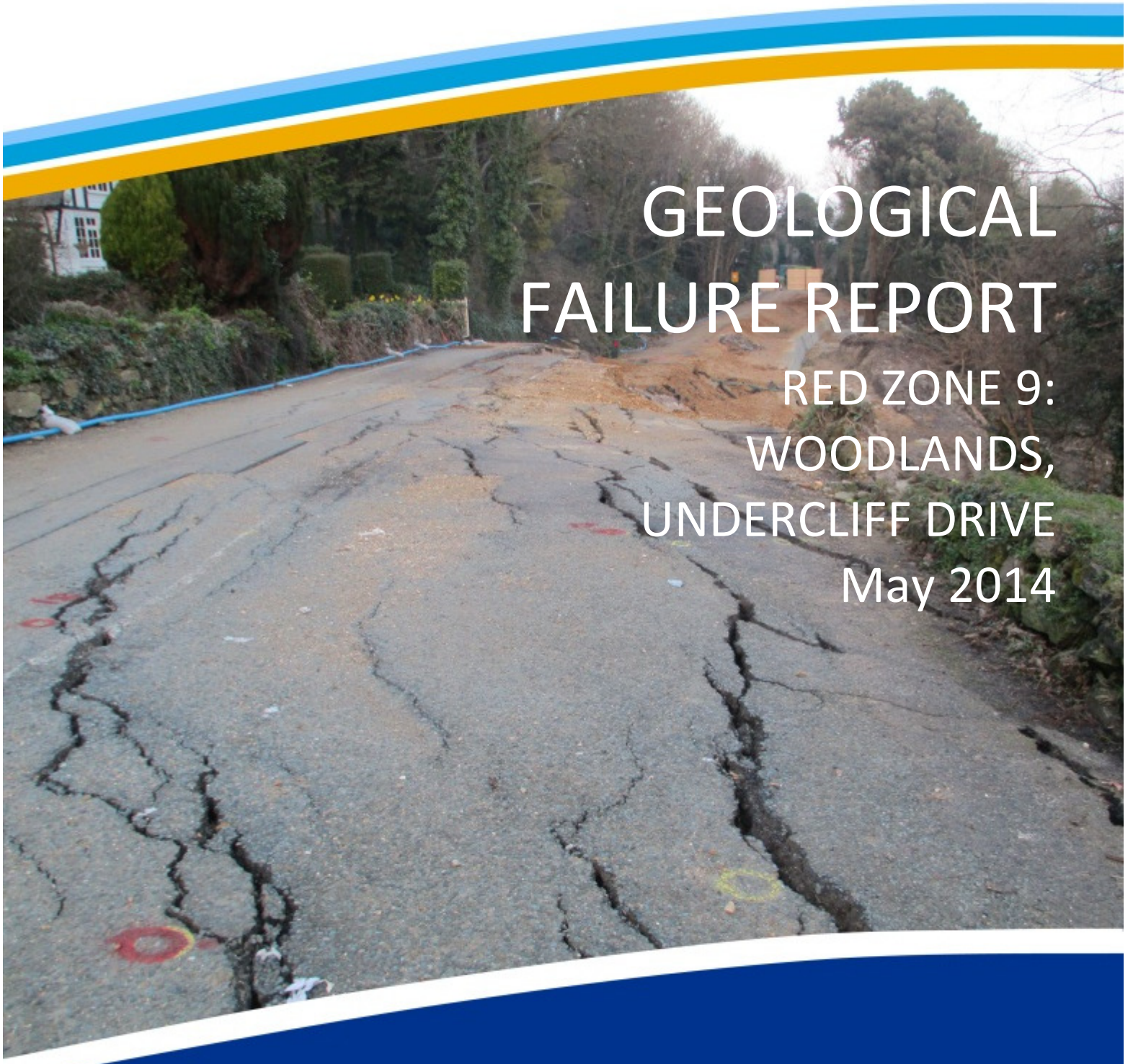
Island Roads



GEOLOGICAL FAILURE REPORT

RED ZONE 9: WOODLANDS, UNDERCLIFF DRIVE

May 2014

www.islandroads.com

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Version	***Report Author***	***Report Checked***	***Report Approved***
4			

Approved for Island Roads Services Limited	**Date**	**Signed**

Contents

1 INTRODUCTION

A Geological Failure occurred at Red Risk Site 9 Woodlands on 10th February 2014. A section of the road that has undergone movement previously has failed during the period of construction works to stabilise the road.

Clause 12.11.1 of the Highways PFI contract stipulates that Service Provider must provide a failure report detailing the nature and proposed costs of remediation, management and or rectification for each Amber or Red zone Geological Failure. This report follows on from the Failure Notice issued by the Service Provider to the Isle of Wight Council in March 2014. Below is a response to each of the clauses required within the contract. Details of the clauses within the contract are given in Table 1 of the Ramboll report in Appendix 1.

2 CONTRACT RESPONSE

2.1 Contract Clause 12.11.1.1

For details of the Geological Failure please refer to Appendix 1 Ramboll Geotechnical Report Sections 1 and 2 which provide updated and more detailed information of those matters contained in the original Failure Notice. An introduction is provided within Section 1 together with its location and also reference to construction activities that have occurred in the area. Under Section 2, information is provided on historical landslide behaviour together with findings from the inspection of the site undertaken on 10th February 2014.

The main failure at Site 9 Woodlands occurred over 14/15th February 2014 at the western end of the geotechnical construction scheme that was underway to stabilise the road. All excavations and construction of the ground anchor reaction beam were complete up to this point.

In addition to the information given in Appendix 1, a plan showing the extent of the ground movement caused by reactivation of the landslide along Undercliff Drive over January/February 2014 is shown in Appendix 3. The main line of the failure cuts across the completed ground beam (part of the geotechnical works), and behind it through the centre of the original carriageway along pre-existing cracks (Fig. 1a). The failure then cuts across into the garden and driveway of the property ‘Allenmore’ (Fig. 1b) and extends into the garden of ‘Mount Lavinia’. The line of failure can then be traced across this property to the south side of the Undercliff Glen Caravan Park. A separate new area of failure developed within the west bound side of the road immediately outside the property ‘Allenmore’ (Fig. 1c) and can be traced through the corner of the property and into the garden of the property ‘Mount Lavinia’.

Figure 1a. Site 9 *Woodlands Geological Failure.* Location at which the failure cuts across the completed ground beam (red arrow).

Figure 1b. Site 9 *Woodlands Geological Failure.* Backscarp of the failure cutting across into the garden of Allenmore.

Figure 1c. Site 9 *Woodlands Geological Failure.* New failure in the west bound carriageway outside the property Allenmore

Downslope of the site at Woodlands there have been metre scale movements indicated by the presence of large tension cracks, visible smooth slip surfaces and displaced vegetation. The area of movement has stretched downslope for more than 100m. A standpipe piezometer has also been destroyed through ground movement within this area of the landslide (located approx. 90m downslope of the geotechnical site).

2.2 Contract Clause 12.11.1.2

Within Appendix 1 Section 3 the implications of failure have been considered. Construction work was adversely affected from week commencing 10th February 2014 onwards. Movement continues to occur within the centre of the failure at Woodlands. Subsequent to the landslip at Woodlands, the site was made safe to the public.

Since gradual movement is still ongoing at Site 9 Woodlands the monitoring programme will be continued for the foreseeable future. Island Roads will continue to undertake weekly surveys and a CCTV system has been put in place to provide security for residents.

Groundwater levels remain high and therefore there remains a high risk that ground movements will continue. Movement continues to be detected within the area of failure at Woodlands and will continue to be monitored.

A full programme for rectification of the site has not been developed at this stage as it is dependent upon the length of time that groundwater levels remain high and there is still risk of ground instability. However a list of potential remediation options is given in

Island Roads will continue to develop a scheme that considers the land instability further and will provide a more long term solution. Any solution will depend upon the actual recorded movement over the coming few months.

2.3 Contract Clause 12.11.1.3

Since the area is now impassable the area has been made safe by placing barriers at both the eastern and western ends with two sections of hoarding to prevent pedestrian access. Warning/danger signs have been attached to the outside of the hoarding and the access has been padlocked. Running adjacent to the hoarding is a section of Heras fencing in place to restrict access around the side of the hoarding. Three railway sleepers have also been placed outside the site with cones and a road closed sign. Inside the site the area has been completely cleared of all site cabins, construction equipment, vehicles and barriers. Photos of the current condition of the site are given in Fig. 2a, 2b and 2c.

Figure 2a. Site 9 *Woodlands Geological Failure.* Hoarding, barriers and signs in place at the eastern extent of the site.

Figure 2b. Site 9 *Woodlands Geological Failure.* The current state of the site.

Figure 2c. Site 9 *Woodlands Geological Failure.* Hoarding, barriers and signs in place at the western extent of the site.

A diversion has been set-up to direct traffic away from the area. Details for this diversion are given in Appendix 2.

2.4 Contract Clause 12.11.1.4

Site inspections are undertaken regularly by Island Roads. Ground movement monitoring and groundwater level measurements are taken from existing instrumentation along the length of the site. The most recent surveys have shown that small scale movement is continuing. Further information on the current monitoring of the site is given in Ramboll Geotechnical Report Sections 2 and 4.

A number of recommendations for increased monitoring of the landslide were outlined by Ramboll in their March 2014 report (see Section 5 of Appendix 1 which includes the report updated to June 2014). The following were implemented by the Service Provider from January 2014:

- Increase inclinometer survey frequency to once per fortnight
- Monitor width of cracks and surface points in the road at Sites 8, 9 and 10 weekly
- Collect and carry out regular reviews of monitoring and rainfall data
- Review remediation proposals in view of revised ground conditions
- Once ground movement has ceased, the area seaward of the site will be re-surveyed

2.5 Contract Clause 12.11.1.5

Although final details concerning rectification of the Geological Failure cannot be produced until ground movement at the site has stopped as indicated by Ramboll Geotechnical Report Appendix 1 Section 6, a number of outline options are provided in Appendix 5 of this report and a brief description of each option is given in the main Geological Failure Report: Seven Sisters Road, St Lawrence to St Catherine's Road, Niton

2.6 Contract Clause 12.11.1.6

Failure costs incurred to date and ongoing weekly costs associated with the failure are included within Appendix 3.

Since movement at the site is still on-going it is not yet possible to provide nor price a Proposed Failure Solution as referred to in Appendix 1 Sections 6 and 7. It is clear from the Ramboll Report that if the road is to remain in its current alignment then significant fill would be required to raise the road back to an acceptable alignment.

2.7 Contract Clause 12.11.2

Resurfacing was due to be completed immediately after completion of the stabilisation works at Site 9 Woodlands. Seeing as the stabilisation works have not been completed due to the Geological Failure, the resurfacing works will not be completed until such time as a proposal for rectification is agreed and implemented.

APPENDICES

APPENDIX 1:

Ramboll Report – Woodlands Site 9, Undercliff Drive Geological Failure

Intended for
ISLAND ROADS

Document type
REPORT

Date
March 2014

ISLE OF WIGHT HIGHWAYS PFI

WOODLANDS SITE 9 UNDERCLIFF DRIVE – GEOLOGICAL FAILURE

RAMBOLL

ISLE OF WIGHT HIGHWAYS PFI
WOODLANDS SITE 9 UNDERCLIFF DRIVE
GEOLOGICAL FAILURE REPORT

Revision **0**
Date **2014/06/03**
Made by
Checked by
Approved by
Description **Geological Failure Report**

Ref 61030594-9-R02

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-	4.03.14	For Island Roads Review	61030594-09-R02	
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Prepared By	Reviewed By	Approved By

Ramboll
Carlton House
Ringwood Road
Woodlands
Southampton SO40 7HT
United Kingdom

tel +44 (0)23 8081 7500

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1. INTRODUCTION

Geological failure of Undercliff Site 9 – Woodlands was first reported on 10 February 2014. Site 9 is located at National Grid Reference 4525 0762 along Undercliff Drive, and is 218 metres long (Figure 1). This site lies immediately east of Undercliff Drive Site 10 – Caravan Park.

The existing road at Woodlands has been affected by repeated major land slippage some 90 metres from the western end of Site 9. Ground movement occurred in the winter 2012/13 prior to the award of the Highways PFI Contract. As a result of the 2012/13 ground movement Undercliff Site 9 was reprioritised, with work planned in the first year of the Highways PFI scheme. The highway was locally resurfaced prior to the commencement of the PFI Contract. The scheme was designed (July 2013) and construction works at this site had begun on 14 November 2013. Construction works had progressed to partial excavation of the existing carriageway, construction of the ground anchor beam and installation of eight ground anchors (unstressed). The east bound lane remained open. Construction photos are presented in Appendix A.

Following the initial notification the site was inspected by the Island Roads Geotechnical Engineer to map out the extent of surface cracking. In addition surface monitoring along the ground anchor beam and existing carriageway was initiated. A site inspection by the Ramboll Geotechnical Engineer was carried out on 13 February 2014 and 17 February 2014. The contract requires a Failure Report to include information as summarised in Table 1. This document summarises the proposed information and assessments required to assess the extent of Geological Failure.

Failure Report Clause	**Text**	**Reference in this Report**
12.11.1.1	Updated and more detailed information of those matters contained in the Failure Notification and Failure Notice;	Section 1 and 2
12.11.1.2	A full and detailed explanation of the impact of the rectification, management and/or mitigation (as applicable) of the Red Zone Failure.	Section 3
12.11.1.3	A full and detailed explanation of how the OpCo has made the affected Project Network Parts and its surroundings safe to the public (including the remediation of all Category 1 Defects in accordance with the provisions of Schedule 2 (*Output Specification*)).	See Island Roads report
12.11.1.4	A full and detailed explanation of what further actions the OpCo is to undertake (including any inspections, tests, surveys and/or assessments in order to determine the full extent of the Red Zone Failure, Amber Zone Failure and/or Geological Failure);	Section 4 and 5
12.11.1.5	A full and detailed explanation of how the OpCo proposes to rectify, manage and/or mitigate (as appropriate) the Red Zone Failure, Amber Zone Failure and/or Geological Failure (**"Proposed Failure Solution"**) which shall, where the OpCo believes no action is required, provide a full explanation of the reasons for such belief, including any implications arising from taking no action.	Section 6 and 7
12.11.1.6	An estimate of the total amount of Failure Costs which the OpCo shall calculate acting reasonably (including all Failure Costs incurred up to the issue of the Failure Report) required to carry out the	See Island Roads report

	Proposed Failure Solution, together with documentary evidence such as full bills of quantity where practicable.	
12.11.2	The OpCo shall at the same time as submitting the Failure Report, amend and submit to the Service Provider pursuant to Schedule 20 (*Review Procedure*) any OpCo Programmes affected by the Proposed Failure Solution.	See Island Roads report

Table 1 Summary of Failure Report Information

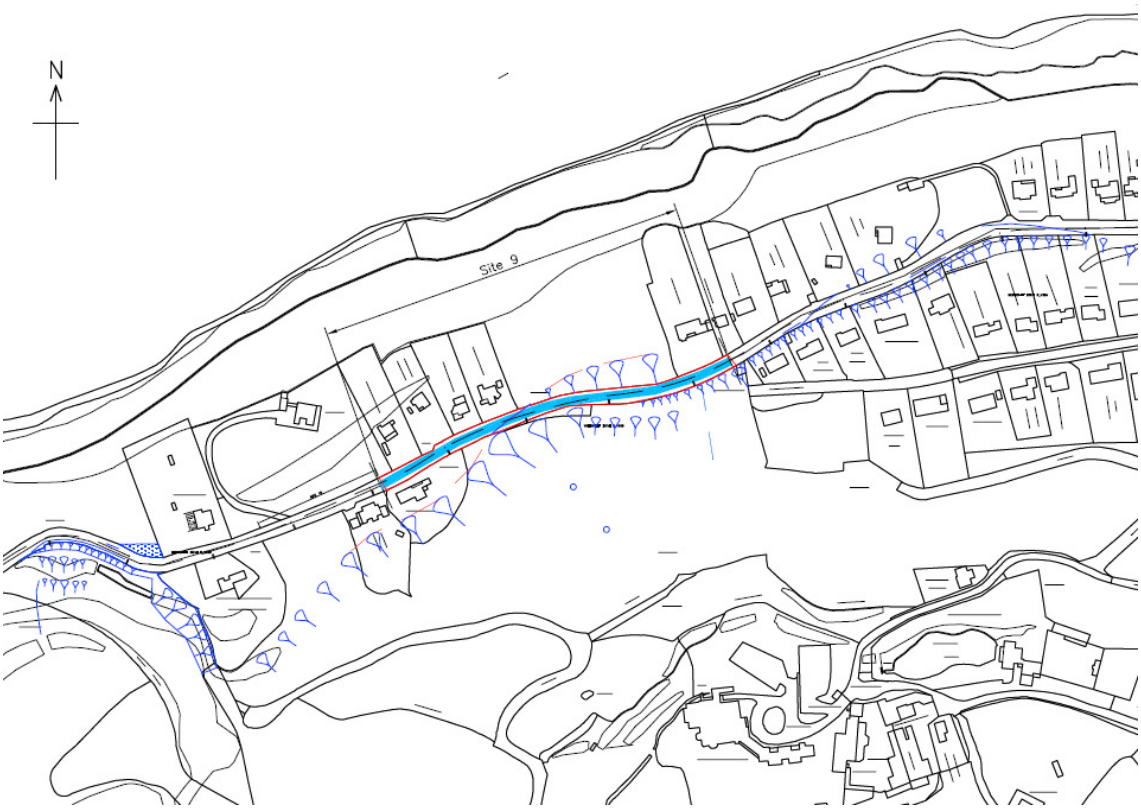


Figure 1 Location of Undercliff Drive Site 9 - Woodlands

2. INITIAL OBSERVATIONS OF LANDSLIDE FAILURE/ BEHAVIOUR

2.1 Site Observations

The main points from the site inspections are summarised in this Section and in Appendix B and Figure 2:

- Tension cracking was first reported on 8 February 2014 at "Allenmore".
- An inspection of the site was carried out on 10 February 2014. The first tension cracks were observed to extend between "Woodlands" and "Allenmore" in the road surface (shown in red) and had in three days extended both east and west.
- The tension cracks initially appeared as either re-opening of existing features or as hairline cracks.

- The westward extension of the tension cracks were aligned below and around "Allenmore". The tension crack in "Allenmore" driveway initially dropped approximately 100 mm in two days and external and internal damage was evident. Displacement then increased to 400 mm, and has since increased further. The north western corner to the foundations had moved along the dpc layer (Photo A1).
- New hairline tension cracks had developed along the Undercliff Drive to the western end of "Allenmore" (13 February 2014). These features continued to open up and displacement gradually developed from hairline to 200 mm wide on 17 February 2014.
- The tension crack opposite "Woodlands" and 30 metres east of "Woodlands" opened by 50 mm to 100 mm between 13 February and 17 February 2014 and began to show signs of downslope displacement.
- Inspection of the ground seaward of the site was difficult, hazardous and limited due to the extensive ivy coverage that masks underlying tension cracks. The following observations have been made:
    - Tension cracks 2 metres wide and 1.5 metres deep found downslope between "Allenmore" and the western half of the ground anchor beam (approximately downslope of where tension cracking was found in Undercliff Drive) on 10 February 2014 (estimated to be 50 metres to 75 metres forward of the site). During the second visit these features were not evident; this may have been due to the vegetation cover or possibly that further ground movement has closed them up.
    - Shallow ground movement downslope of the site within the Gault Clay (mudslide) debris is evident as shown in Photo A2, where the upper 3 metres of soil had moved several metres laterally.
    - There are zones where trees are tilted but it is not possible to assess if these are new or old features; they do coincide with the area where more recent features are evident.
    - A series of rotational blocks seaward of "Allenmore" and "Woodlands" show that the ground seaward of the exposed rotational blocks have moved relative to the blocks. These features have opened up to 300 mm to 400 mm wide tension features that were several metres deep (Photo A3) on the down slope side.
    - The lateral boundary of the shallow slide was seen during the site visit on 13 February 2014 and was approximately in line with the middle eastern quarter of the ground anchor beam.
    - Surface water features were encountered approximately 75 metres to 100 metres downslope of the site. It was not clear if these were spring feed and/or if the existing drainage system had become disrupted.
    - There is recent shallow movement in the Gault Clay scarp slope over a 40 metre width approximately 200 metres downslope of the site along with a series of trees that have been pushed over.
- The ground anchor beam had multiple hairline cracks at its mid-point (13 February 2014). The beam was subsequently mechanically cut before the larger scale movement began, to save as much of the beam as possible.
- The existing pumped drainage system that pumped water from the landward side of the road into an existing drainage system was disconnected and a temporary surface discharge pipe allowed water to flow over the beam downslope and back into the original discharge system, outfalling to the pond at the bottom of the slope.

Site 9 Woodlands and Site 10 Caravan Park, whilst situated immediately adjacent to each other and within the landslide complex, are subject to two different landslide mechanisms. An extract of the published Geomorphology Map (Sheet 5) is reproduced in Figure 3. This shows Site 9 to

be located in the head scarp position of an area of multiple rotational block failures that lies immediately above a retrogressing mudslide complex. The retrogressing slide complex extends approximately 160 metres downslopes of Site 9. This is in contrast to Site 10 where the mudslide complex extends to the shoreline. A zone of rotational blocks forms a feature separating the landslide complexes downslope of each site.

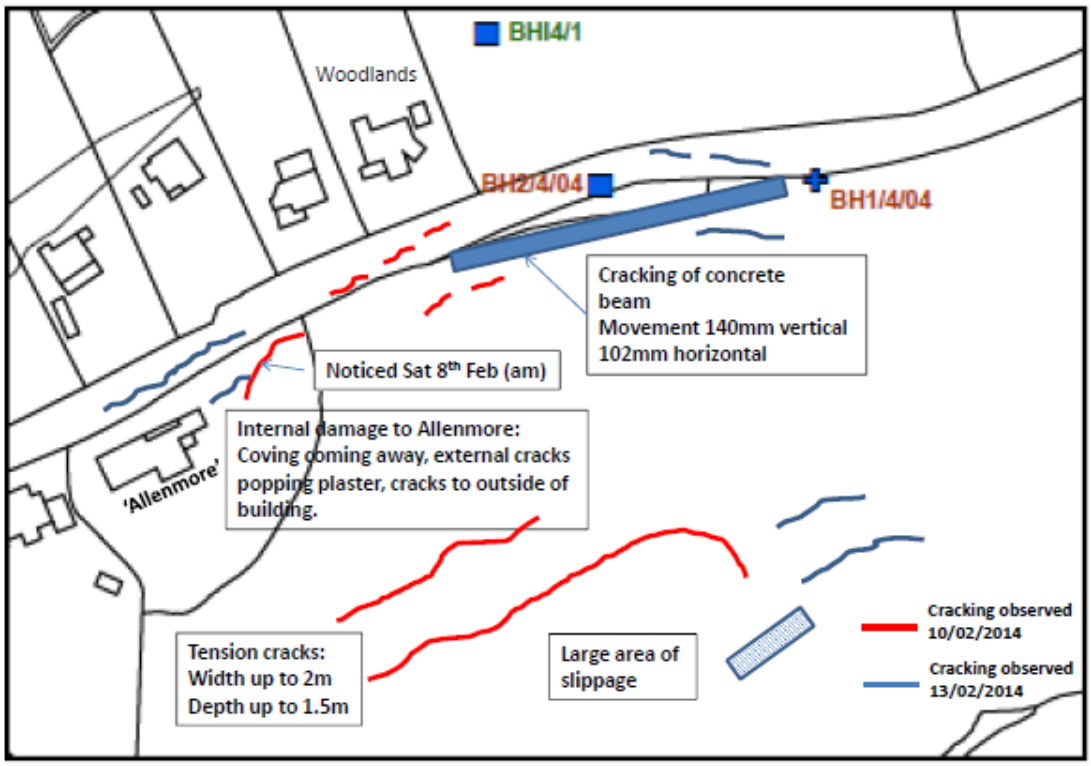


Figure 2 Summary of tension cracking observed on 10 and 13 February 2014

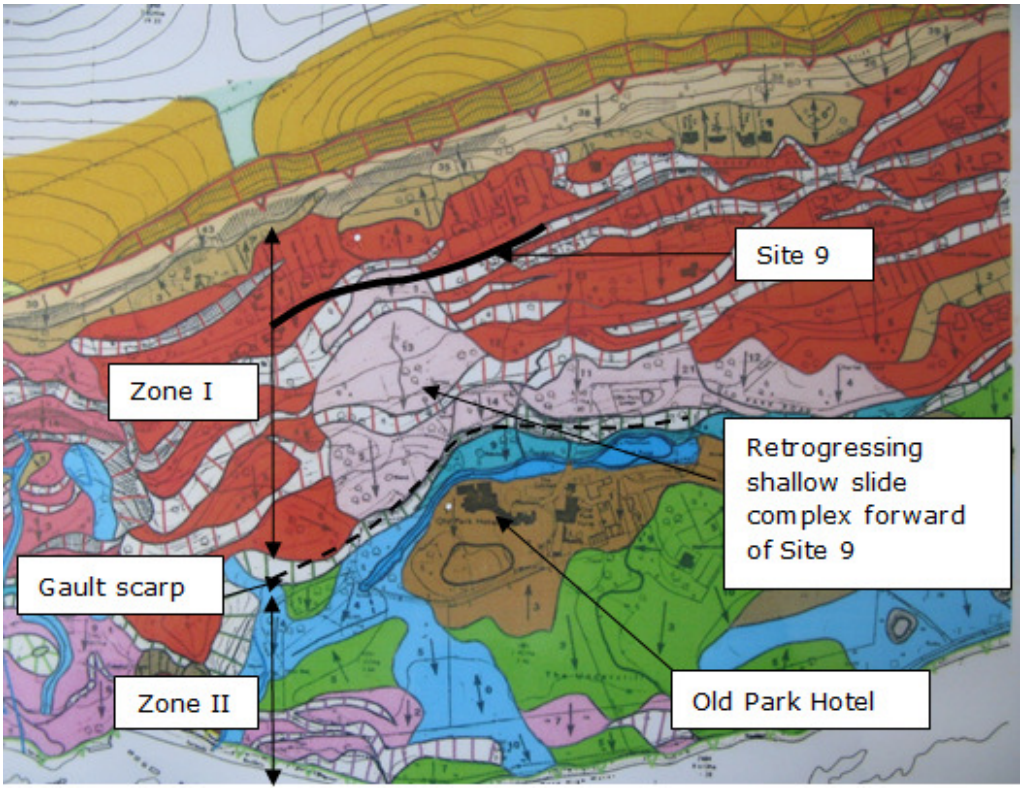


Figure 3 Extract of Geomorphology Map Site 9 and Site 10

The site observations suggest that shallow movement within the retrogressing mudslide complex has occurred, and this is likely to have removed support to the landward rotational blocks. A rotational block appears to have reactivated in the zone separating Site 9 and Site 10, and a new feature (or old dormant feature) developed 150 metres westwards, south of the red sites, to and beneath the Caravan Park.

2.2 Historical Landslide Behaviour

In 2001 a period of heavy rainfall resulted in major sliding at various locations along the Undercliff including Site 9. Further movement and cracking has occurred, with the most recent being in the winter of 2012/2013.

Subsequent to previous large scale ground movements along the Undercliff, a landslide forecast model was developed for the Undercliff by High-Point Rendel in 1996 based on the work by Lee *et al* (1991). In order to try and predict the likelihood of future movements along the Undercliff, data was collected concerning the occurrence and location of previous landslides and the volume of rainfall preceding them. The model gave a threshold value of effective rainfall (the percentage of total rainfall that enters the ground) over a preceding 4 month period which would be likely to cause instability or increased ground movement rates within the Undercliff landslide complex. When comparing the occurrence of previous landslide events with the corresponding 4 month antecedent effective rainfall (4AER) value it appears to correlate with ground movement events with a good degree of accuracy (Figure 4). Once the 4AER value drops back to below the threshold value the likelihood of further movements at that point in time is reduced. The Isle of Wight Council has employed this model in order to aid assessment of the likelihood of ground movements in areas throughout the Undercliff. Table 2 summarises the trigger threshold values. This placed the rainfall during February and March 2014 as Class 3, and at risk of major instability.

Landslide Forecast Class			
Class	**Trigger Value (4AER mm)**	**Location**	
		Major	**Minor**
Class 1	<410	Blackgang	The landslip, Luccombe, Mirables
Class 2	410 - 540	The landslip, Luccombe, Mirables, Blackgang	Woodlands
Class 3	540 - 640	ALL	Bonchurch, Ventnor, St Lawrence
Class 4	>640	ALL	ALL

Table 2 Summary of Landslide Forecast trigger values based on rainfall

Minor events at Woodlands typically occur in Class 2 events when the 4 month AER value is between 410 mm and 540 mm.

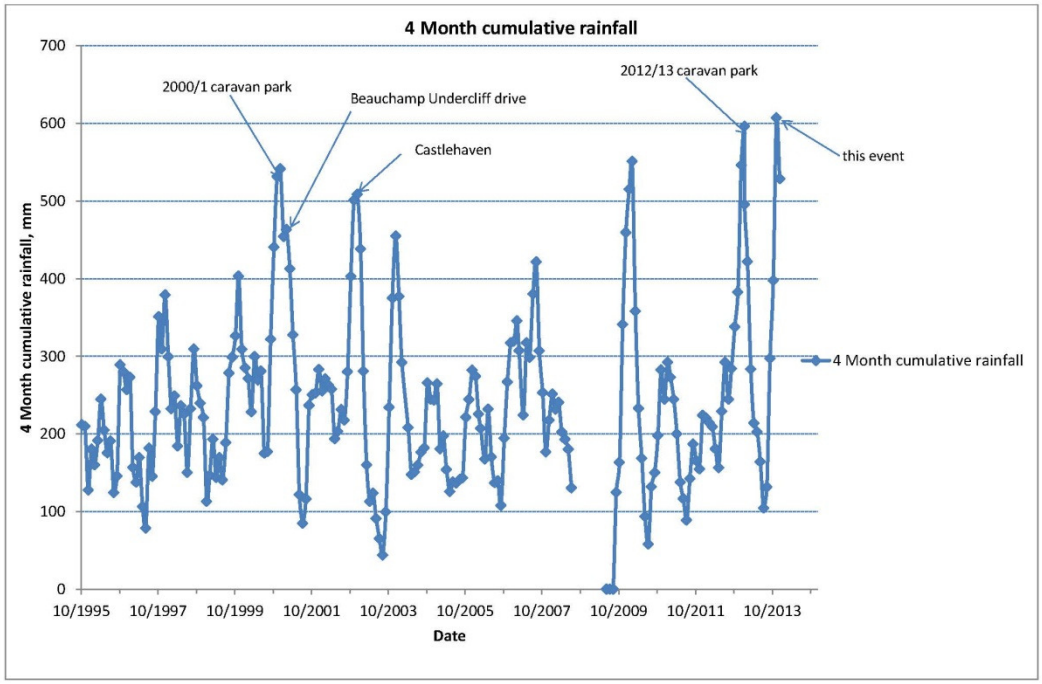


Figure 4 Four Month Moving Average Rainfall and Landslide Events

An image of the site taken on 12 March 2013 is shown in Figure 5. Localised resurfacing was carried out prior to Contract award. A site inspection was carried out on 24 July 2013 during the detailed design phase. An image taken of the site at that time is shown in Figure 6.

Figure 5 View of Site 9 taken on 12 March 2013

Figure 6 View of Site 9 taken on 24 July 2013 showing resurfacing carried out prior to contract award

2.2.1 Ground instrumentation

A location of the available monitoring points is shown in Figure 7, which comprise piezometers installed at a range of depths to monitor groundwater, and inclinometers to 50 metres depth to measure ground movement.

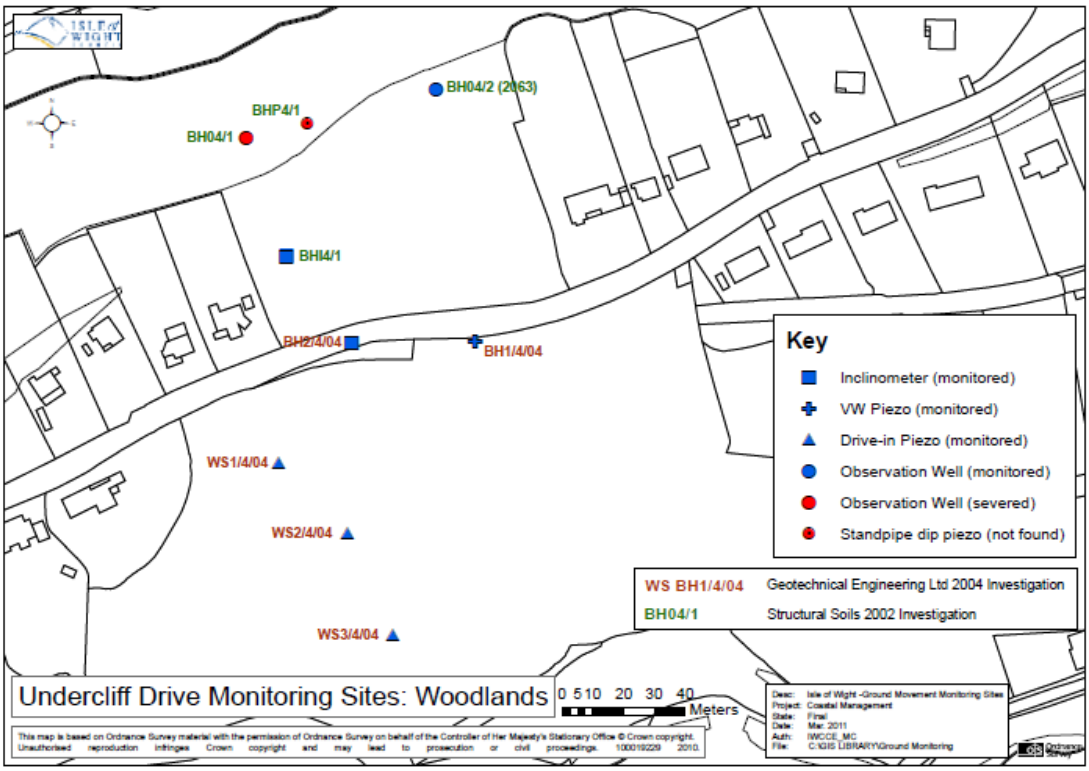


Figure 7 Monitoring locations, Undercliff Drive Site 9 - Woodlands

Figure 8 Ground anchor beam monitoring points

Data from ground instrumentation are presented in Appendix C.

During the 2012/13 landslide event surface ground markers were installed in Undercliff Site 9 and the adjacent Site 10 Woodlands. A summary of the records from this is presented in Appendix C. Surface movement of the road continued up to the last available record that was taken in 14 March 2013. The position of the ground anchor beam was re-surveyed on 11 February to compare it against the as-built location. The results are presented in Appendix C.

2.3 Observations from Monitoring Data

The following observations are made:

- Piezometers immediately landward of the site began to show increases in groundwater levels in the first two weeks in December 2013
- Groundwater levels in piezometer 2063 remained above trigger levels following the 2012/13 event until 24 September 2013. There was some evidence of ground movement affecting the road when the site was inspected during the detailed design.
- A rapid rise in levels began on 12 December 2013, and these increased significantly above trigger levels and above those recorded in the 2012/13 ground movement event. Levels here remain above landslide trigger levels.
- In contrast vibrating wire piezometers installed through the highway deeper into the landslide material do not show evidence of groundwater pressure increases.
- Groundwater levels in piezometers downslope of the site are 1 metre to 2 metres higher than previously recorded levels.
- Inclinometer 4304 located in the Undercliff Drive opposite Mount Lavinia shows start of ground movement at approximately 14 metres to 15 metres depth in the period January 2014 to date. There is approximately 10 mm incremental movement per week at this depth. Prior readings suggest negligible displacement at this level. Movement has begun to tail off at this location.
- Inclinometer I4 does not show any appreciable movement; this is located landward of Undercliff Drive, adjacent to "Woodlands".
- Inclinometer 2404 recorded 80 mm movement at approximately 9 metres depth during the 2012/2013 winter ground movement episode before becoming severed.
- In the 2012/13 event surface movement on the carriageway continued to at least the middle of March 2013, some three and a half months after its initiation.
- The change in survey position of the ground anchor beam shows a south-south easterly trend. The western half shows a drop in level of 100 mm, and a south-south east lateral movement of 100 mm to 150 mm on 13 February 2014. Movement at this location is continuing.
- Ground movement from the monitoring information ties in with surface observations. The highest movement is on the western half of the ground anchor beam, and is extending both east and west.
- Subsurface movement has also extended to the inclinometer opposite Mount Lavinia suggesting more extensive ground movement at depth in the top of the underlying Gault landslide debris.

2.4 Preliminary Stability Review

Construction at Site 9 commenced on 14 November 2013 and at the time of the geological failure excavation of the existing ground had been carried out to accommodate the ground anchor beam and select granular fill earthworks. The reinforced concrete ground anchor beam had been constructed, and eight ground anchors drilled but not connected to the beam or stressed.

A preliminary review of stability analysis has been carried out to assess if the works were detrimental to stability of the slope. This shows that the construction works have a slight improvement on overall stability, and therefore not a component driving failure.

The landslide system downslope of the site comprises a retrogressing mudslide within landslide debris, largely comprised of disturbed Gault Clay. Typically shallow near surface instabilities are reported to occur i.e. within the upper 3 metres to 4 metres of surface levels. Groundwater levels in this zone have risen by 1 metre to 2 metres above last year's levels, and currently approximately 3 metres below ground level (mbgl) 40 metres downslope of the site reducing to ground level approximately 120 metres downslope of the site. This is consistent with site observations of seepages/springs downslope of the site. The much higher groundwater in the shallow slide complex significantly increases the risk of the instigation of shallow slip surfaces. The increase in groundwater has been included in the stability model to assess the risk of shallow ground movement. It is found that shallow slips in the mudslide downslope of the site have factors of safety below unity and are more likely to fail than the larger slip mechanisms affecting the road directly.

It was recognised during the tender and detailed design that the stability of Undercliff Drive was sensitive to shallow landslides in the ground downslope of the site; this area lies several hundred metres outside of the designated red site and hence stabilisation of this element of the landslide is out of the scope of the current contract i.e. shallow ground movement downslope of the site was considered as a "geological failure mechanism".

The site observations and the stability model indicate that shallow slides downslope of the site had developed, with the formation of much wider tension cracks in the ground downslope of the site; at the same time hairline features and slight reopening of existing defects were apparent in Undercliff Drive. This type of movement would have led to rapid loss of support to the rotational blocks and may explain why the tension cracking and landslip features in Undercliff Drive developed in a relatively short timeframe.

It is noted that the existing drainage discharge pipe was observed to be intermittently exposed and likely to be leaking; surface water features were evident in the proximity of the discharge pipe; it is not clear if they represent one of the same feature. The current discharge system has been repaired and reconnected to the existing drainage pipe that outfalls to the pond at the bottom of the slope.

3. IMPLICATIONS OF FAILURE

- A significant Geological failure occurred prior to the installation of the proposed stabilisation solution for site 9. The failure has extended approximately 150 metres west from the previous defect and extends beyond the zone of support that would have been provided by current ground anchor strengthening solution.
- The geological failure has expressed itself in a relatively short time frame.
- The failure has occurred partly along the previous geological features, but during this event it has extended a significant distance west (by approximately 150 metres) and downslope of the red risk site boundaries, into private land. It is possible that these are new geological features or that the failure has resulted in reactivation of old dormant features.
- Groundwater levels in piezometer 2062 remained above trigger levels after the 2012/13 event. Site inspections carried out during the detailed design showed some evidence that the highway had suffered tension cracking/ settlement.
- From 12 December 2013 groundwater levels rose rapidly and continued to rise significantly higher (approximately 0.88 metres) than those recorded at the time of the 2012/13 failure.
- Site observations indicated that shallow ground movement downslope of the site was occurring in the early stages of landslide development, with tension cracks some two

metres wide seen immediately downslope of the site. Shallow ground movement will have led to loss of support (tension cracks seaward of the exposed rotational blocks) and most likely led to the subsequent reactivation of the smaller rotational blocks and rotational blocks adjacent to the Undercliff. This loss of support may explain why movement occurred relatively quickly in the Undercliff Drive.

- Groundwater levels at the site remain high and there remains a very high risk that movement will continue.

4. INTERIM MEASURES

A large scale geological failure has been initiated and developed in a relatively short time frame. The following measures have been carried out:

- Ground anchor beam was cut to avoid total loss
- Vehicular access is no longer possible due to the landward extent of the failure
- The existing pumped drainage system was diverted over ground to avoid subsurface leakage.
- Monitoring has been established and is continuing.

5. INFORMATION TO ASSESS EXTENT OF GEOLOGICAL FAILURE

The following information and actions have been implemented to assess the extent of the geological failure.

- Review remediation proposals given the revised site conditions
- Continue to collect all monitoring data available to date and rainfall data
- Increase frequency of inclinometer readings to fortnightly
- Monitor surface points in road surface at weekly intervals
- Monitor width of cracks in road surface at weekly intervals
- Carry out regular reviews of monitoring data with Island Roads to assess continuation of movement Resurvey the ground surface seaward of the site along the same cross section as that carried out during the design to establish the change in ground profile once the landslide event is complete
- Once the current landslide event is complete the ground surface seaward of the site should be resurveyed along the same cross-section as that carried out during the design to establish the change in ground profile

6. ESTIMATE FOR TIME FRAME FOR GEOLOGICAL FAILURE RECTIFICATION

At the time of preparing this report the full extent of landslide and its effect on Undercliff Drive Site 9 is unlikely to have been fully realised. Since the first issue of this report ground movement has continued. As a result a full programme for rectification of the red site has not been developed at this stage; this is dependent on the length of time ground movement continues. Ground movement continued for a period of 3 months to 4 months during the 2012/13 landslide

event. A timeframe for rectification will be developed subsequent to this failure report (or as to be agreed with the Isle of Wight Council). The initial outline programme of the proposed actions which have now been completed is given in Appendix D.

7. ESTIMATE OF FAILURE COST

An estimate of failure cost has not been established as the geological failure is still continuing. Given the movement that has occurred the current ground anchor solution is no longer suitable. If the road is to remain in its current alignment then significant fill would be required to raise the road back to an acceptable alignment. Remedial measures, if they were deemed possible, are likely to use a combination of techniques, and most likely include as one of the components deep wells to control groundwater levels. Groundwater control was initially proposed by during the tender stage, however subsequently not taken forward due to environmental restrictions associated with the site. A number of potential remediation proposals are presented in Appendix 5 of the Island Roads Report.

8. REFERENCES

Lee E M and Moore R 1991. Coastal Landslip Potential Assessment: Isle of Wight Undercliff, Ventnor. Report to the DoE.

APPENDIX A

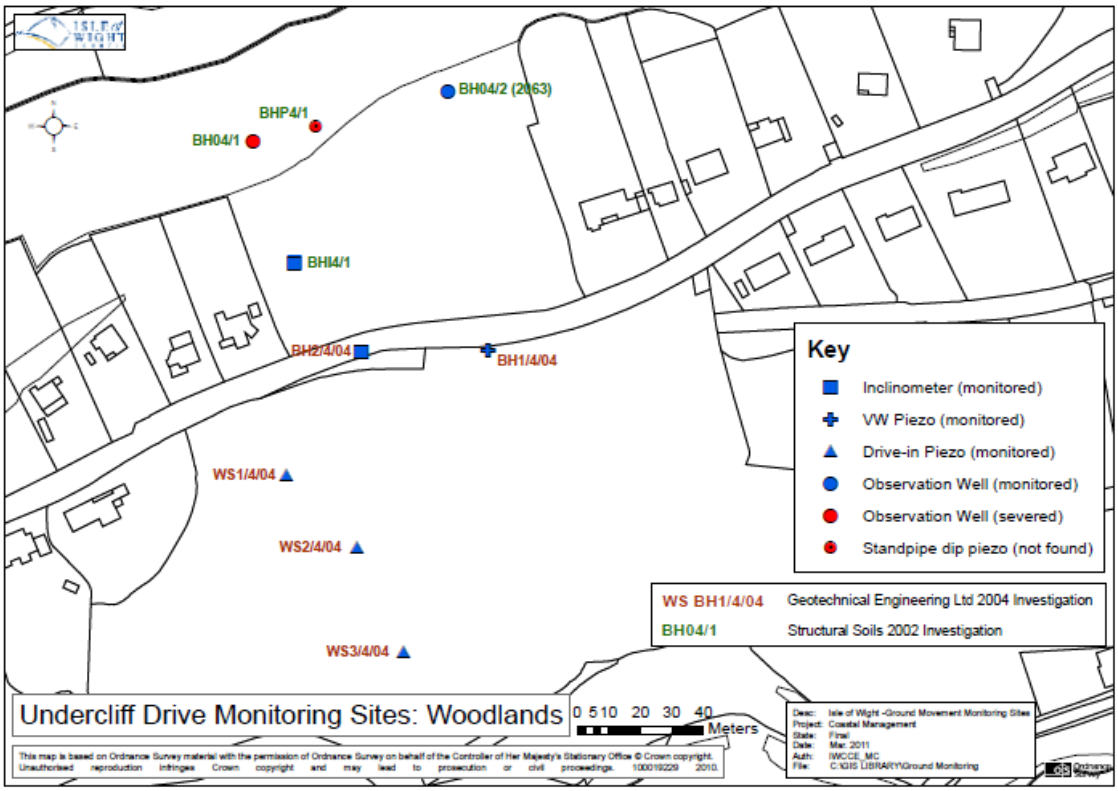
PHOTOGRAPHS

A 1 1 Photo of north west corner of Allenmore showing foundation displacement

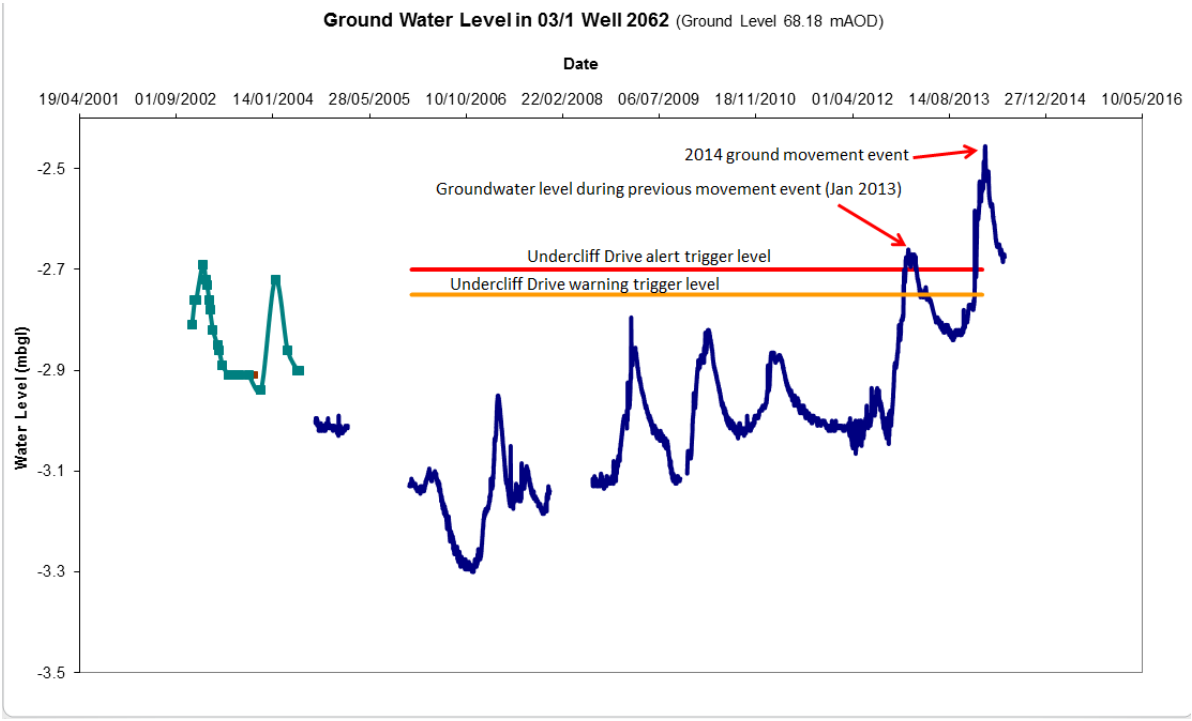
A 1 2 Shallow sliding Downslope of the Site

APPENDIX B

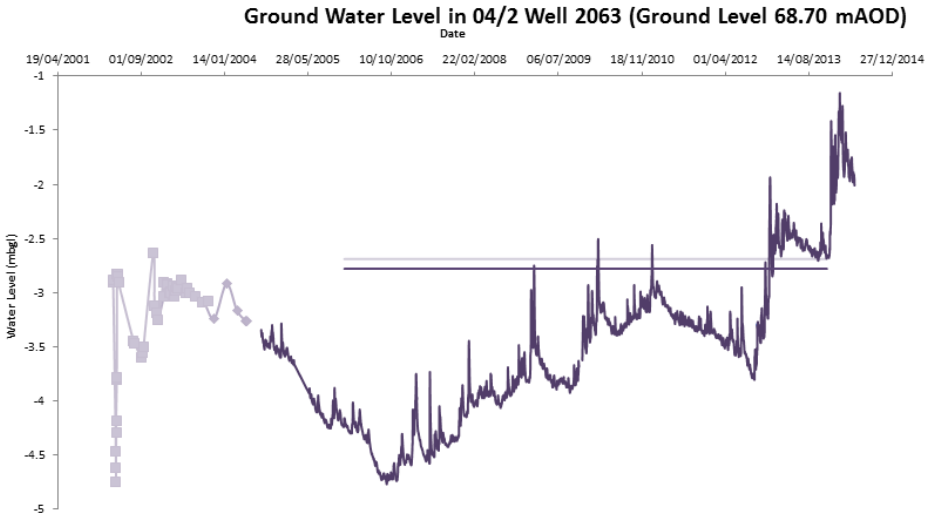
GROUND MONITORING DATA



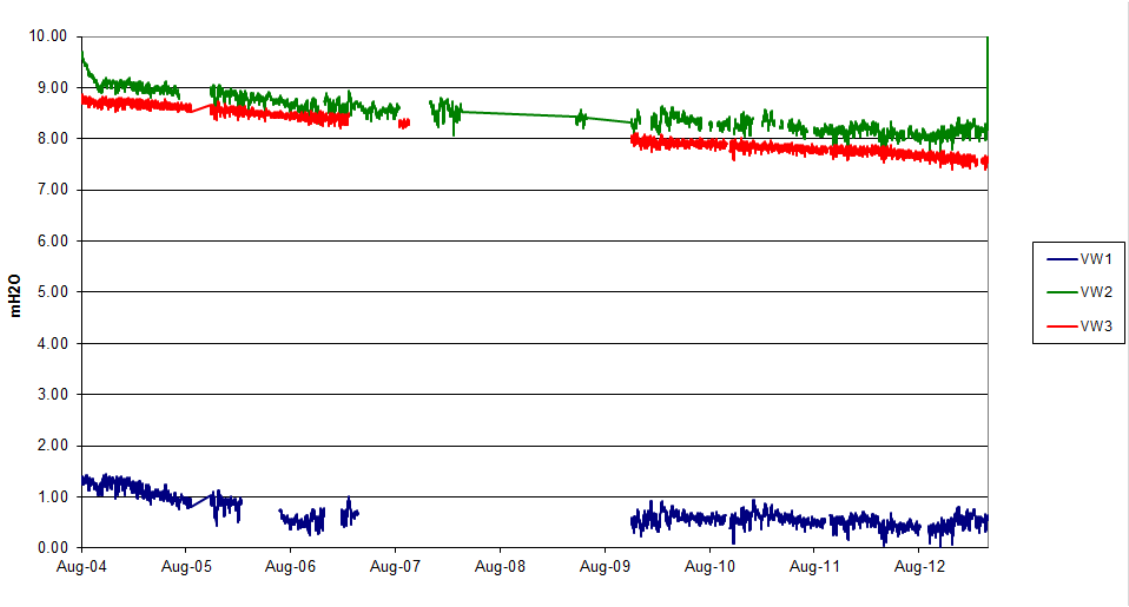
Appendix B- 1 Monitoring Locations, Site 9



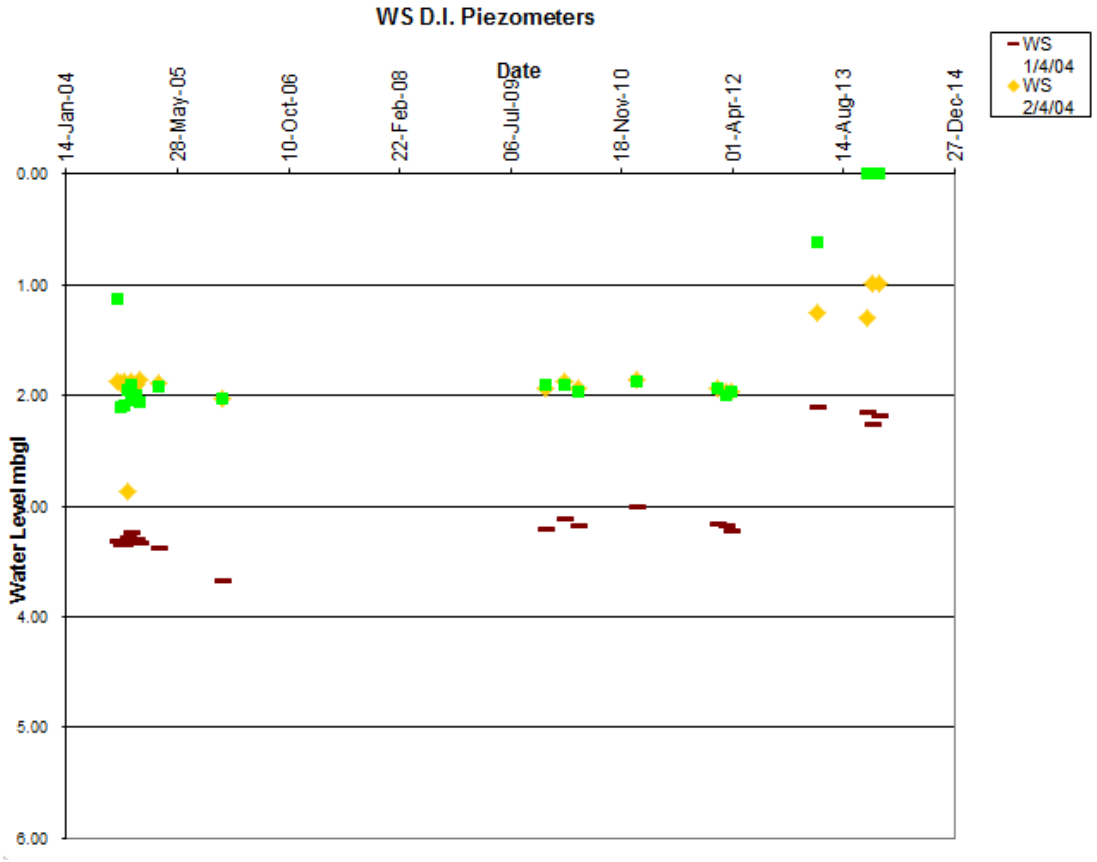
Appendix B- 2 Groundwater Records Well 2062



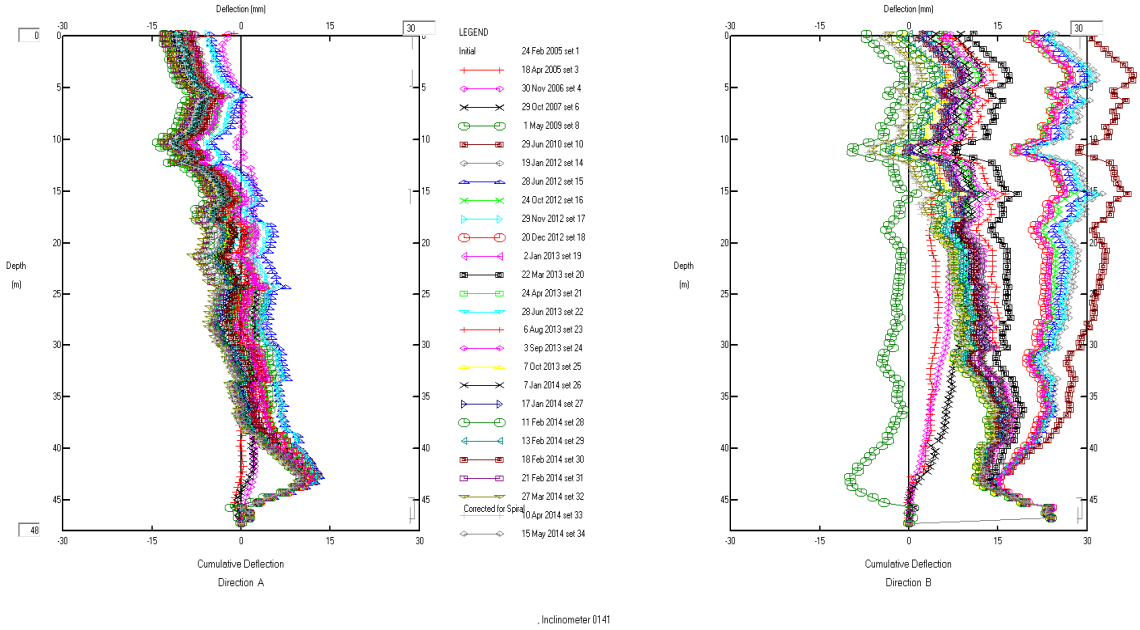
Appendix B- 3 Groundwater Records Well 2063, landward of the Highway



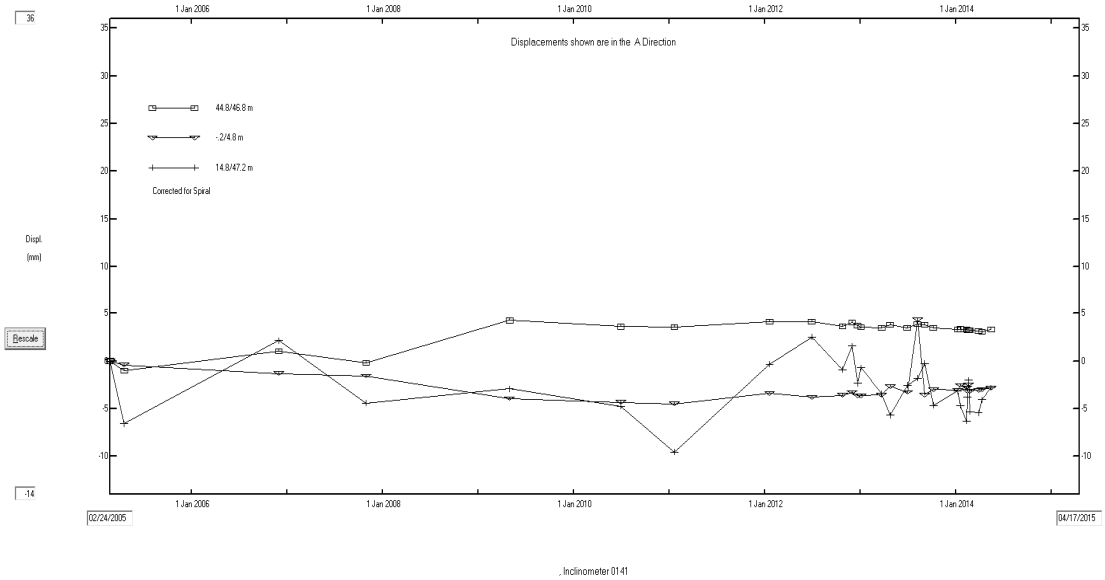
Appendix B- 4 Groundwater Records Vibrating Wire Piezometers 1404 with the Highway



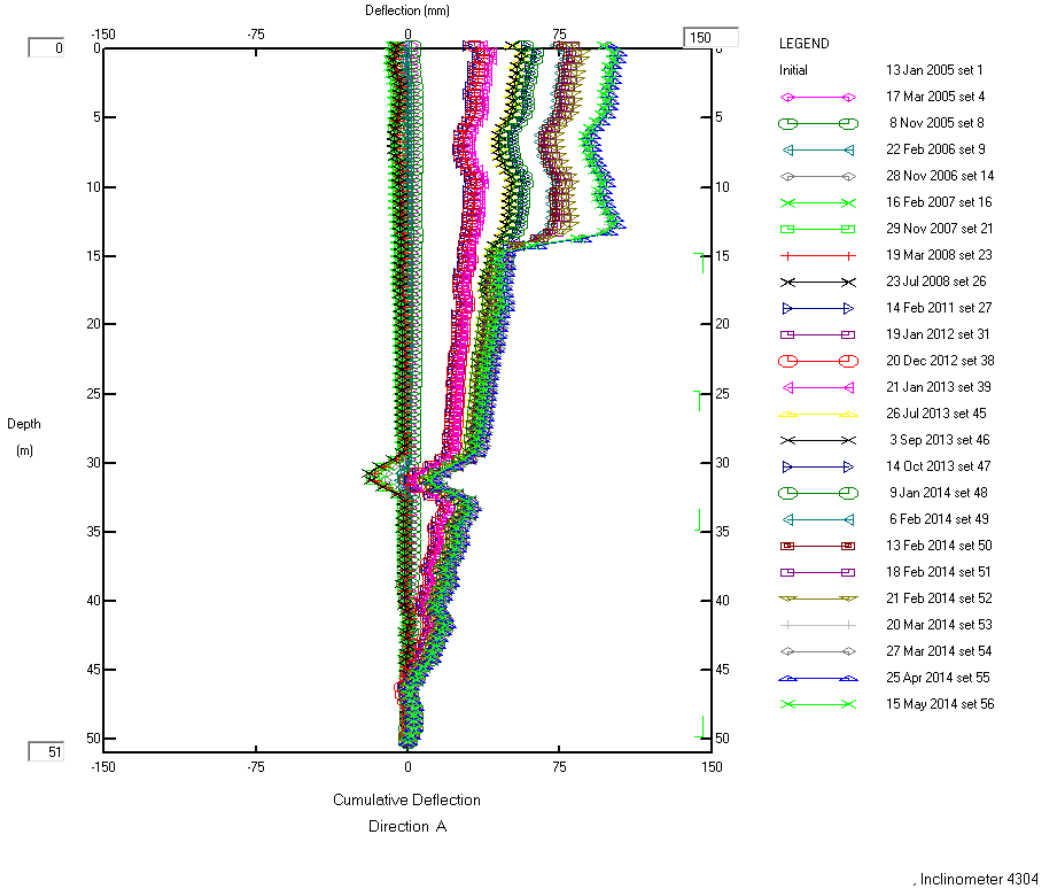
Appendix B - 5 Groundwater Records – Standpipe Piezometers Downslope of the Highway



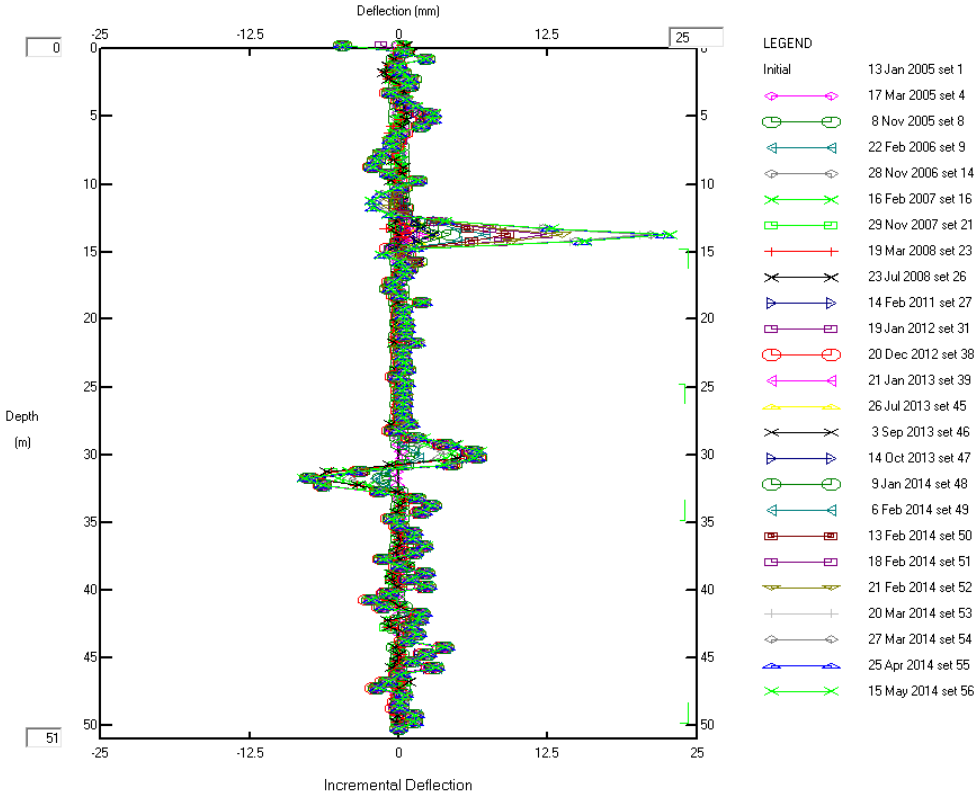
Appendix B- 6 Inclinometer I/4 - cumulative deflection plots



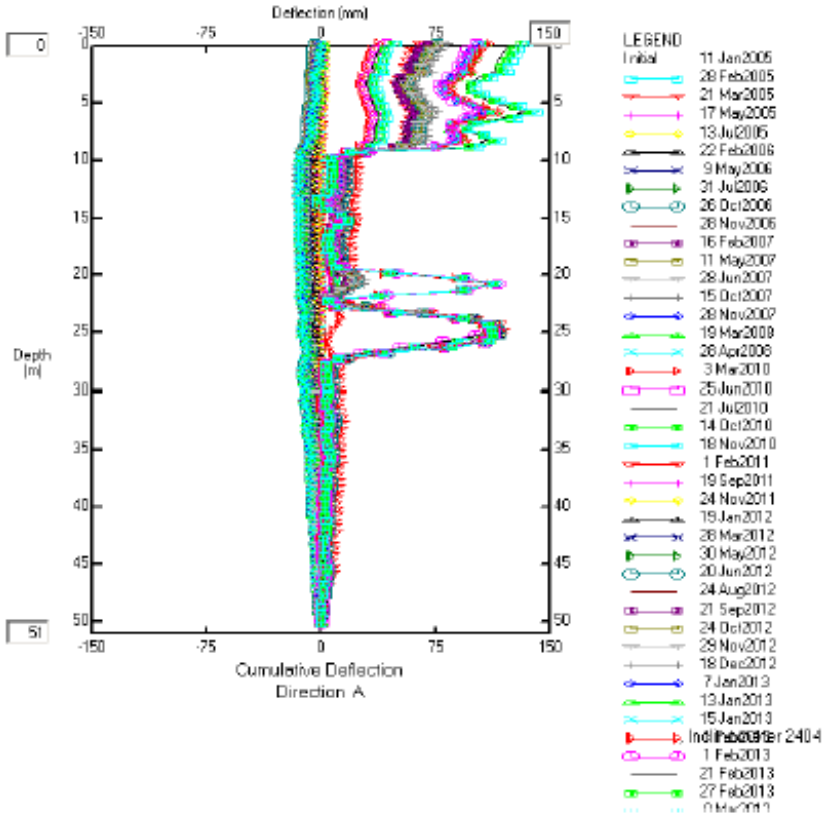
Appendix B- 7 Inclinometer I/4 - rate of displacement plots



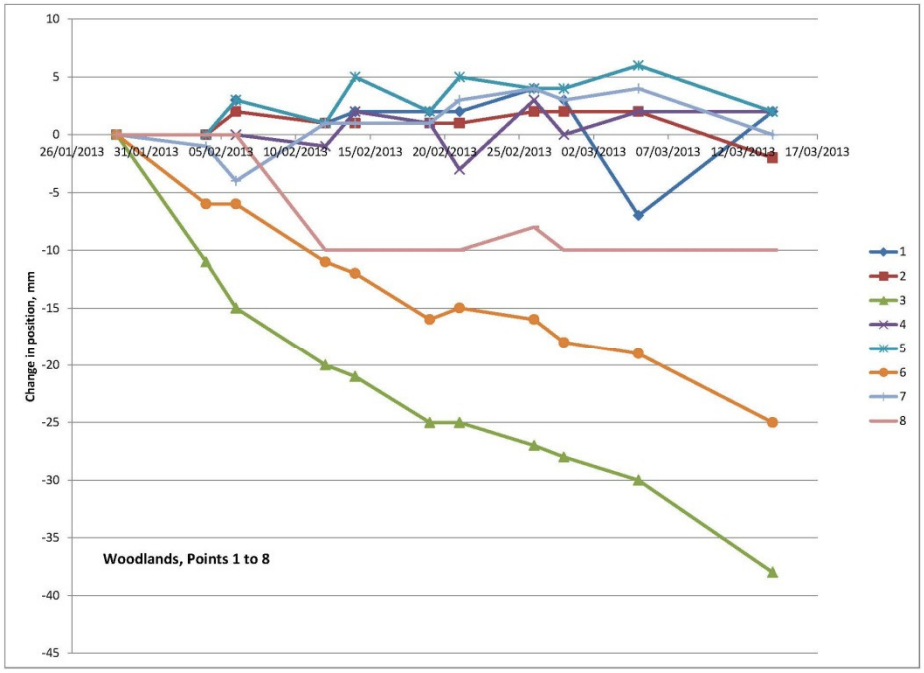
Appendix B- 8 Inclinometer 4304 Cumulative Displacement Plot



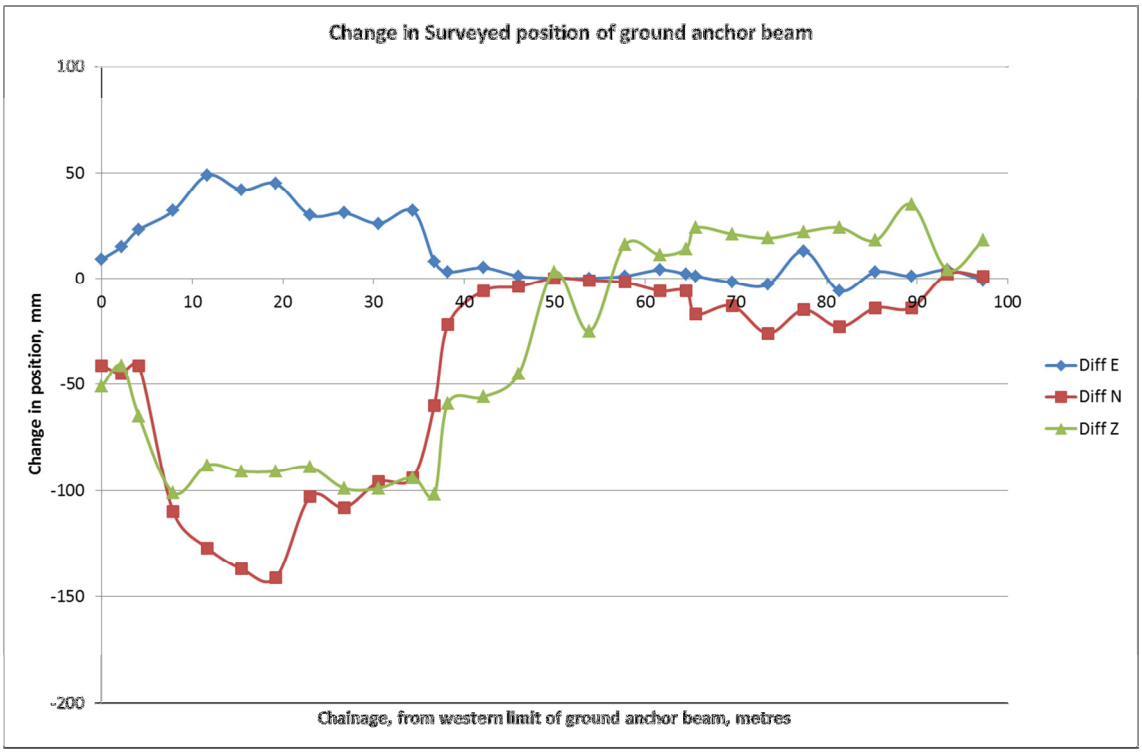
Appendix B- 9 Inclinometer 4304 Incremental Plot



Appendix B- 10 Inclinometer 2404 Incremental Plot. This instrument was severed due to ground movement during January/February 2013.



Appendix B- 11 Surface Monitoring Points Established 2012/13 event

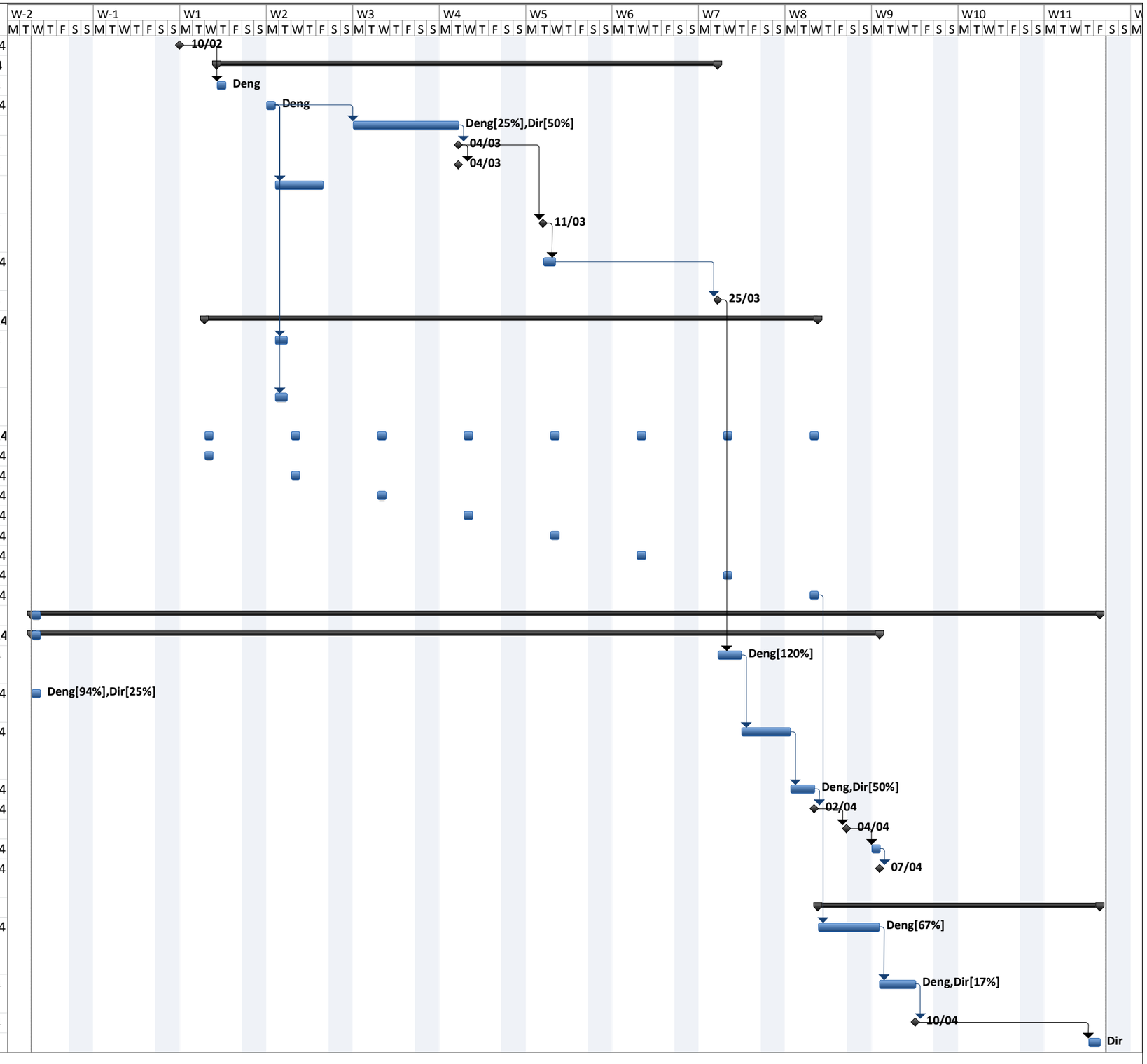


Appendix B- 12 Change in Ground Anchor Beam Level from construction to 14th February 2014 (Movement direction: Diff E: Easting, Diff N: Northing, Diff Z: Level).

APPENDIX C

OUTLINE PROGRAMME

ID	Task Mode	Task Name	Duration	Start	Finish
1		Undercliff 9- Woodlands	0 days	Mon 10/02/14	Mon 10/02/14
2		**Initial Site Review**	**30.47 days**	**Thu 13/02/14**	**Tue 25/03/14**
3		Site Visit	1 day	Thu 13/02/14	Thu 13/02/14
4		Site Visit	1 day	Mon 17/02/14	Mon 17/02/14
5		Prepare Failure Notice	7 days	Mon 24/02/14	Tue 04/03/14
6		Issue Action Plan to IR	0 days	Tue 04/03/14	Tue 04/03/14
7		Meeting IR	0 days	Tue 04/03/14	Tue 04/03/14
8		IR collate monitoring data	4 days	Mon 17/02/14	Fri 21/02/14
9		Finalise Action Plan and issue IR	0 days	Tue 11/03/14	Tue 11/03/14
10		Issue to IOW Council for review	1 day	Tue 11/03/14	Wed 12/03/14
11		Address IOW Comments	0 days	Tue 25/03/14	Tue 25/03/14
12		**Monitoring**	**38.33 days?**	**Wed 12/02/14**	**Wed 02/04/14**
13		Establish surface peg monitoring in landslide forward of site	1 day?	Mon 17/02/14	Tue 18/02/14
14		Establish surface monitoring in road	1 day?	Mon 17/02/14	Tue 18/02/14
15		**Monitoring**	**38.33 days**	**Wed 12/02/14**	**Wed 02/04/14**
16		1	1 day	Wed 12/02/14	Wed 12/02/14
17		2	1 day	Wed 19/02/14	Wed 19/02/14
18		3	1 day	Wed 26/02/14	Wed 26/02/14
19		4	1 day	Wed 05/03/14	Wed 05/03/14
20		5	1 day	Wed 12/03/14	Wed 12/03/14
21		6	1 day	Wed 19/03/14	Wed 19/03/14
22		7	1 day	Wed 26/03/14	Wed 26/03/14
23		8	1 day	Wed 02/04/14	Wed 02/04/14
24		**Failure Report (Cl 12.8)**	**66.67 days?**	**Wed 29/01/14**	**Fri 25/04/14**
25		**Interim Failure Report**	**52.2 days**	**Wed 29/01/14**	**Mon 07/04/14**
26		Review data up to failure	2 days	Tue 25/03/14	Thu 27/03/14
27		Interim monitoring review	1 day	Wed 29/01/14	Wed 29/01/14
28		Assess sensitivity/adequacy of existing solution	2 days	Thu 27/03/14	Mon 31/03/14
29		Prepare report	2 days	Mon 31/03/14	Wed 02/04/14
30		Issue to IR	0 days	Wed 02/04/14	Wed 02/04/14
31		Meeting with IR	0 days	Fri 04/04/14	Fri 04/04/14
32		Address IR comments	1 day	Mon 07/04/14	Mon 07/04/14
33		Issue to IOW Council for review	0 days	Mon 07/04/14	Mon 07/04/14
34		**Finalise report**	**17.67 days?**	**Wed 02/04/14**	**Fri 25/04/14**
35		Review monitoring and incorporate monitoring review	3 days	Wed 02/04/14	Mon 07/04/14
36		finalise assessment of existing	3 days	Mon 07/04/14	Thu 10/04/14
37		Issue Report	0 days	Thu 10/04/14	Thu 10/04/14
38		Meeting with IR	1 day?	Thu 24/04/14	Fri 25/04/14

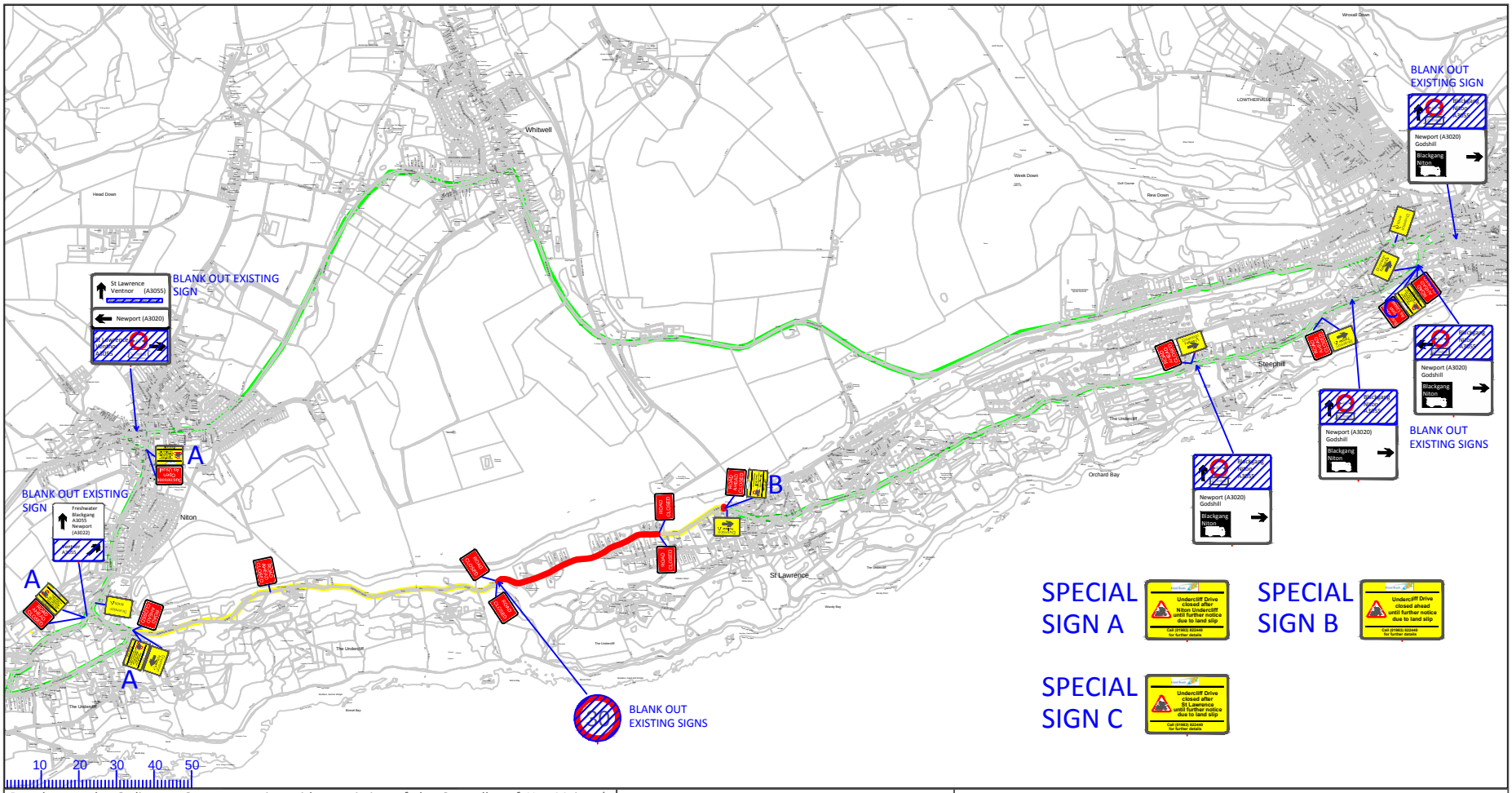


Project: Undercliff 9 Notice programme
Date: Wed 04/06/14

Task	Summary	External Milestone	Inactive Summary	Manual Summary Rollup	Finish-only		
Split	Project Summary	Inactive Task	Manual Task	Manual Summary	Deadline		
Milestone	External Tasks	Inactive Milestone	Duration-only	Start-only	Progress		

APPENDIX 2:

Drawing 1 – Undercliff Drive Landslip Diversion



UNMARKED

Rev.	Description	Initials	Date

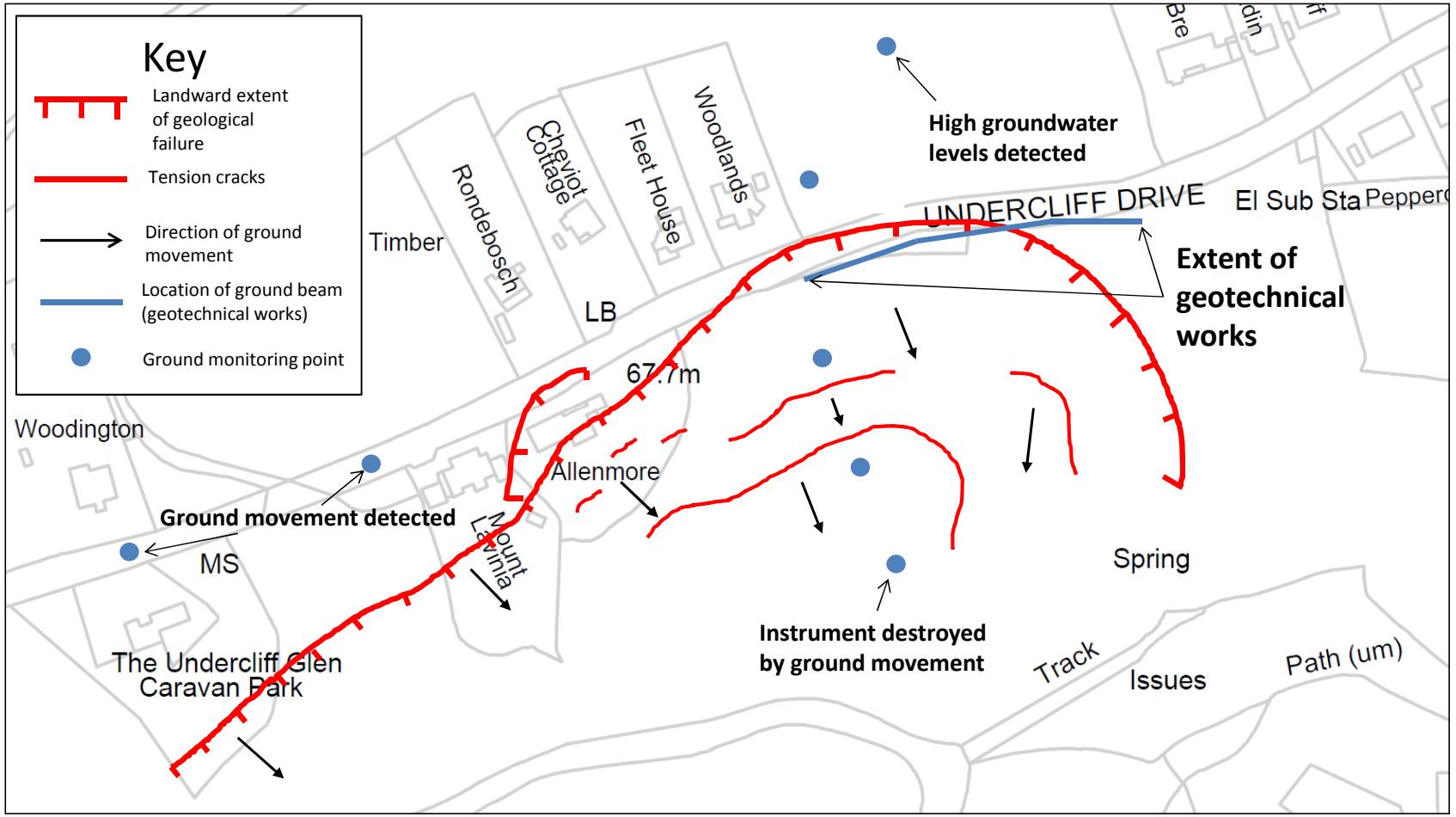
Island Roads

Paul Herbert, Service Director, Island Roads
Island Roads, St. Christopher House, 42 Daish Way, Newport, Isle of Wight, PO30 5XJ

Project	Geological Failure Report Red Zone 9: Woodlands, Undercliff Drive	Drawing Title	Drawing 1: Undercliff Drive Landslip Diversion
Checked	BM IS	Date	30/04/14
Approved	IS	Date	
Scale	Not to scale	Revision	
Classification		Contract Sheet No.	
Drawing Number	1	Sheet x of x	1 of 1

APPENDIX 3:

Drawing 2 – Extent of Ground Movement Along Undercliff Drive (2014 Event)



Notes

Rev.	Description	Initials	Date

Island Roads
St. Christopher House
42 Daish Way
Newport
Isle of Wight
PO30 5XJ

Paul Herbert
Service Director, Island Roads

Classification: UNMARKED

Project

Drawing Title

Drawing 2: Extent of ground Movement along Undercliff Drive

Drawn		Date	
Checked		Date	
Approved		Date	
Scale		Revision	
Contract Sheet No.		Sheet x of x	
Drawing Number			

APPENDIX 4:

Failure Costs Incurred and On-going Costs

Undercliff 9

Costs incurred

Item	Description	Quant	Unit	Rate	Total
	John Peck Construction Costs				
1	Costs from John Peck Construction for A.J Geotechnical Services Ltd (drillers) abortive cost. The cost was a settlement sum to cover the rig and equipment back to the mainland, payment of hotel bookings made, loss of profit due to cancellation of works etc. Island Roads agreed sum	1.00	sum		
2	De-mobilisation of John Peck. Island Roads agreed sumsum	1.00	sum		
3	Site Hoarding as per photos provided in the Geological Failure Report.	1.00	sum		
4	Office and Toilet for security team (period 20/02/14 to 31/03/14)	5.00	weeks		
5	Gateman (period 20/02/14 to 28/02/14)	1.00	sum		
	Reports				
6	Failure Report from Ramboll (note that hopefully as conditions improve, Ramboll will be able to provide further recommendations, the costs of which will be considered seperately at a later date)	1.00	sum		
	Site Security				
7	Heras fencing (hire from Monday 10th February 2014 to 04th May 2014) 22 No panels	12.00	week		
8	Visit to maintain fence line and check security	12.00	visit		
9	Signage	8.00	No		
10	Barriers & cones	1.00	sum		
	Surveys				
11	Weekly Survey costs from Topographical & Engineering Surveys Ltd which commenced 06th March 2014	8.00	week		
	CCTV Cameras				
12	CCTV Cameras (cost split two ways between sites)	1.00	sum		
	Total				**£ 28,345.15**

Ongoing Costs (w/c 05th May 2014 onwards)

Item	Description	Quant	Unit	Rate	Total
1	Weekly Survey Cost from Topographical & Engineering Surveys Ltd	tba	week		
2	Weekly Broadband Cost for CCTV cameras (provisional sum)	tba	week		
3	Weekly site visits to check site	tba	week		
4	Heras Fencing Panels in conjunction with permanent hoarding	tba	week		
	Total	**tba**	**week**	**335.75**	**tba**

APPENDIX 5: Remediation Options and Approximate Costs

Undercliff Highway Options

Key Access Options:

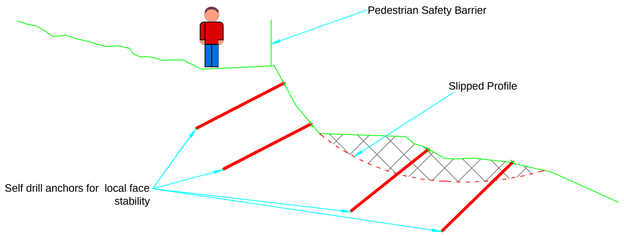
1. Re-establish Pedestrian Access Only
2. Repair and re-open road with access from one direction only
3. Repair and re-open road
4. Establish new inland access route to properties
5. Construct a temporary vehicle access route
6. Permanent road closure

Access Option	Stabilisation Option	Pros	Risks	Prelim outline cost range*
1	Self-drill anchors and pedestrian barrier	No substantial removal of failed material required	Does not address the long term geological risk	£250k - £500k
		Pathway can be moved further inland (north) to reduce requirements for stabilisation of slipped mass	Long term loss of vehicle access	
		Use of flexible footpath surface to absorb minor movements	Will require regular monitoring, inspection, and repair	
		Limited impact on environment		
2	Self-drill anchors and deep wells	Relatively quick construction method	Will require limited change inland of road route	£1m - £2.5m
		Only limited removal of slipped material required	Location still at risk from overall geological failure	
			Will require regular monitoring, inspection, and repair	
			Discharge of water may require new outfall to sea subject to EA Approval and Discharge consent	
			Limited Working area, special measures may be required for safe access	
2	Reinforced Soil Block and Drainage	Will allow route of road along current alignment	Removal of slipped material required, temp works/monitoring needed to reduce	£2m - £4m

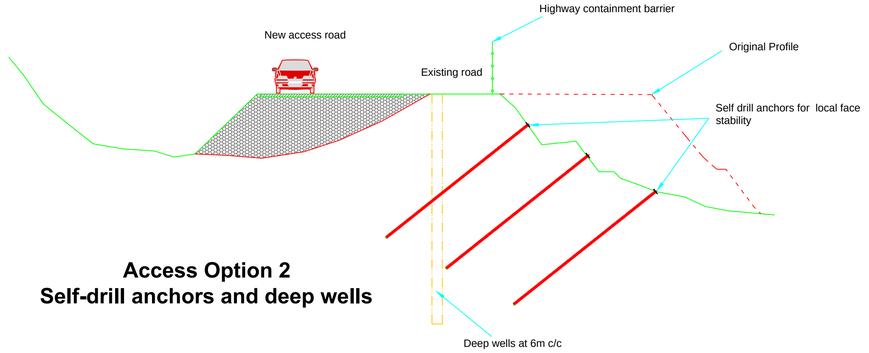
			risk of re-activation of slip	
		Drainage helps address overall geological failure mechanism	Discharge of water may require new outfall to sea subject to EA Approval and Discharge consent	
		'Soft' facing for the reinforced soil works to allow planting	Ongoing monitoring, inspection and maintenance regime required	
			Reduced risk of geological failure but still not complete removal of risk	
			Limited Working area, special measures may be required for safe access	
3	Reinforced soil block with hard facing, drainage, strand anchors	Drainage and strand anchors help address overall geological failure mechanism	Hard facing not in keeping with surrounding environment	£6m - £10m
		Hard facing reduces maintenance requirements	Discharge of water may require new outfall to sea subject to EA Approval and Discharge consent	
			Limited Working area, special measures may be required for safe access	
			The Environmental Impact of the Permanent Works will require approval from EA and associated agencies	
			Reduced risk of geological failure but still not complete removal of risk	
			Removal of slipped material required, temp works/monitoring needed to reduce risk of re-activation of slip	
3	Pile supported road deck	Provide long term solution which is resistant to increased range of geological failures	Significant temporary works required for construction access	£12m - £20m
		Reduced scope of maintenance required	Will require cosmetic measures to bring in keeping with local environment	
		Can be designed to provide long term stabilisation for deep slips but this will	Disturbs sub-surface groundwater environment	

		have a cost implication		
			Potential for slope failure either side of the structure will need to be considered, potential need for non-piled stabilisation at either end of route	
			Long term monitoring required	
4	Up-slope face stabilised by bolting and netting	Provides longer term protection for road and properties	Return visits will be required to stabilise emerging failures	£200k - £500k
		Reduced quality route pavement can be used	Access for works will be difficult, almost certainly roped access	
		Route independent of overall geological failure mechanism	Long term maintenance of rock slope vegetation will be required	
4	Establish rock fall protection structure	Provides long term protection with no upslope measure needed	Rockfalls will still occur therefore continuing property risk	£300k - £500k
		Route independent of overall geological failure mechanism	Protection structure will have a visual impact	
			Protection structure will require regular inspection	
5	Temporary Road at Niton End of Failure	Low Cost	Short Life solution, will require further works in the near future	Less than £100k but will require further expenditure in future
		Low environmental impact	Ongoing monitoring of temporary road and slipped zone will be required	
6	Permanent Road Closure	Low cost and environmental impact	No vehicular or footpath access to properties between 'Woodlands' and Undercliff Glen Caravan Park'	Less than £100k

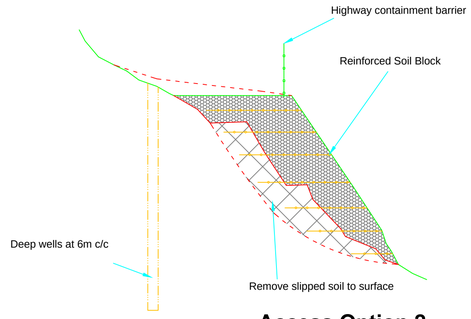
*Preliminary cost estimate based on cost of comparable schemes and industry data. A more detail cost assessment can be produced following further detailing of options and assessment of length of application.



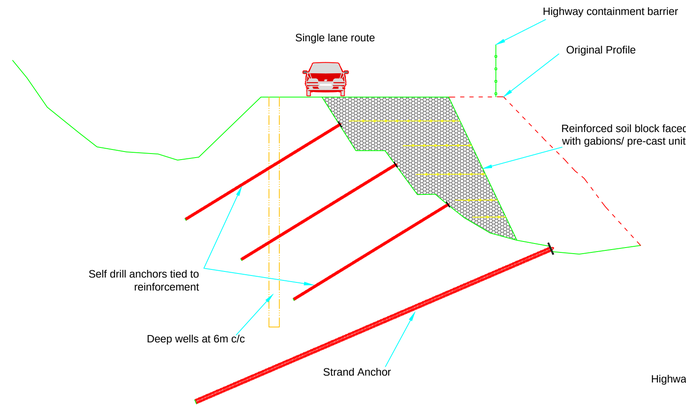
Access Option 1
Self-drill anchors and pedestrian barrier



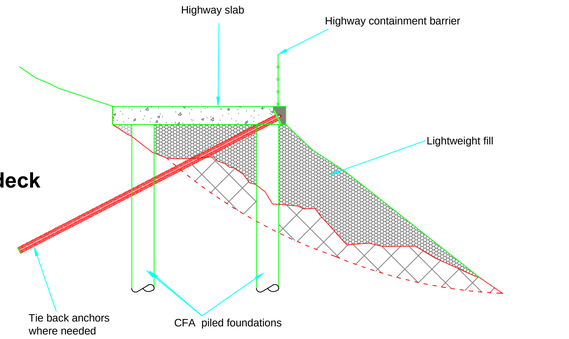
Access Option 2
Self-drill anchors and deep wells



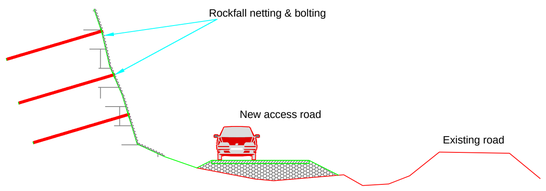
Access Option 2
Reinforced Soil Block and Drainage



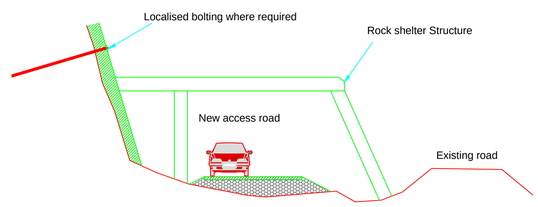
Access Option 3
Reinforced soil block with hard facing, drainage, strand anchors



Access Option 3
Pile supported road deck



Access Option 4
Up-slope face stabilised by bolting and netting



Access Option 4
Rock fall protection structure

Access Option	Stabilisation Option	Pros	Risks	Prelim outline cost range
1	Self-drill anchors and pedestrian barrier	No substantial removal of failed material required	Does not address the long term geological risk	
		Pathway can be moved further inland (north) to reduce requirements for stabilisation of slipped mass	Long term loss of vehicle access	
		Use of flexible footpath surface to absorb minor movements	Will require regular monitoring, inspection, and repair	
		Limited impact on environment		
2	Self-drill anchors and deep wells	Relatively quick construction method	Will require limited change inland of road route	
		Only limited removal of slipped material required	Location still at risk from overall geological failure	
			Will require regular monitoring, inspection, and repair	
			Discharge of water may require new outfall to sea subject to EA Approval and Discharge consent	
			Limited Working area, special measures may be required for safe access	
2	Reinforced Soil Block and Drainage	Will allow route of road along current alignment	Removal of slipped material required, temp works/monitoring needed to reduce risk of re-activation of slip	
		Drainage helps address overall geological failure mechanism	Discharge of water may require new outfall to sea subject to EA Approval and Discharge consent	
		'Soft' facing for the reinforced soil works to allow planting	Ongoing monitoring, inspection and maintenance regime required	
			Reduced risk of geological failure but still not complete removal of risk	
			Limited Working area, special measures may be required for safe access	
3	Reinforced soil block with hard facing, drainage, strand anchors	Drainage and strand anchors help address overall geological failure mechanism	Hard facing not in keeping with surrounding environment	
		Hard facing reduces maintenance requirements	Discharge of water may require new outfall to sea subject to EA Approval and Discharge consent	
			Limited Working area, special measures may be required for safe access	
			The Environmental Impact of the Permanent Works will require approval from EA and associated agencies	
			Reduced risk of geological failure but still not complete removal of risk	
			Removal of slipped material required, temp works/monitoring needed to reduce risk of re-activation of slip	
3	Pile supported road deck	Provide long term solution which is resistant to increased range of geological failures	Significant temporary works required for construction access	
		Reduced scope of maintenance required	Will require cosmetic measures to bring in keeping with local environment	
		Can be designed to provide long term stabilisation for deep slips but this will have a cost implication	Disturbs sub-surface groundwater environment	
			Potential for slope failure either side of the structure will need to be considered, potential need for non-piled stabilisation at either end of route	
			Long term monitoring required	
4	Up-slope face stabilised by bolting and netting	Provides longer term protection for road and properties	Return visits will be required to stabilise emerging failures	
		Reduced quality route pavement can be used	Access for works will be difficult, almost certainly roped access	
		Route independent of overall geological failure mechanism	Long term maintenance of rock slope vegetation will be required	
4	Establish rock fall protection structure	Provides long term protection with no upslope measure needed	Rockfalls will still occur therefore continuing property risk	
		Route independent of overall geological failure mechanism	Protection structure will have a visual impact	
			Protection structure will require regular inspection	
5	Temporary Road at Niton End of Failure	Low Cost	Short Life solution, will require further works in the near future	

NOTES

Key Access Options:

1. Re-establish Pedestrian Access Only
2. Repair and re-open road with access from one direction only
3. Repair and re-open road
4. Establish new inland access route to properties

Rev.	Description	Drawn	Chkd.	Apprvd.	Date
-	FOR REVIEW	SKH	RA	SLW	20.05.14

Client: Island Roads

Project: ISLE OF WIGHT HIGHWAYS PFI

RAMBOLL
tel 023 8081 7500 fax 023 8081 7600 southampton@ramboll.co.uk
www.ramboll.co.uk

Drawing Title: UNDERCLIFF DRIVE
HIGHWAY STABILISATION OPTIONS
FOR REVIEW

Scale (at A1): AS SHOWN | Date: MAY 14 | Drawn: SKH

Drg. no.: 61030594/9/SK/600/06 | Rev.: -

10 0 10 20 50 100mm NATURAL SCALE

ORIGINAL DRAWING SIZE 841 x 594

Island Roads

www.islandroads.com