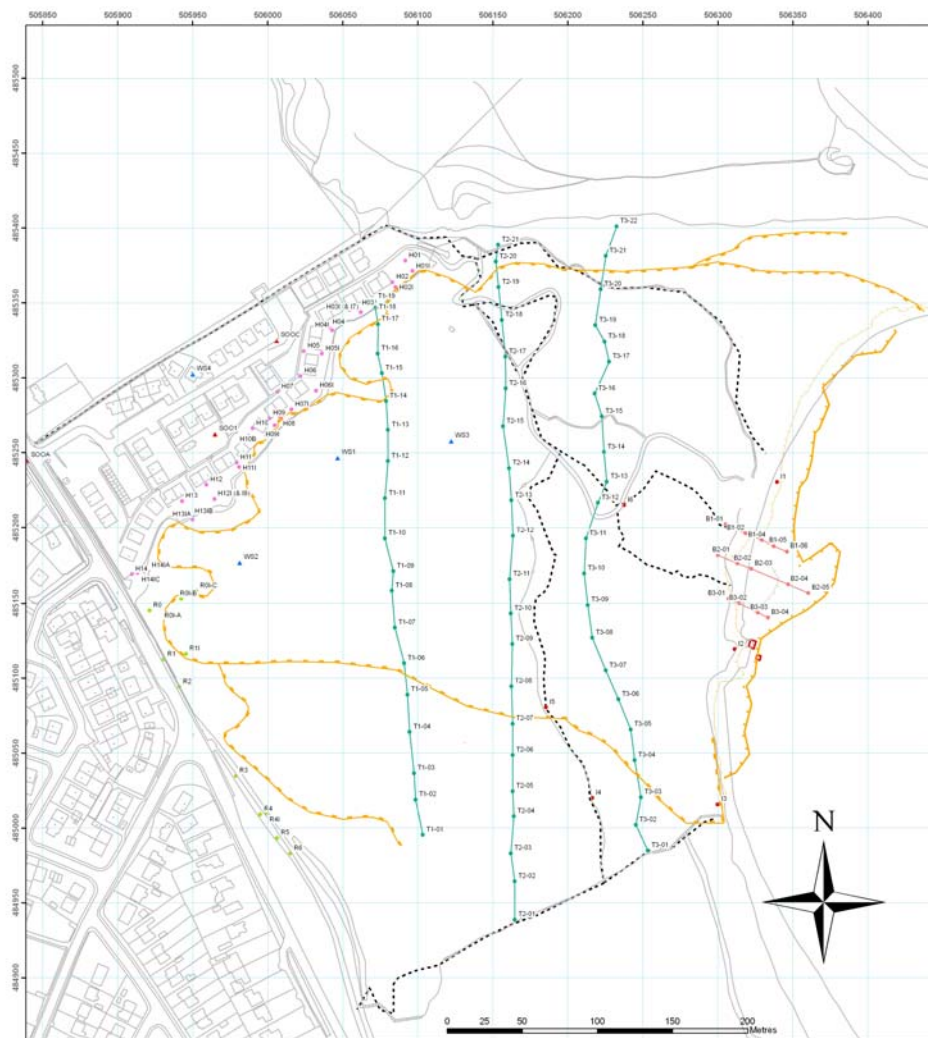


Cayton Cliff & Cornelian Bay, North Yorkshire Monitoring Report

Report No.: 007 Issue Date: 17.3.09

Monitoring data and analysis:

1. Ground Marker Network: February 2009 (30.1.09- 2.3.09)
2. Groundwater: 5.12.08- 27.2.09
3. Rainfall: Scarborough (1995- January 2009)
Knipe Point (11.12.08- 28.2.09)



Legend

Active Landslide (2 May)

Survey Points (23-24 April)

- Kinpe Point Headscarp Pin
- A165 Headscarp Pin
- Transect Pin (Landslide Body)
- Transect Pin (Landslide Toe/ Beach)
- Fixed Inspection Point
- Water Sampling Point
- Local Survey Control Network Point

Survey Lines (23-24 April)

- Path
- Pillbox
- Transect (Landslide Toe/ Beach)
- Transect (Landslide Body)
- Remnant Boulder Arc
- Cliff Toe
- Landslide Toe Platform

Monitoring Layout Cayton Cliff, North Yorkshire (Version 6.5.08)

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Client

The National Trust

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Knipe Point Headscarp Recession

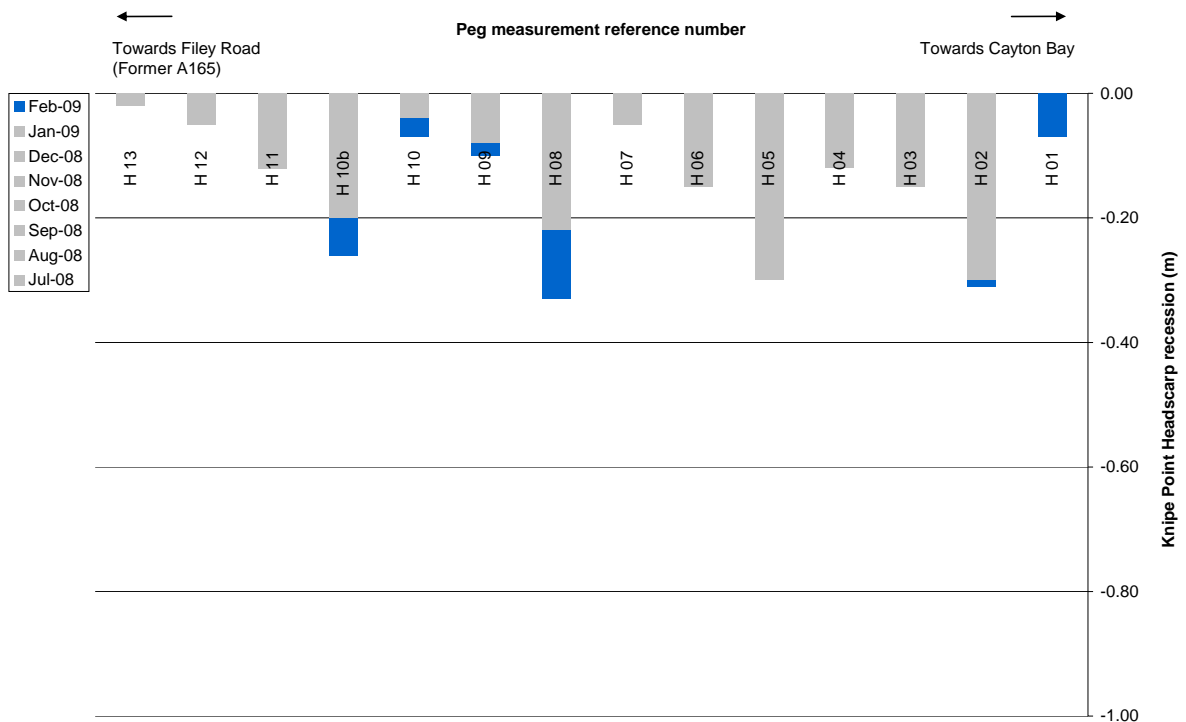


KEY RESULTS

- Recession measured at 6 pins during February (equal or less than 0.1 m monthly). Focus of activity between H08 and H10b
- Block displacement near H11/ H10b, remains active (Photo 1)
- Recent gully of the scarp face near H9 due to surface water runoff; renewed activity underlying the headscarp at H06, H07, H11, & H13; and fresh tension cracking beneath the headscarp (H09 to H12) (Photo 1)

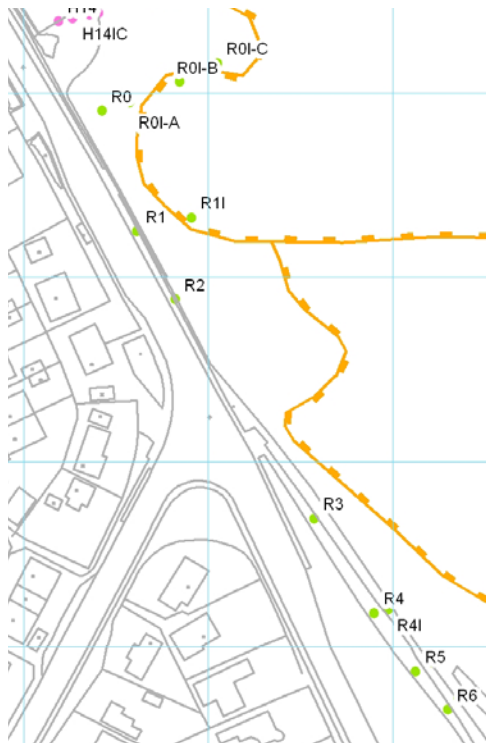
RECOMMENDATIONS

- Continue twice weekly (Tue. & Fri.) observations and monitoring
- Carefully observe and monitor the developing headscarp recession failures between H06 & H13
- **Maintain vigilance through the winter. Owing to potential seasonal rainfall and elevated groundwater, the risk of ground movement and cliff recession is much increased**



Note: bars in the graph show total monthly recession measured since 1.7.08. Refer to user notes at the end of this report. Average monthly error of ± 0.04 m.

Former A165, Filey Road, Headscarp Recession

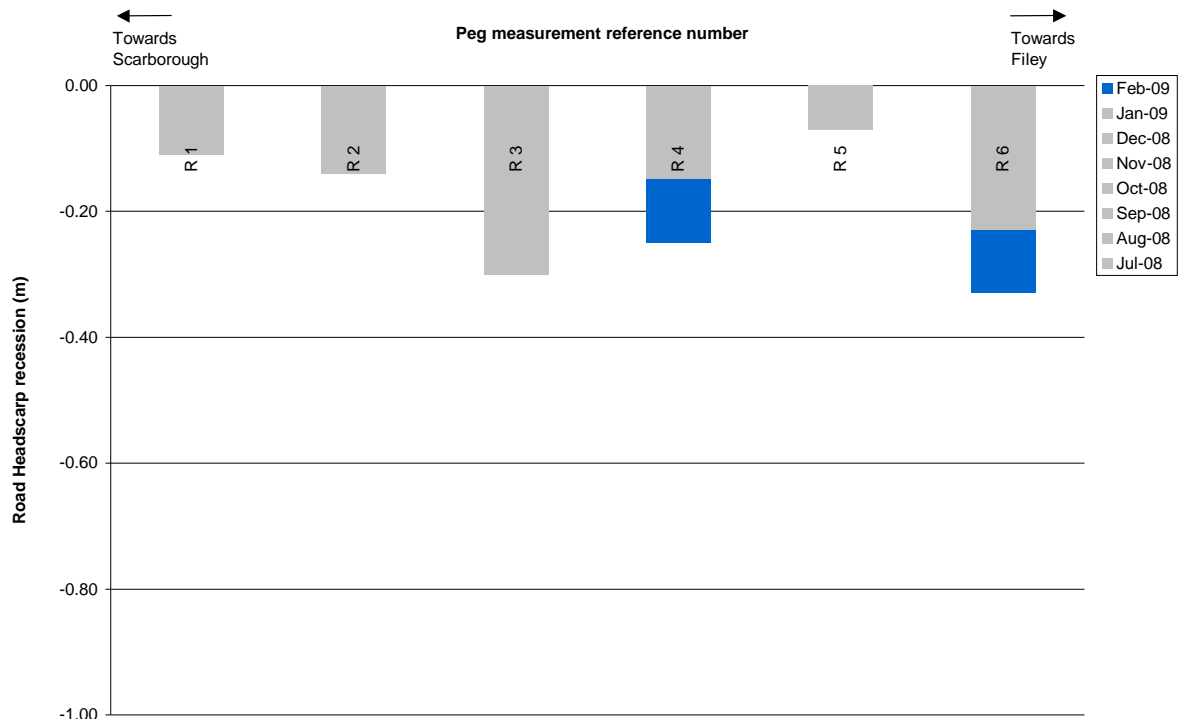


KEY RESULTS

- No significant recession of the headscarp observed; the changes indicated by the graph are likely to reflect measurement error rather than real change
- A surface crack and shallow depression along the road between R0 and R1 was reported on 1.8.08. The crack is being monitored by SBC
- Recent, small, shallow slides/ flows seaward of the road, at locations of pre-existing activity

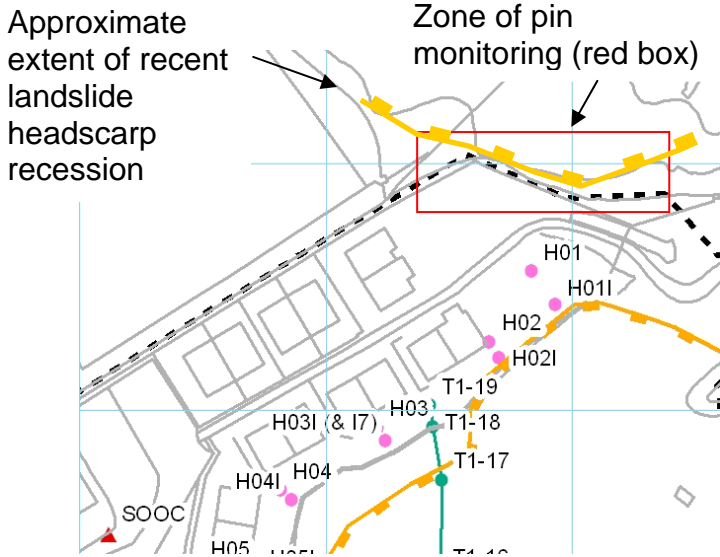
RECOMMENDATIONS

- Continue twice weekly (Tue. & Fri.) observations and monitoring
- Record any change to the road surface and verge, between R0 to R2
- **Maintain vigilance through the winter. Owing to potential seasonal rainfall and elevated groundwater, the risk of ground movement and cliff recession is much increased**



Note: bars in the graph show total monthly recession measured since 1.7.08. Refer to user notes at the end of this report. Average monthly error of ± 0.06 m.

Cornelian Bay Headscarp Recession

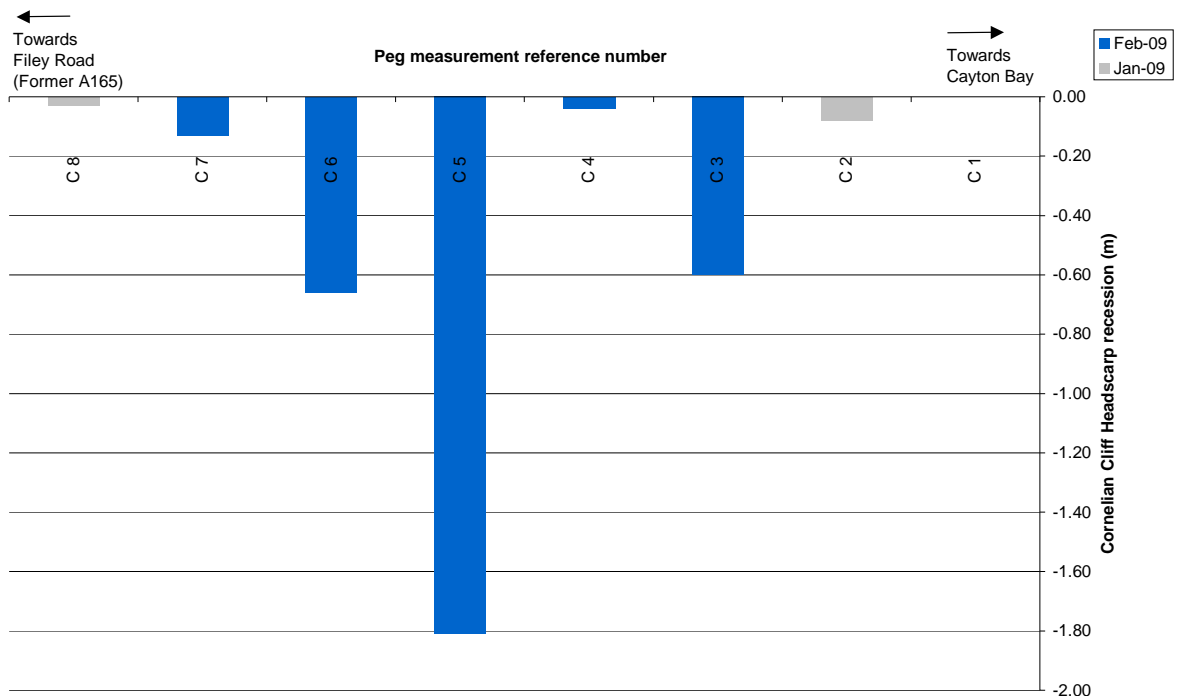


KEY RESULTS

- This landslide headscarp remains around 75-100 m in length. The fresh scarp continues to recede inland (up to 1.8 m), steepen, and increase in height. Underlying failure blocks, and broken drainage pipes continue to be displaced downslope (Photo 2)
- The headscarp now adjoins the boundary fence line around pins C5 and C6 (Photo 2)
- The pin network has been extended inland to allow the continued monitoring of future headscarp recession

RECOMMENDATIONS

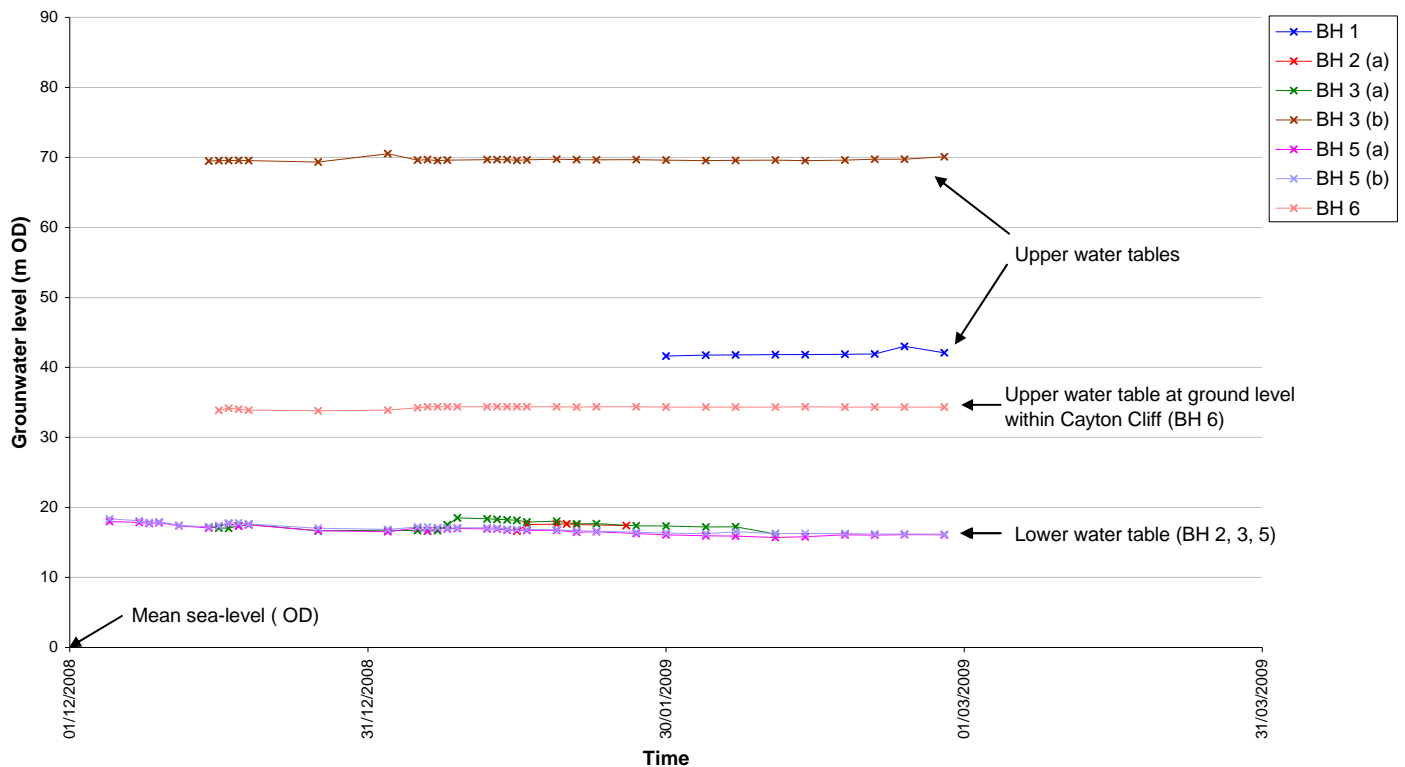
- Continue twice weekly (Tue. & Fri.) observations and monitoring
- Review fence line ownership and repositioning options, in the event that continued recession undermines the current boundary



Note: bars in the graph show total monthly recession measured since 12.1.09. Refer to user notes at the end of this report. Average monthly error of ± 0.04 m.

Groundwater Conditions

Cayton Cliff and Knipe Point Groundwater Levels



KEY RESULTS

- BH 2 (b) and BH 4 are not shown as no water strikes are currently detected
- Existence of a lower water table (BH 2, 3, & 5) which has ranged 15.7-18.5 m O.D.; with a trend of slightly reduced levels over the last few months
- Overlying upper water tables at BH 1 and BH 3
- BH 6 the water level is at or near to the ground surface

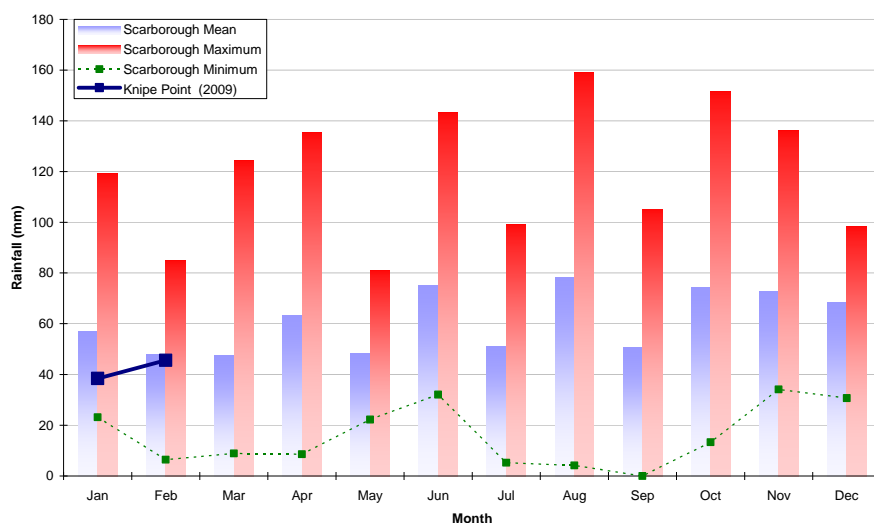
RECOMMENDATIONS

- Maintain operation of the boreholes (as currently specified)
- Undertake maintenance of boreholes (BH 2, BH 3, BH 4) to achieve full working

Rainfall Conditions

A. Monthly

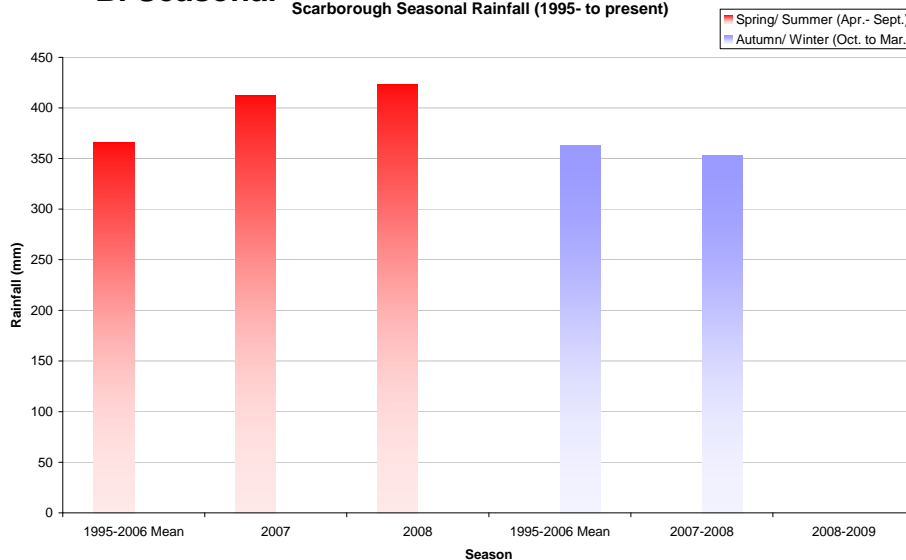
Monthly rainfall at Scarborough (1995-2006), & Knipe Point (2009)



Month	Scarborough average (1995-2006) mm	Scarborough (SN: 2291)		Knipe Point	
		mm	% of average	mm	% of average
Dec. 2008	68.6	64.2	-6 %	43.8 (65% complete)	N/A
Jan. 2009	57.1	39.1	-32 %	38.4	-33 %
Feb. 2009	48	No data	No data	45.6	-5 %

B. Seasonal

Scarborough Seasonal Rainfall (1995- to present)



Season(s)	Scarborough Spring/ Summer (April- September)		Scarborough Autumn/ Winter (October- March)	
	mm	% of average	mm	% of average
1995-2006 (Average)	365.8	N/A	363.0	N/A
2007	412.0	+13 %	-	-
2007-2008	-	-	353.1	-3 %
2008	423.4	+16 %	-	-
2008-2009 (until end of Jan.)	-	-	Still to be calculated	Still to be calculated

KEY RESULTS (MONTHLY)

- Knipe Point weather station operational by 11.12.08, at 80 m O.D.
- Rainfall at Knipe Point and Scarborough are similar so far
- December 2008 was of near average wetness
- In contrast January 2009 was much drier than average (-33%). Although February 2009 was near average

KEY RESULTS (SEASONAL)

- Mean rainfall across spring-summer and autumn-winter seasons are near equal
- Spring-summer 2007, prior to the Cayton Cliff landslide reactivation, was 13% wetter than average
- Spring-summer 2008 was 16% wetter than average
- Recent autumn-winter seasons have been drier than average, although landslide failure events have still followed (e.g. Cayton Cliff 1.4.08)
- The 2008-2009 autumn-winter may turn out to be significantly drier than the norm, which may reduce the likelihood of major landslide reactivation as we approach spring

RECOMMENDATIONS

- Maintain operation and maintenance of the Knipe Point weather station (as currently specified)

Photo 1: Ongoing failure and recession of the Knipe Point headscarp (A: 30.1.09; B: 27.2.09)

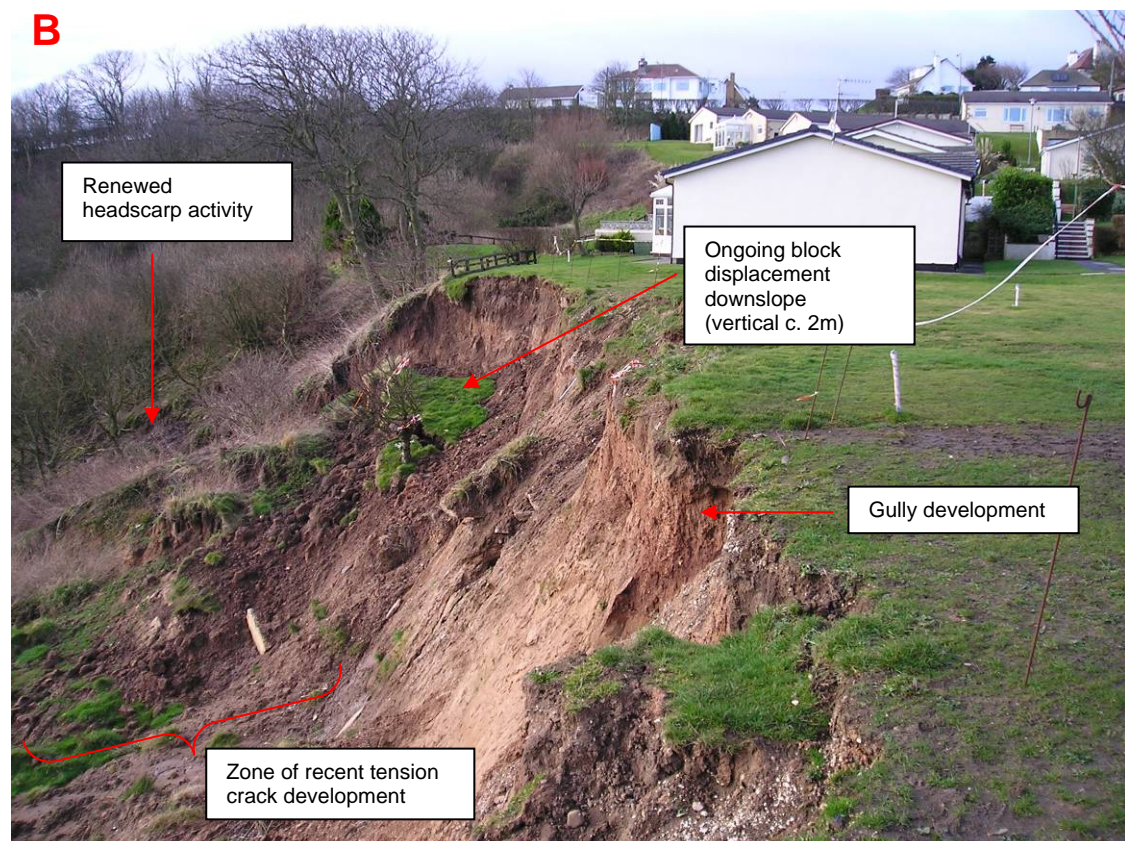


Photo 2: Shallow slide development in the Cornelian Bay landslide basin
(Immediately north of Knipe Point) (A: 20.1.09; B & C: 27.2.09)



USER GUIDE

1. Background to the report:

A major reactivation of the Cayton Cliff landslide complex occurred on 1st April 2008. The landslide has led to recession of the headscarp and the loss of three bungalows at Knipe Point in April and May 2008. Further cliff top property, major services, and Filey Road (former A165) are at risk from landslide activity and headscarp recession in the future. More recent (post October 2008) headscarp recession at Cornelian Bay is also ongoing, adjacent to the Knipe Point residential area.

An observation and monitoring strategy has been developed for the site. This now comprises:

- Regular survey of a fixed ground marker network**, which permits an assessment as to whether these landslides are changing or not. *Operational since April 2008;*
- Regular survey of sub-surface groundwater levels**, within the boreholes drilled for the site ground investigation. This provides a record of the changing levels of groundwater that is important in the control of ground movement. *Operational since December 2008-January 2009;*
- Continuous automatic recording of weather conditions** (rainfall, air and ground temperature) at Knipe Point, which influence groundwater conditions. *Operational since December 2008.*

These monitoring reports provide a technical summary of the observation and monitoring results to inform stakeholders of present and future forecast landslide activity, and potential consequences at Cayton Cliff and part of the Cornelian Bay landslide.

2. Monitoring methodology:

a) Slope observation and monitoring (surface)

This comprises a ground marker network installed in specific landslide areas (See Table 1). Observations and taped measurements of the landslides are made from these markers. For example, at the headscarp, regular measurements are made from a fixed marker to features of interest (e.g. the edge of headscarp) (Figure 1). All measurements are recorded on a monitoring record sheet.

Tension cracks are also noted, as these extension fractures are commonly associated with landslide induced ground movement (Figure 2).

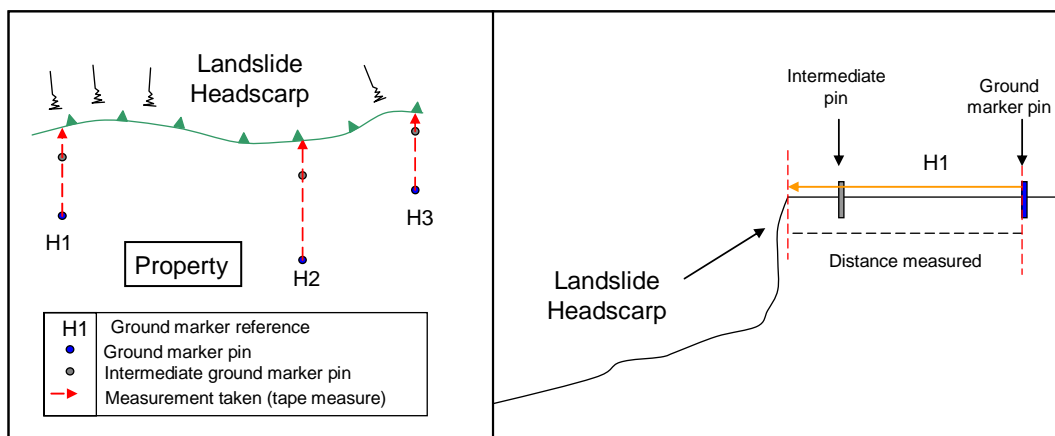


Figure 1. Schematic of ground marker measurement at the Headscarp

Landslide area	Monitoring components	No.	Purpose
Knipe Point Headscarp	Measurement pins	15	Measure headscarp recession and evidence of tension cracks
	Field observation points	3	Visual observations of change
A165 Headscarp	Measurement pins	7	Measure headscarp recession and evidence of tension cracks
Cornelian Bay (Jan. 2009)	Measurement pins	8	Measure headscarp recession and evidence of tension cracks

Table 1. Summary of the ground marker network

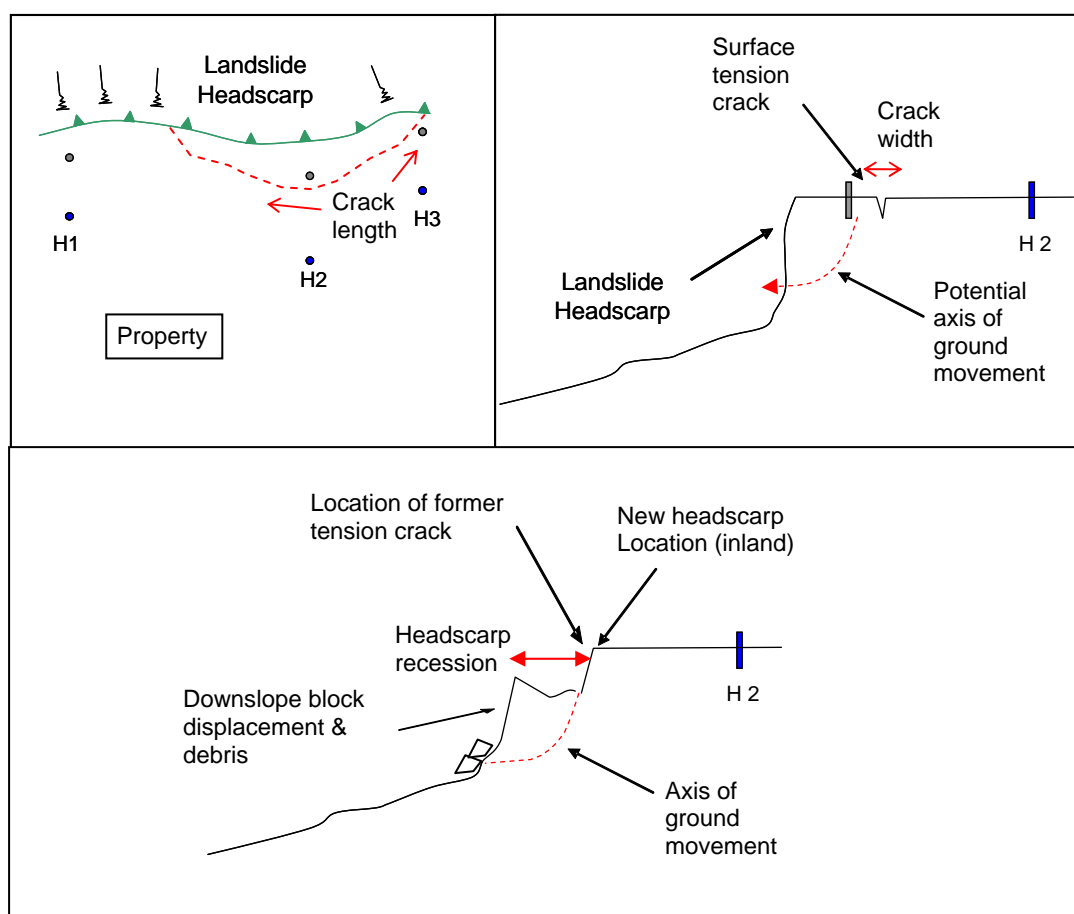


Figure 2. Schematic of tension cracking, and subsequent block displacement (ground movement) at the headscarp, and their measurement axes

b) Groundwater (sub-surface)

Six boreholes of variable depth (56 to 110 m below ground level) were drilled between October 2008 and January 2009 (Figure 3 shows their locations); these have either one or two piezometer standpipe tubes installed within. These tubes permit the measurement of sub-surface groundwater levels across selected rock and soil layers. Water levels are detected by lowering a water sensor (a dip meter) from the ground surface (Figure 4), and the presence/absence and depth of water are recorded on a monitoring record sheet. Table 2 summarises the key characteristics of these installations.



Figure 3. Borehole locations at Cayton Cliff and Knipe Point

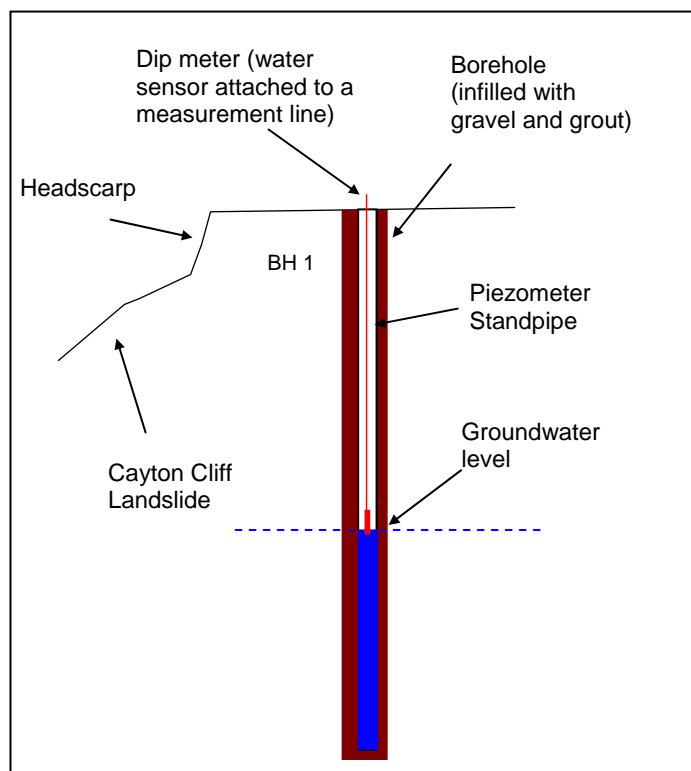


Figure 4. Schematic of ground water level measurement

Borehole Number	Location	Number of Installations	Installation ground level (m O.D.)	Drilled depth (below ground level, m)	Piezometer basal depth (below ground level, m)
1	Next to former A165	1	86.1	110.0	45
2	Knipe Point car park, near garages	2	86.6	97.4	a) 97 b) 25
3	Knipe Point, next to no. 20	2	79.1	95.8	a) 75 b) 38
4	Knipe Point, next to no. 7	2	70.0	90.2	b) 90 a) 63
5	Cayton Cliff woodland (access closed)	2	30.1	75.7	a) 75 b) 32
6	Cayton Cliff woodland (access closed)	1	34.4	56.3	30

Table 3. Summary of the borehole monitoring network

c) Weather conditions

An automatic weather station, installed mid-December 2008, has since recorded air and ground (-0.1m) temperature conditions, and rainfall amounts every 10 minutes. These records are stored electronically by an in-built data logger (small computer), which are downloaded once every 2 weeks, when the weather station is also maintained.

3. Analysis of monitoring results

a) Ground marker network:

Field measurements are entered into a master database, and measurement errors are identified and calculated (average standard deviation). The data are plotted on a graph to show the amount of recession recorded by month, since 1st July 2008 (Figure 5). The graphs reveal that headscarp recession is sporadic over time with some locations and time points recording no recession (i.e. no change is shown on the graph). Other locations show a variable amount of recession from one time to another confirming the unpredictable nature of headscarp recession due to variable weather and ground conditions.

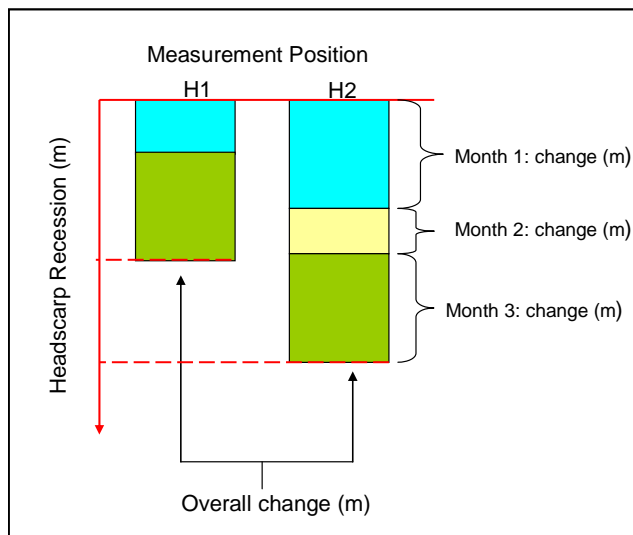


Figure 5. Explanation of cumulative change

b) Groundwater & Rainfall

These data are entered into a master database, where they are analysed and plotted onto graphs to reveal trends over time.

4. Where is your property at Knipe Point?

Figure 6 provides a plan of the properties at Knipe Point. This will help locate a property relative to the preceding maps of the observation and slope monitoring network.

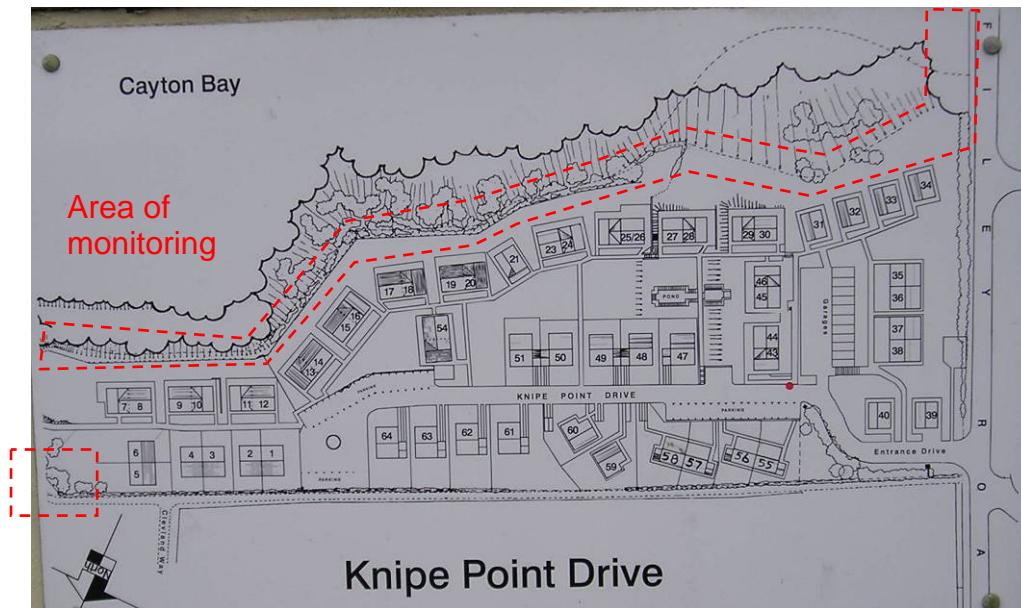


Figure 6. Map of the Knipe Point Development