between AA18 and AA19** | **Chainage:** 2980 - 2990 |
|---|---|
| | **Grid Ref:** NG 91183 37657 – NG 91201 37664 |

**Description:**

The rockfall occurred in May 2007.

The rockfall originated from a natural crag 100m above road level.

**Existing Remedial Works:**

**February 2008:**

Location of failure had vegetation and tree removal. Failure scar and surrounding area was heavy scaled. 1 No. 4m dowel installed. Attempt to remove tree trunk unsuccessful, strapped to face until future remedial works for removal, by Skye Rope Access.

**Inspection Findings:**

No significant change since February 2008 remedial works.

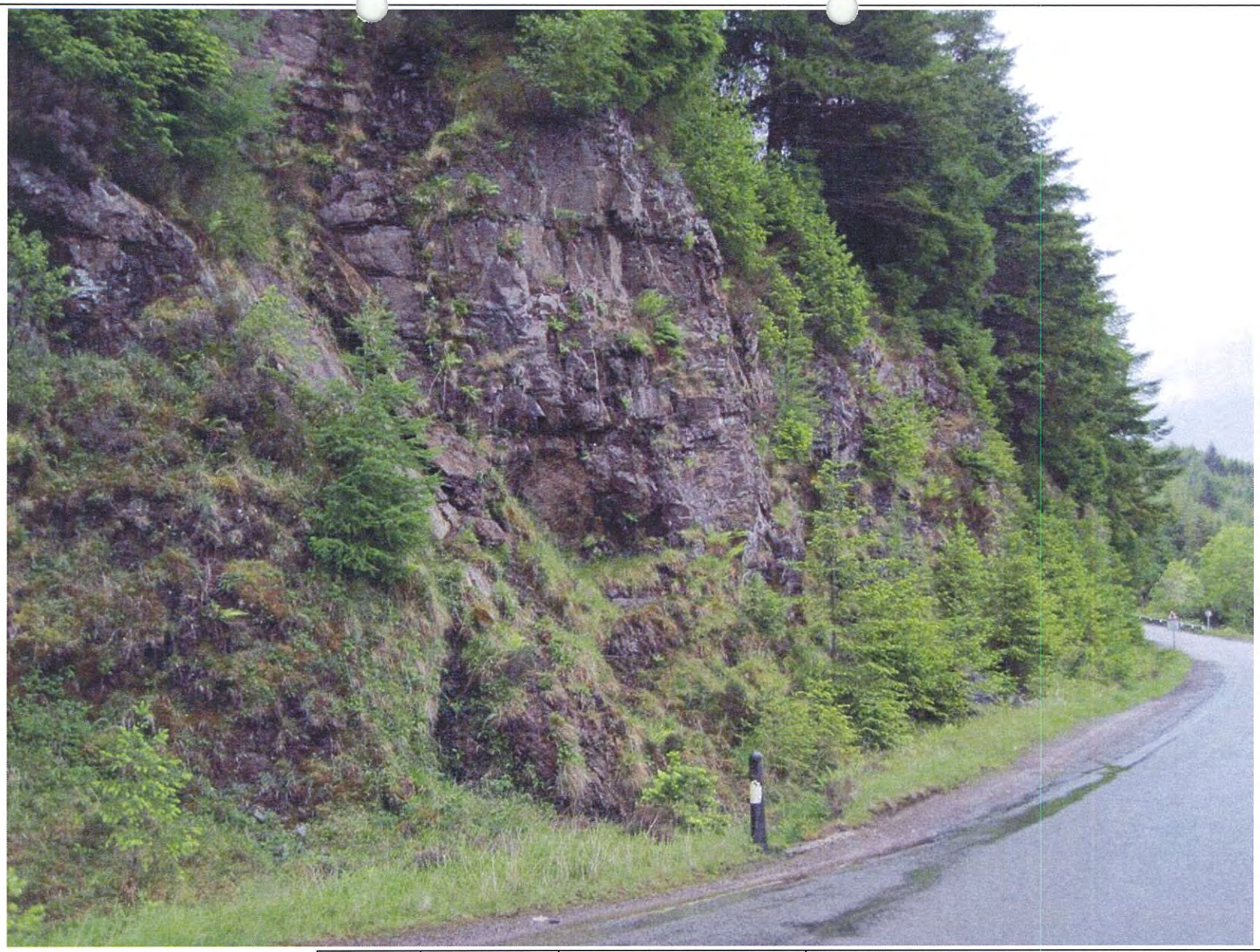
**Remedial / Maintenance Works Required:**

Keep area under observation for signs of deterioration and fresh rockfall.

Remove strapped trunk and cut root ball flush with rock face during next remedial works contract (Phase VI).

# Appendix B

**Annual Rock Slope Inspection Photographs June 2009**



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|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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| | |
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA1 |
| project no: 454.1 | figure no: FIGURE 1 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA2 |
| original size | A4 | | project no: **454.1** | figure no: **FIGURE 2** |


| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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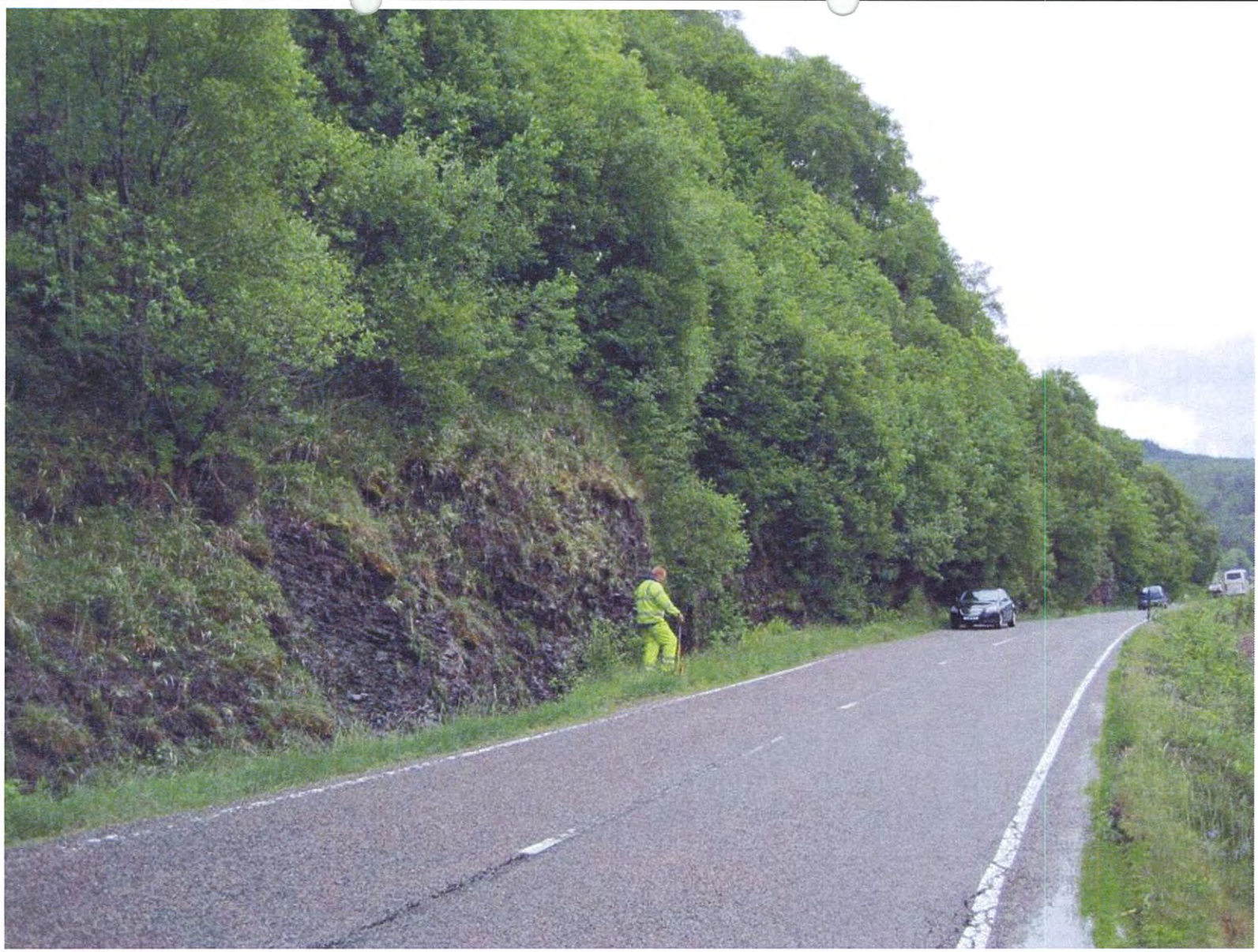
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA3 |
| project no: 454.1 | figure no: FIGURE 3 |



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|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA4 |
| original size | A4 | | project no: **454.1** | figure no: **FIGURE 4** |

| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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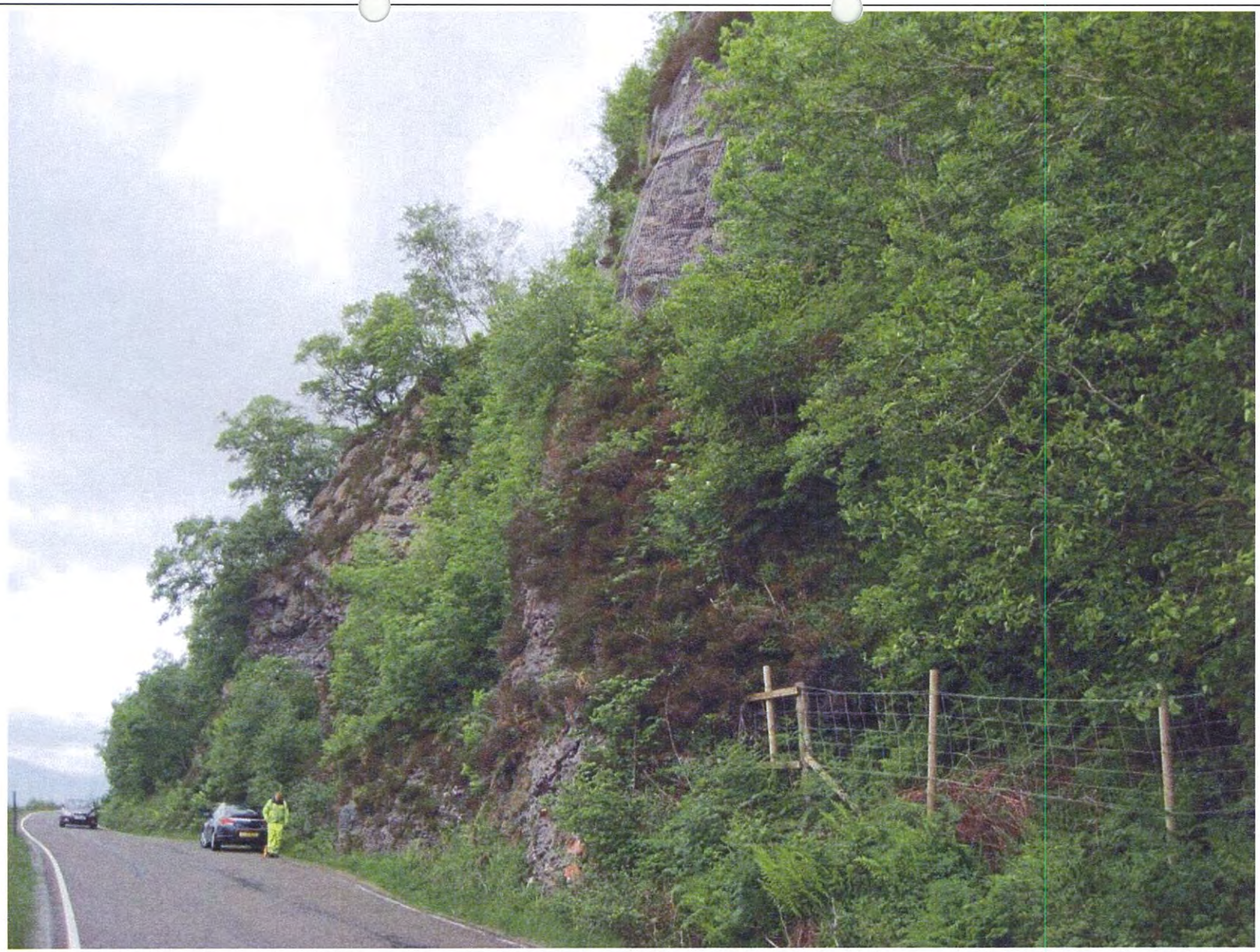
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA5 |
| project no: 454.1 | figure no: FIGURE 5 |



| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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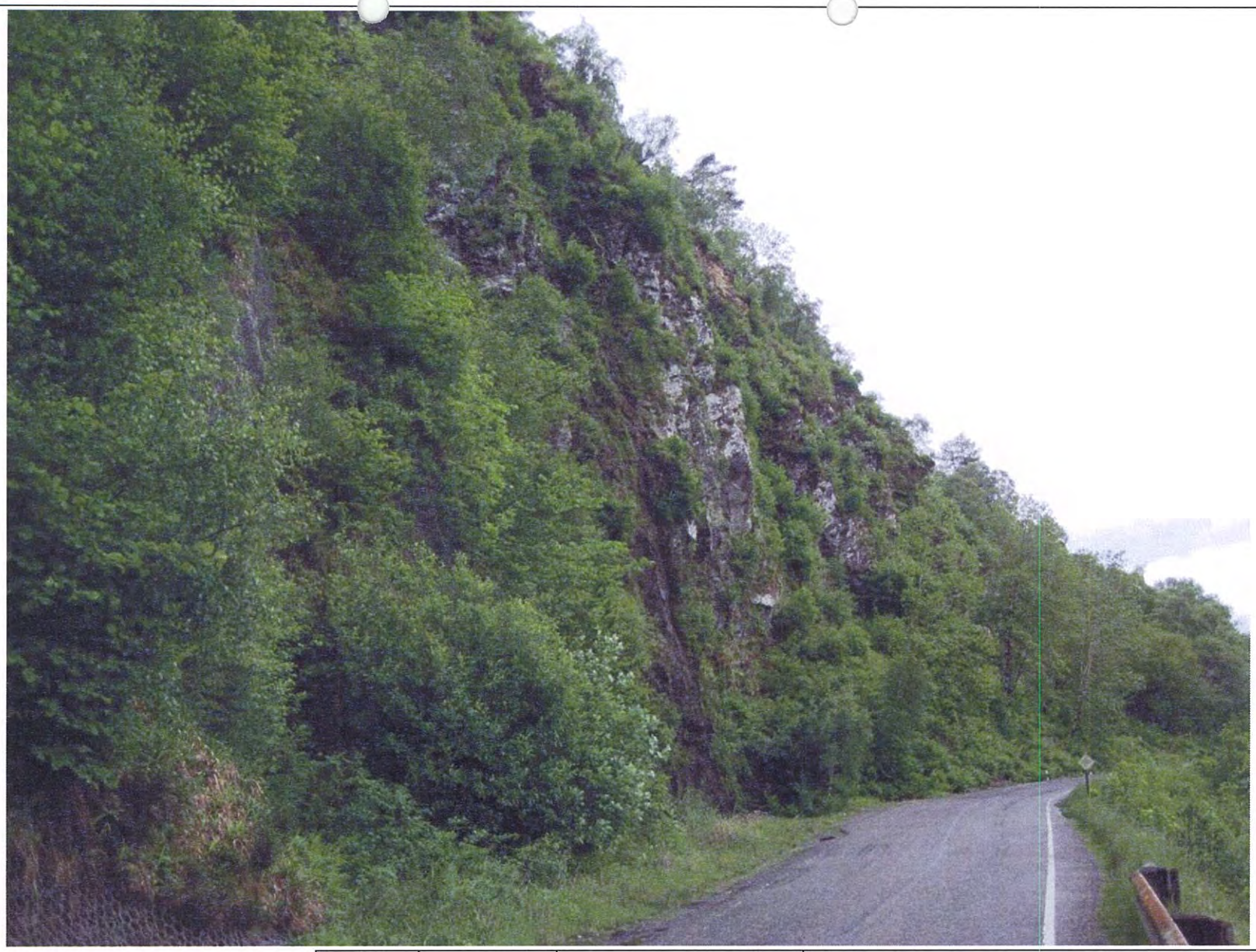
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA6 |
| project no: 454.1 | figure no: FIGURE 6 |



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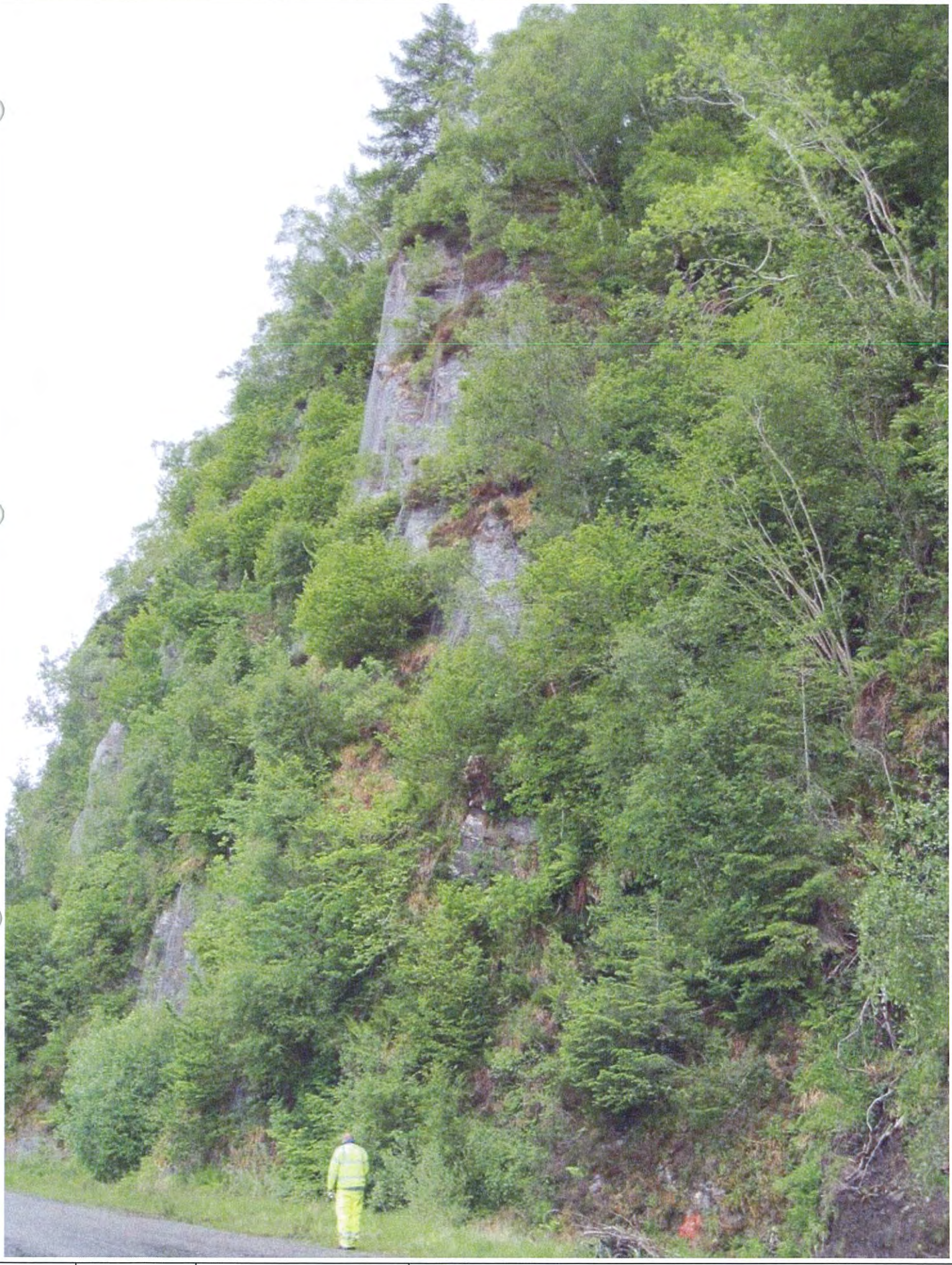
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA7 |
| original size | A4 | | project no: **454.1** | figure no: **FIGURE 7** |



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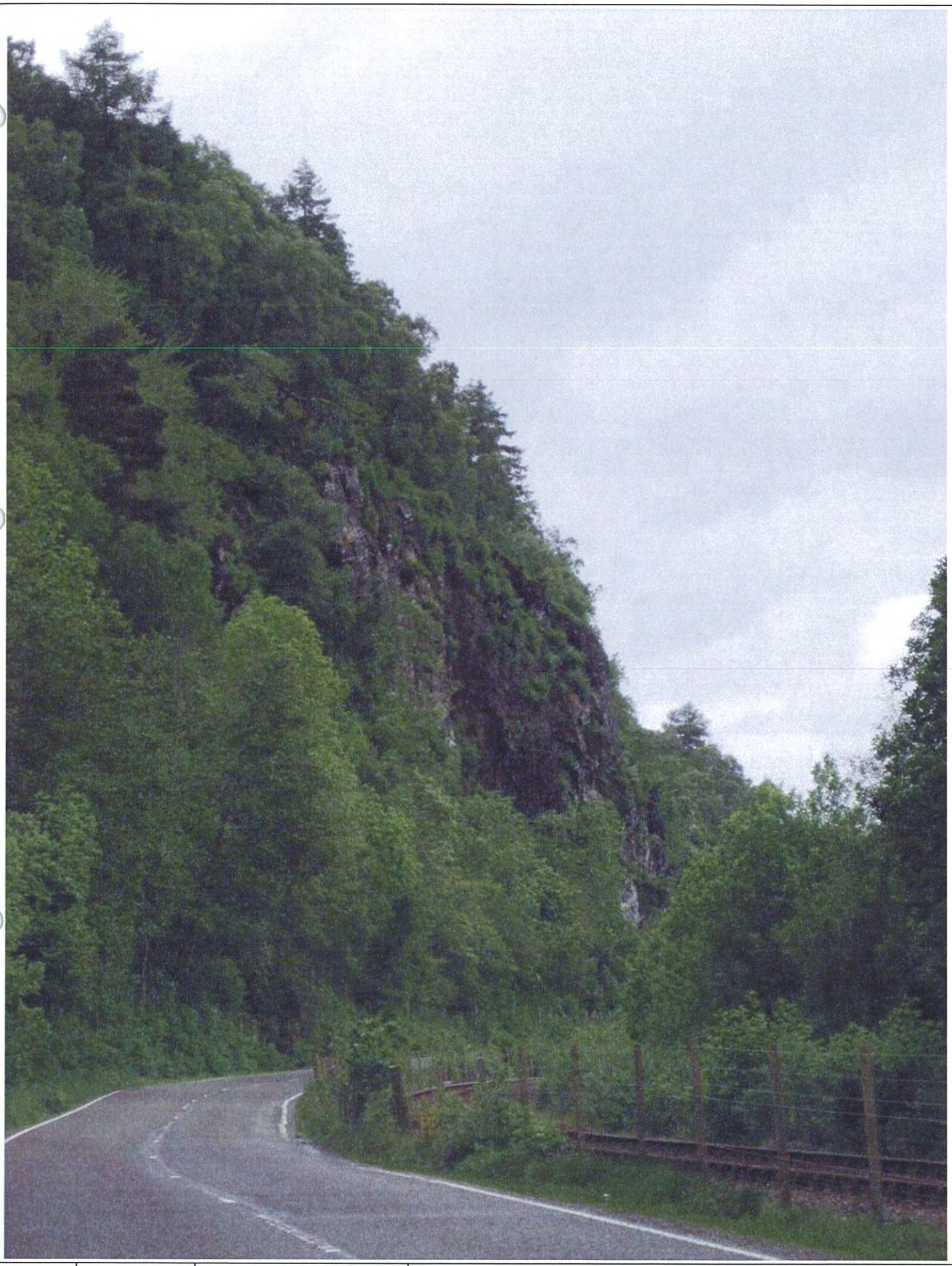
| drawn | RMD | coffey geotechnics<br>SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA8 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 8 |

454.1-100521-P1.1-Annual10



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| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA9 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 9 |

| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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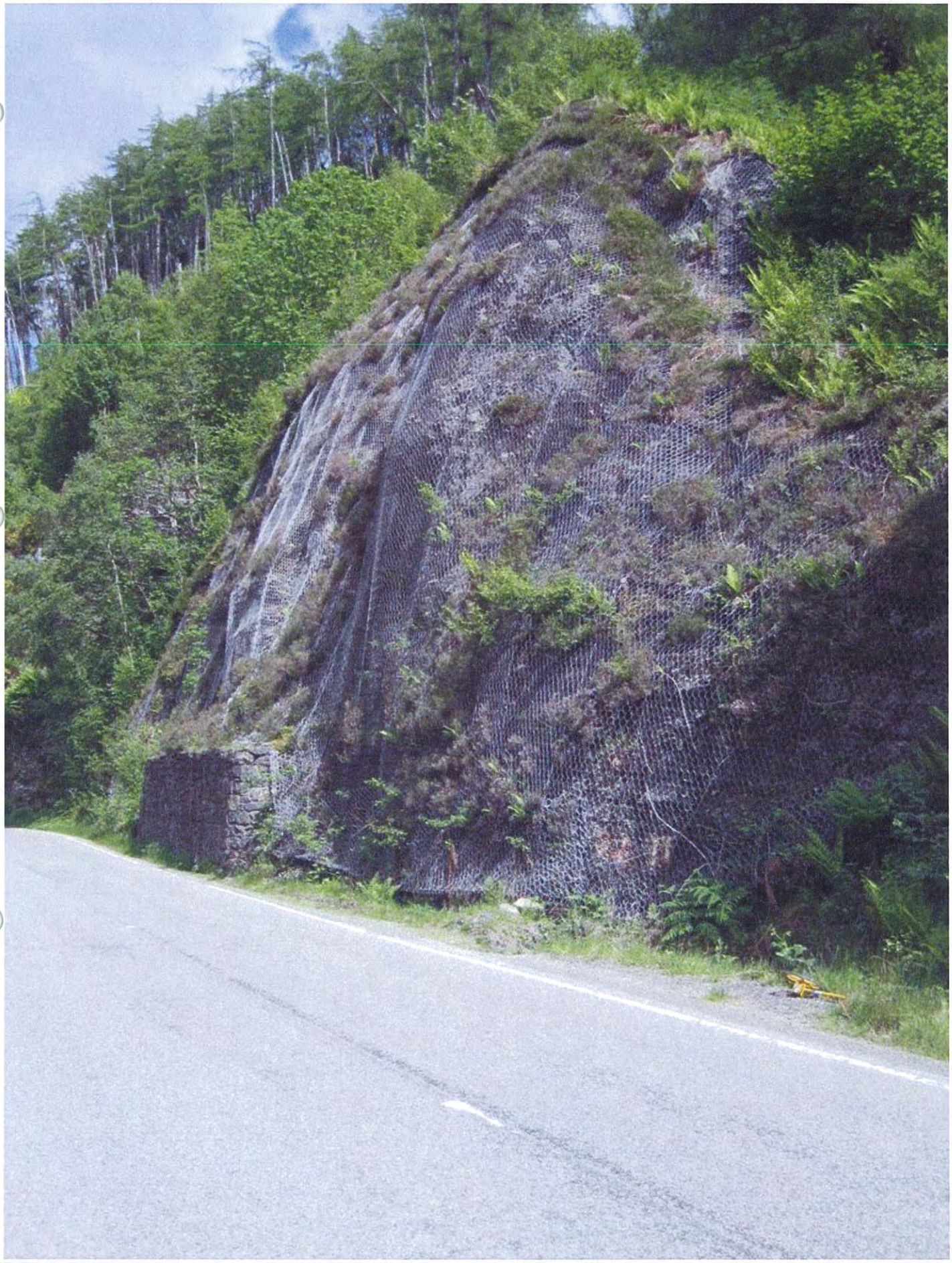
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA10 |
| project no: 454.1 | figure no: FIGURE 10 |



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|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA11 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 11 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 08/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA12 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 12 |

454.1-100521-P1.1-Annual1

| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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SPECIALISTS MANAGING THE EARTH

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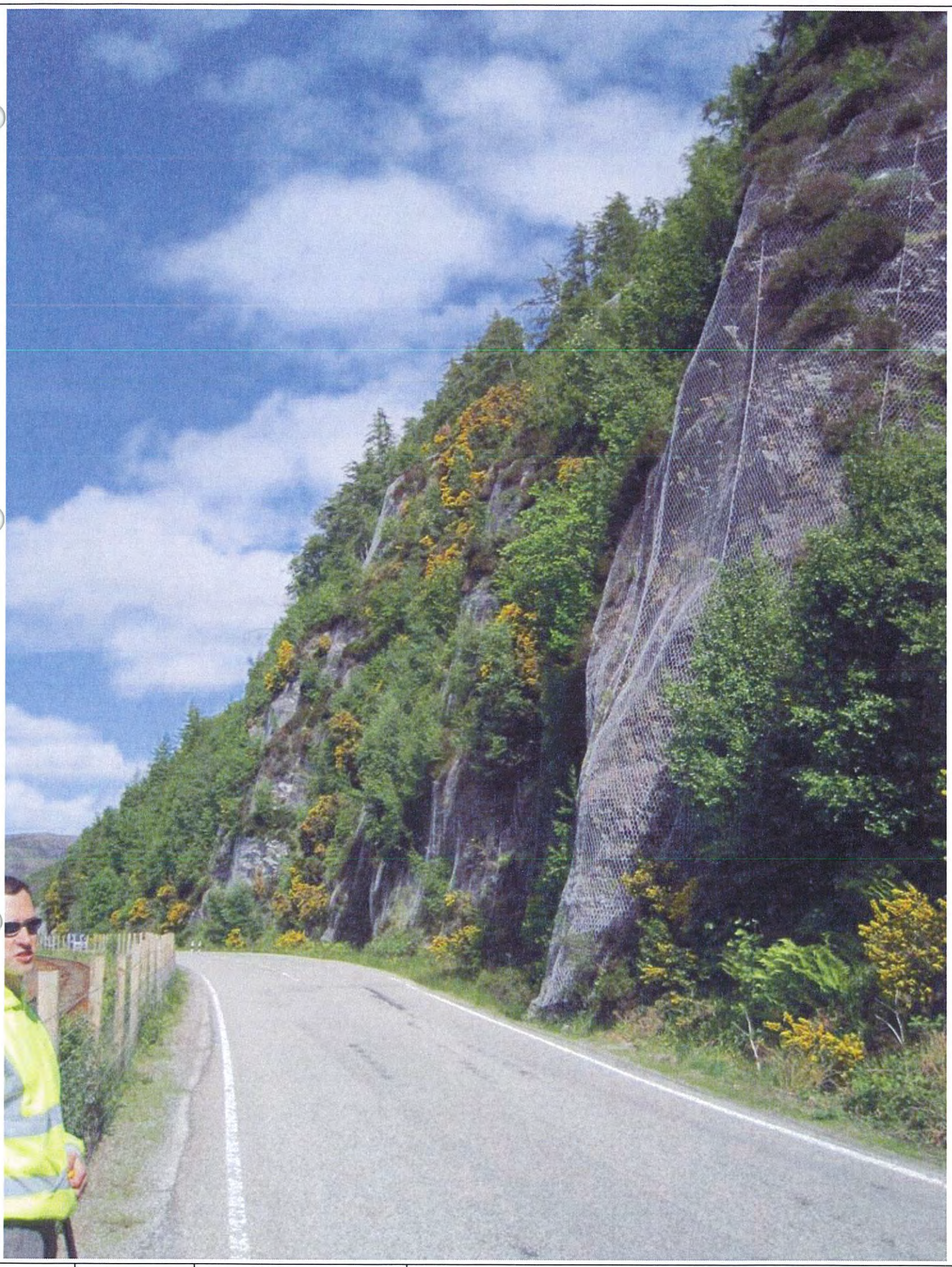
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA13 |
| project no: 454.1 | figure no: FIGURE 13 |

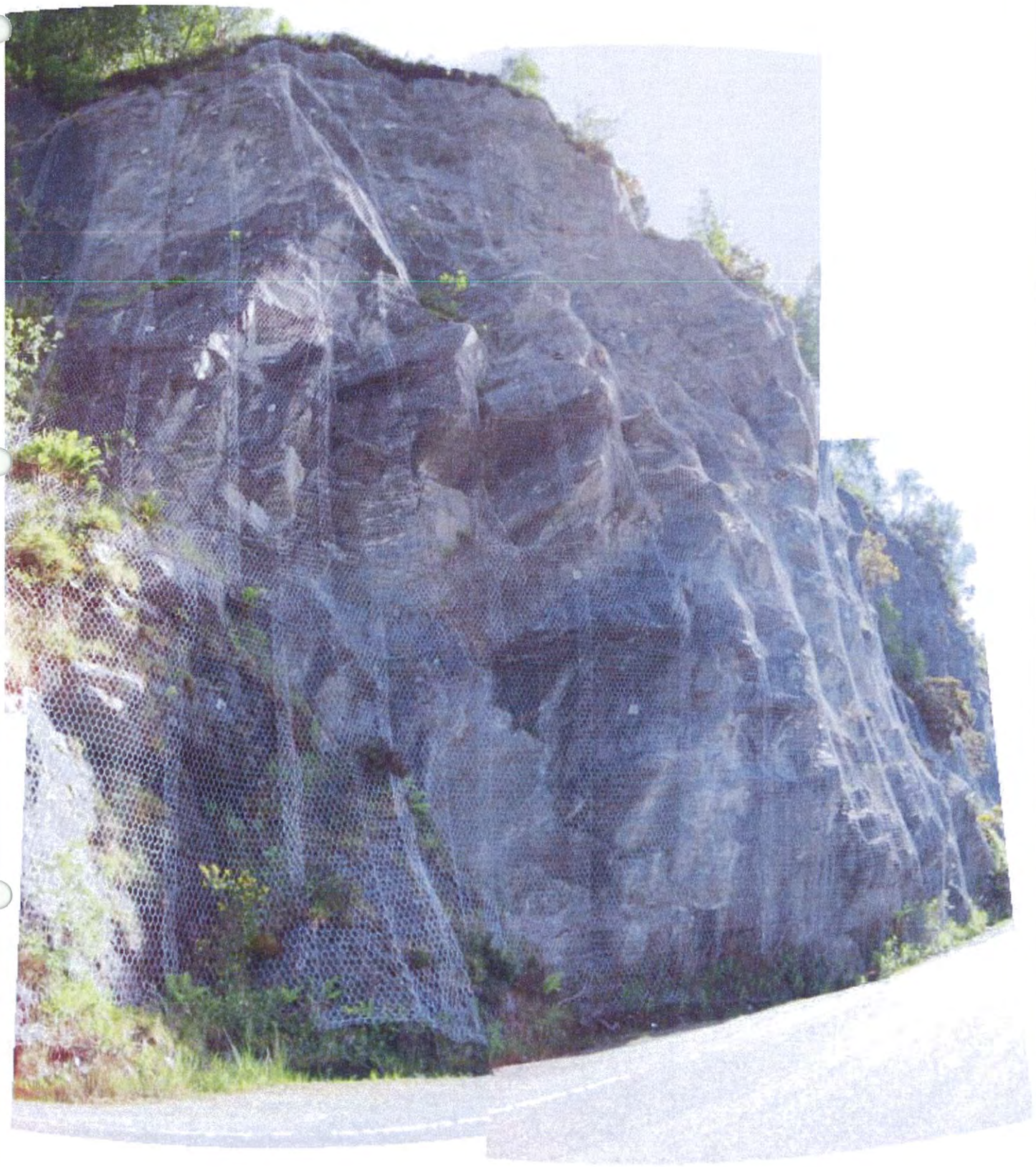
| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| ate | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA14 West |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 14 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA14 East |
| original size | A4 | | project no: **454.1** | figure no: **FIGURE 15** |



| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics<br>SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA15 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 16 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA16 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 17 |



| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 09/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA17 |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 18 |

| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

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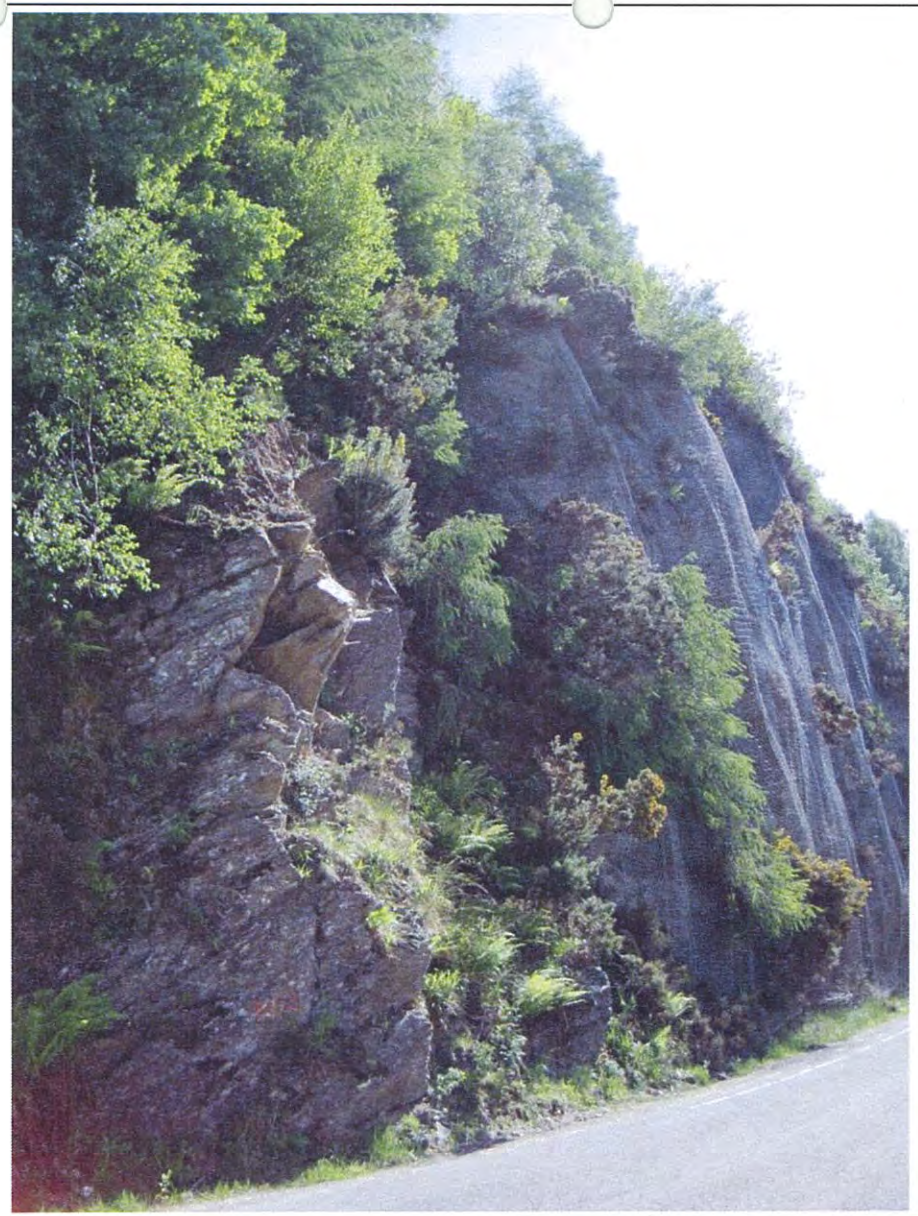
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA18 |
| project no: 454.1 | figure no: FIGURE 19 |



| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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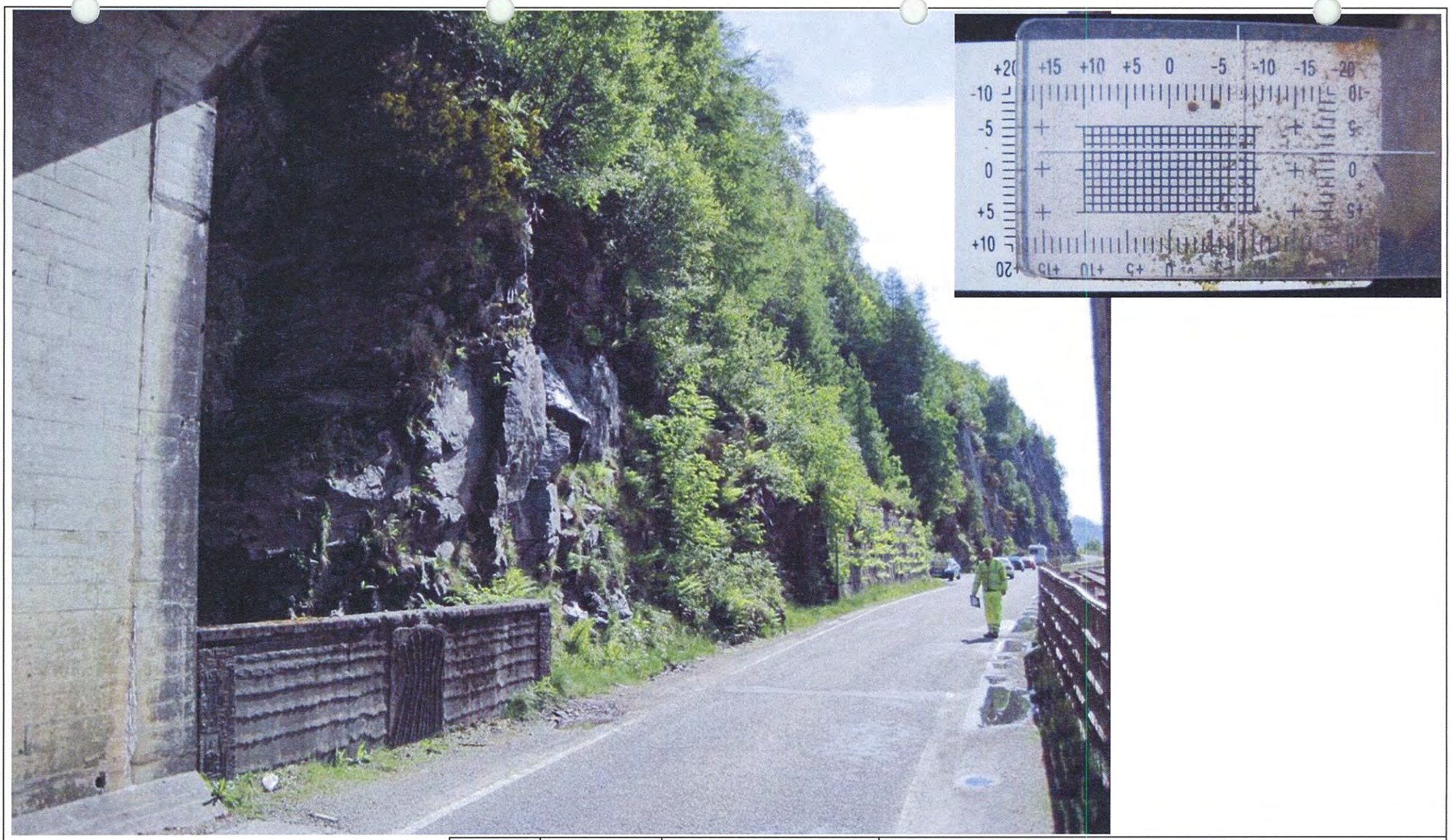
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA19 |
| project no: 454.1 | figure no: FIGURE 20 |




| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA20 |
| project no: 454.1 | figure no: FIGURE 21 |

| | |
|---|---|
| drawn | RMD |
| date | 10/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

| | |
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA21 |
| project no: 454.1 | figure no: FIGURE 22 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 10/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA22a |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 23 |

| | |
|---|---|
| drawn | RMD |
| date | 10/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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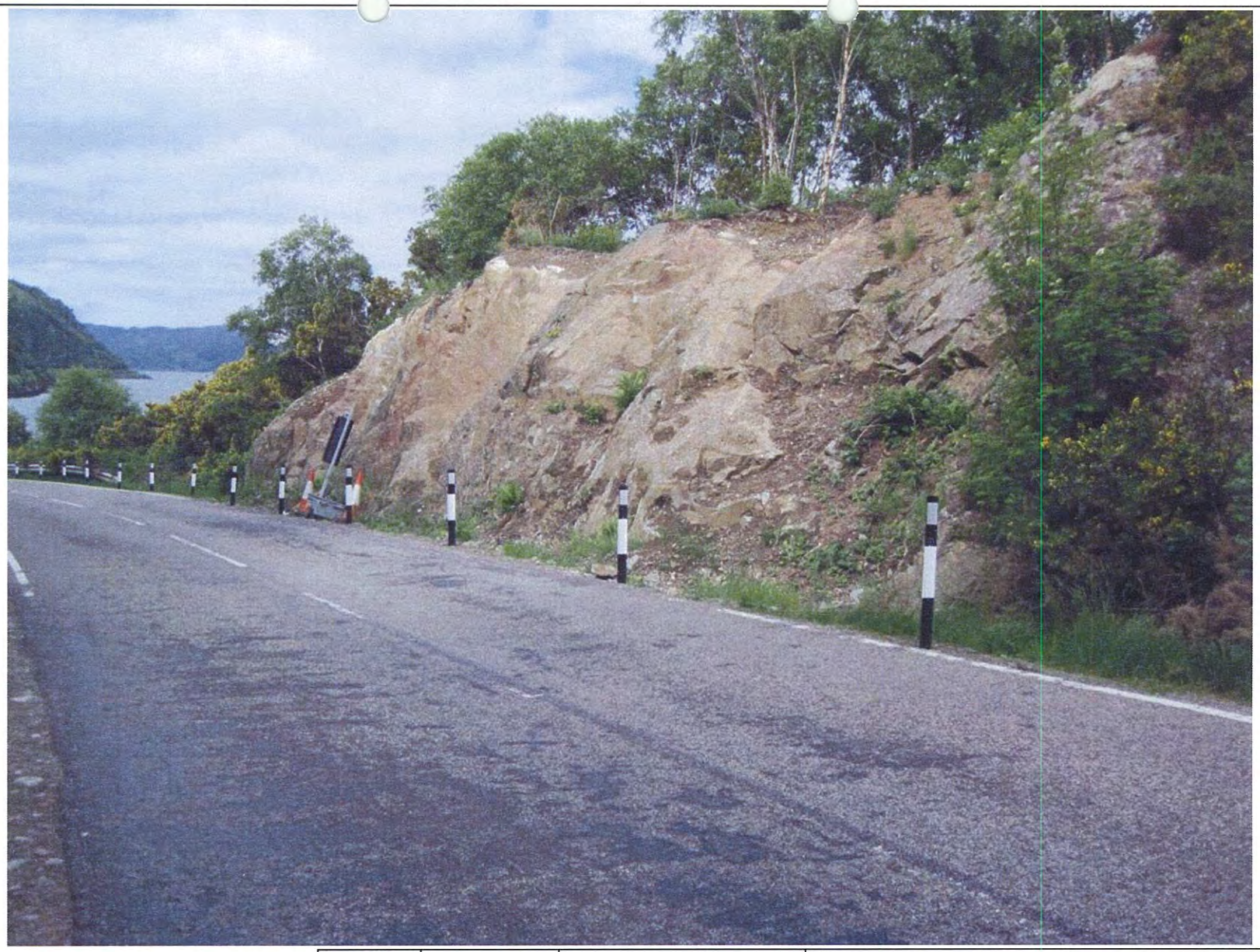
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA22b |
| project no: 454.1 | figure no: FIGURE 24 |



| | |
|---|---|
| drawn | RMD |
| date | 10/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

| | |
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA23N |
| project no: 454.1 | figure no: FIGURE 25 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 10/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Slope AA23S |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 26 |

| | |
|---|---|
| drawn | RMD |
| date | 10/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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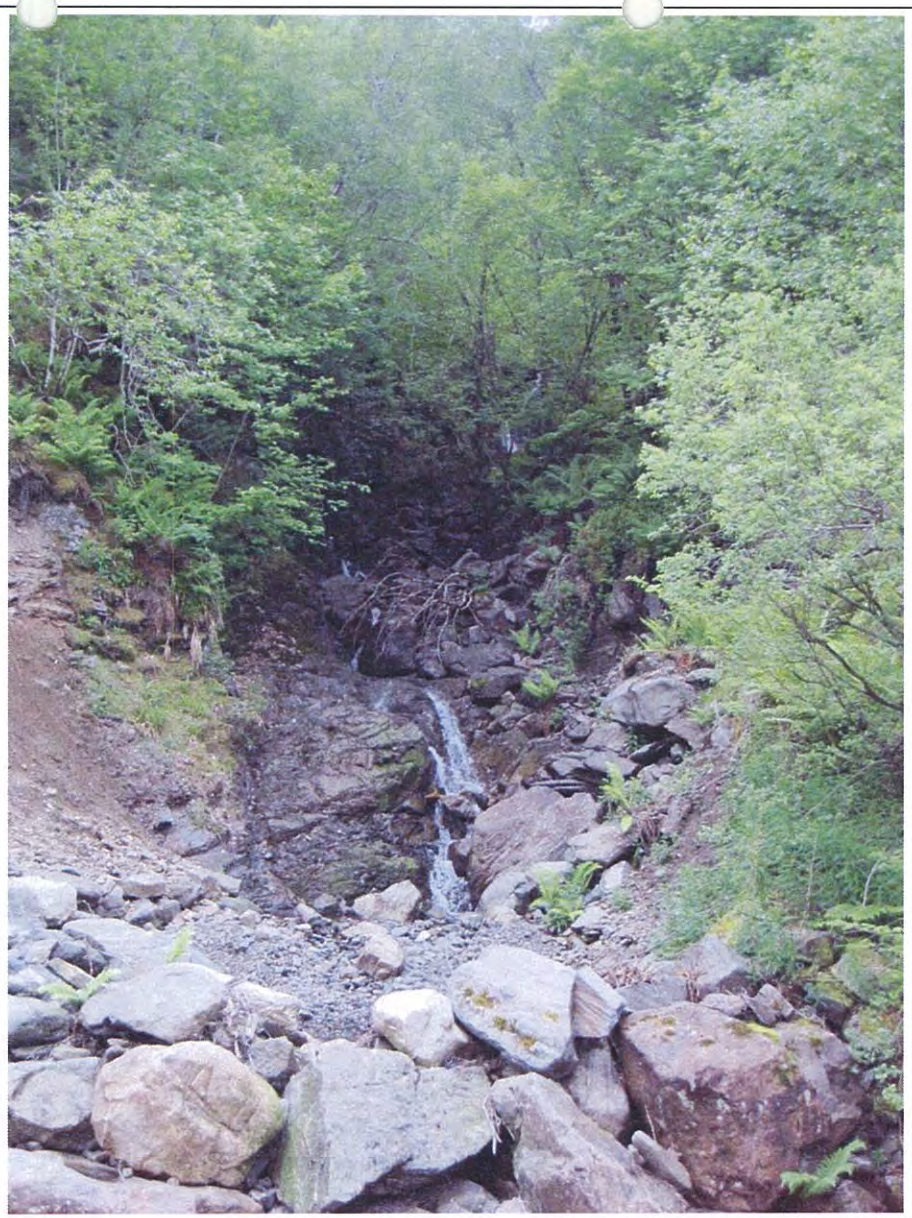
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Slope AA24 |
| project no: 454.1 | figure no: FIGURE 27 |



| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

| | |
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | Frenchmans Burn |
| project no: 454.1 | figure no: FIGURE 28 |

| | |
|---|---|
| drawn | RMD |
| date | 10/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

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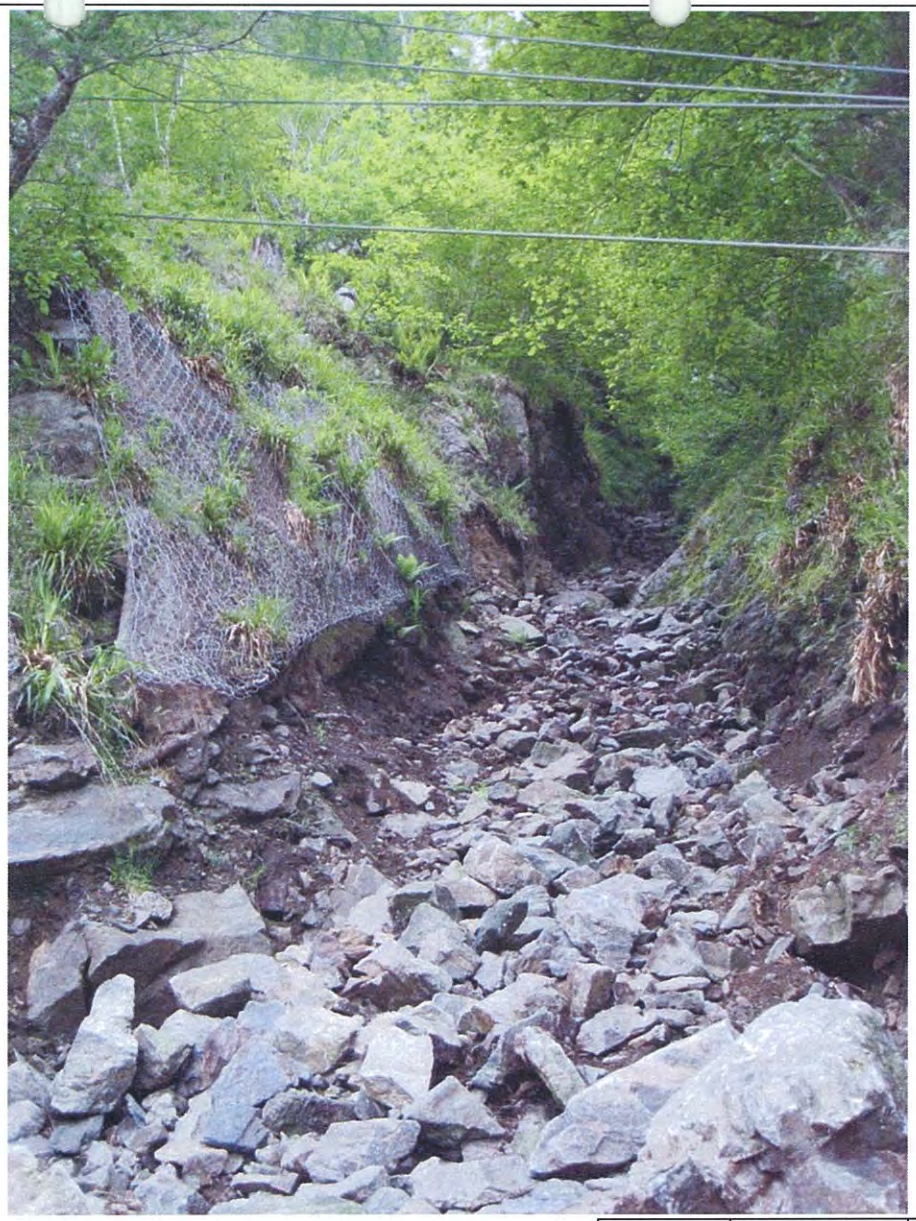
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | AA5 / AA6 Drainage Pipe |
| project no: 454.1 | figure no: FIGURE 29 |



| | |
|---|---|
| drawn | RMD |
| date | 09/06/2010 |
| scale | NTS |
| original size | A4 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

| | |
|---|---|
| client: | The Highland Council |
| project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| title: | AA19/AA20 Gully |
| project no: 454.1 | figure no: FIGURE 30 |

| | | | | |
|---|---|---|---|---|
| drawn | RMD | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | The Highland Council |
| date | 10/06/2010 | | project: | A890 Stromeferry Bypass<br>Annual Rock Slope Inspection - June 2010 |
| scale | NTS | | title: | Natural Crag – Source of September 2009 Rockfall |
| original size | A4 | | project no: 454.1 | figure no: FIGURE 31 |

# Appendix C

## Rock Slope Failure Mechanisms

coffey geotechnics
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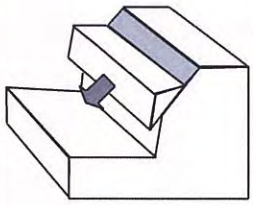
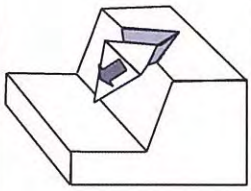
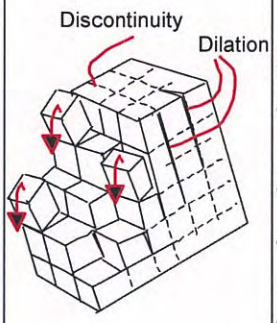
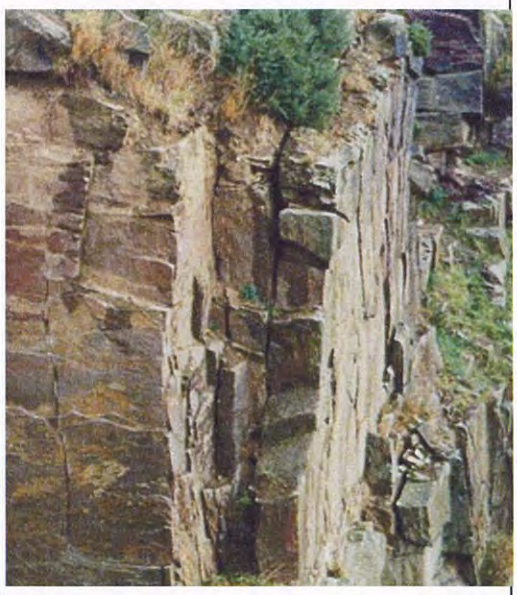
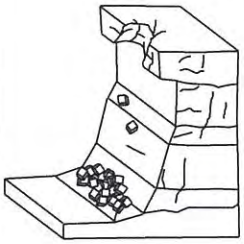
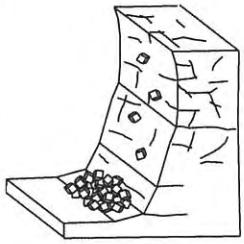
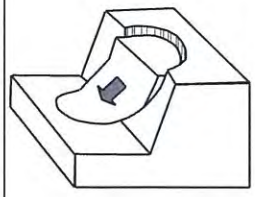
## Rock Slope Failure Mechanisms

| Mechanisms | Description | Example |
|---|---|---|
| **Plane**<br>  | Movement down a discontinuity plane.<br><br>General criteria for failure are:<br>• Discontinuity dip < slope angle.<br>• Discontinuity dip > friction angle of discontinuity plane.<br>• Discontinuity plane must "daylight" on the face.<br>• Dip direction should generally be within ± 20° of the face dip direction. |  |
| **Wedge**<br>  | Movement of a wedge shaped rock mass down two intersecting discontinuity planes in the direction of the intersection.<br><br>General criteria for failure are:<br>• Intersection must dip < face angle.<br>• Intersection must dip > friction angle of discontinuity planes.<br>• Intersection must "daylight" on the face.<br><br>Wedges may repeat at intervals due to nature of intersecting discontinuity planes. |  |
| **Toppling**<br>  | Movement out of the slope of elongated overbalanced blocks, developing due to rotation about the toe of the block. Once the centre of gravity of the block acts beyond its toe the block will topple.<br><br>General criteria for failure are:<br>• Discontinuity set spacings producing vertically elongated, overbalanced blocks which lean out of the slope.<br>• Steeply inclined discontinuity dipping into the slope.<br>• Basal release discontinuity which must either dip out of the slope at < friction angle of discontinuity, or be sub-horizontal.<br>• May require steeply inclined discontinuity forming a side release plane. |  |

| | | |
|---|---|---|
| **Block Fall**<br>  | Sporadic, un-preceded detachment & falling from a rock slope of an isolated, protruding or unsupported boulder (>200mm*) or larger sized block.<br><br>Fall is initiated by:<br>• Gravity: initiated by removal of support due to ravelling & blockfall.<br>• Weathering: propagation of a discontinuity plane between block & rock slope where load stress on the block > the shear and tensile strength of the connecting material plane.<br>• Vegetation: may provide a destabilising force e.g. roots "jacking" material.<br>• Movement is rapid & the block may dislodge further material from the rock face. Fall material generally accumulates at the toe of the slope. May subsequently involve bouncing, rolling, sliding & fragmentation of the block/s.<br>• Block dimensions are governed by spacing & orientation of discontinuities (natural or blast induced) within the rock mass. |  |
| **Ravelling**<br>  | Ravelling is a near surface mechanism generally occurring in weak or closely fractured (natural and blast induced discontinuities) rock masses.<br><br>• Continuous, detachment & fall of mineral grains, gravel sized (2 - 63mm*) fragments & occasional cobble sized (63 - 200mm*) blocks from a rock slope. This material may fall or roll down slope forming talus on & at the toe of the slope.<br>• Driving mechanisms include long-term stress relief, physical & chemical weathering processes that gradually weaken & deteriorate a rock mass.<br>• Ravelling results in progressive natural regression of an exposure. This proceeds until a stable slope angle between crest & toe is formed. |  |
| **Curvilinear failure**<br>  | Occurs in soil masses, soft rock masses and heavily jointed or broken hard rock masses.<br><br>Materials behave like an engineering soil & a rotational slip occurs through the rock mass, forming a circular 'spoon like' geometry. |  |

***According to the size categories defined in BS EN ISO 14688-1:2003.**