# The Stability of the Victorian Clay Railway Embankment in Grange Park, London N21

# The Effects of Tree Felling and Vegetation Removal


**By Peter Johns**
**On Behalf of The N21 Rail Action Group**

## Introduction

Network Rail has recently carried out the total clearance of trees and vegetation either side of the railway line at Grange Park. Embankment stability and the safe running of a railway line on a potentially unstable embankment has been advanced as reasons for these works.

As a retired civil engineer, with over thirty years experience working in soil mechanics, I have major concerns about the work that Network Rail is undertaking and believe that the reasons put forward by Network Rail for the vegetation clearance are probably a "red herring".

**There is a large body of academic literature which supports the view that tree roots reinforce clay slopes rather than destabilise them.** This is because tree roots suck moisture from the clay which becomes stiffer and stronger as a result. However, it is my contention, backed up by numerous academic papers, that the felling of trees poses even greater risks to the stability of an embankment. Where there are trees present, the roots contribute to the stability of the soil; however, once trees are felled, the roots gradually decay, leaving passages within the embankment into which water can now penetrate, softening the clay and weakening it further.

This is a phenomenon well known and understood in the field of building foundation design. Further information can be found under “Foundation Design in Relation to Ground Movements – the effects of vegetation – Ref. 1.

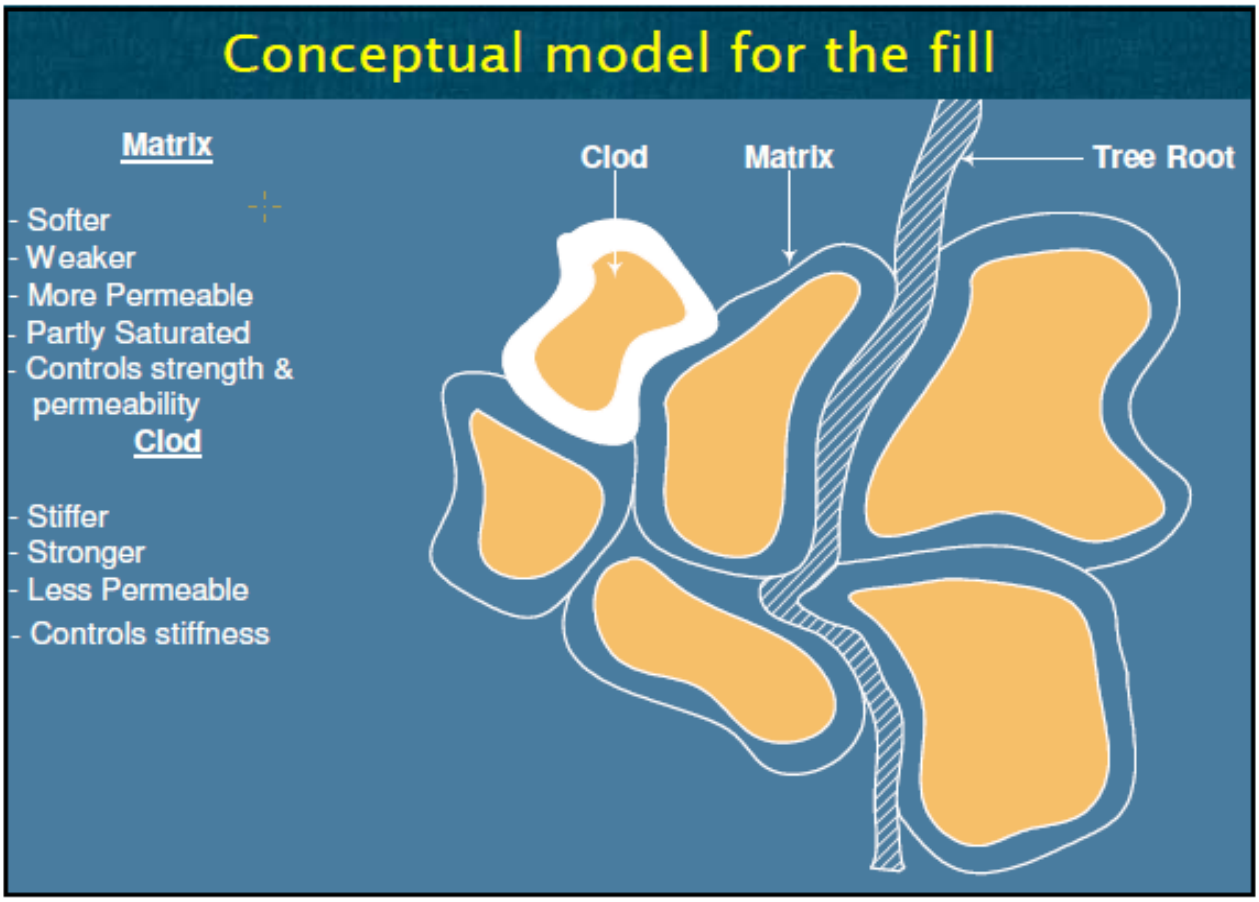
This report is intended to challenge Network Rail’s stated reasons for undertaking this wide-scale vegetation clearance in Grange Park and that problems with stability within these old clay embankments may be getting worse but the removal of trees and other vegetation is ***not*** going to solve the problem but ***make it worse.***

**It is concluded that Network Rail, as a matter of policy, looks to have chosen the option of the cheap short-term solution without fully considering the long-term consequences thereof its actions; let alone the impact on the natural habitat or lives of local residents and its own rail customers.**

## Background

The railway embankments found in Grange Park were formed by end tipping hand excavated clay spits or clods (a spit is an undisturbed lump of clay cut by a small spade used in this type of excavation) and compacted using those resources available in late Victorian times. The result was an embankment that was not very well compacted. (fig.1)

**Figure 1**




More can be read about the traditional methods used to construct these embankments on pp27-29 of reference 2.

At the time of construction of the Hertford loop doubts must have existed concerning the strength of the embankments and as a result the stations at Grange Park and Enfield Chase have station buildings at the base of the embankment and a lightweight platform structure. Poplar trees which have extensive root systems and high moisture demand were often planted to limit the build-up of moisture within the clay embankment.

**Railway engineers of late have realised that these embankments are becoming weaker and research has identified three factors as contributing to their concerns.**

1. The first is the cyclical wetting and drying of the clay embankment. Research has shown that the greater the difference between summer and winter moisture contents the faster the clay loses strength. The number of cycles is also a factor.

2. The second was brought about by the demise of steam in the late Fifties. With steam locomotives it was necessary to reduce as far as possible the risk of track side fires and as a result vegetation close to the railway was heavily maintained. Around 1960 that maintenance of vegetation virtually stopped overnight and since then trees and undergrowth have grown almost unchecked.

3. The third is the recent meteorological phenomena of extremely dry summers and wet winters.

**Until quite recently these embankments had not given rise to any problems.**

Network Rail has been clearing vegetation along embankments in the local area for the past three years. As long ago as October 2008, a meeting was held with Network Rail, as a result of the uproar amongst local residents caused by tree felling along the railway line in Winchmore Hill.

Safety, linked to the risk of dead trees falling across the tracks, maintenance of sight lines and leaf fall during the autumn was advanced as the reason for the necessity of this work.

Whilst vegetation clearance was less pervasive, concern was also expressed at that meeting, as to both the reasons for the work and the remedy, by local residents. Local residents in Winchmore Hill have had conflicting answers from Network Rail, as to whether the project has been completed, or whether further work is still to be undertaken.

As Network Rail moved further up the line, it seems likely that the organisation was keen to avoid a further public outcry and local resistance prior to the start of the project work. As a result, there was very little notification provided to local residents, limited to a letter distributed only to residents directly bordering the embankment, which referred merely to “vegetation clearance” in relation to “important safety work to stabilise the embankment”, in the run up to Christmas.

## Network Rail’s national vegetation clearance strategy

Research has also been carried out into Network Rail's previous record of track side maintenance. The results are alarming. A Sunday Times article from 2003 claims that Network Rail had adopted a policy of much more aggressive approach to the maintenance of track side vegetation i.e. they cut it all out.

Other news items from other parts of the country and the recent occurrences in London N21 seem to indicate that this policy has not changed. The Sunday Times article ‘Trees blitzed to keep trains running’ can be read at

http://www.timesonline.co.uk/tol/news/uk/article885399.ece

## Network Rail's argument for vegetation clearance in Grange Park

The reason for the urgent felling of trees cited by Network Rail since the public outcry was the threat to public safety, brought about by instability within the embankment and seasonal wetting and drying of the clay. It was argued by Network Rail that this is exacerbated by the presence of deciduous trees which, because of the large seasonal variation in moisture demand, increases the magnitude of swelling and shrinkage within the clay embankment.

However, it has been noted, that in the letter sent out to residents in December by Network Rail, there was no mention made of safety concerns, merely the need for operational improvements.

At a recent public meeting in Grange Park in February, chaired by constituency MP David Burrowes, Network Rail used emotive language to emphasise the problem, such as references to "**huge** deciduous trees drawing **huge** quantities of water" ....and that these trees were "**sucking the life out of the embankment."**

Network Rail also explained how ash on the embankment **"burned away leaving large holes full of soggy mush".**

It is my contention that all this is, at best, misleading but is mostly nonsense. To strengthen a clay its water content is **reduced (i.e. by sucking it out)**, and **ash burning away?** Polite commentary is therefore very difficult.

## Academic research on vegetation and soil destabilisation

Network Rail's reasons advanced for tree clearance must be viewed with suspicion, especially as the site clearance has been so extensive and many of the trees removed were not growing on the embankment.

It should be borne in mind that trees grow slowly, clay absorbs moisture slowly and fatigue loss of strength is a function of both the magnitude of stress reversal and the number of cycles through which the clay fill is put.

As there is only one cycle per year it takes many years before this loss of strength starts to be noticed. Unstable slopes are indicated by the growth pattern of trees. Trees on a stable slope grow vertically but on a slope that is slowly creeping the trunks develop curvature. (fig 2)

**Figure 2**
**Deformed tree growth as a result of hillside creep.**

More can be found in Ref.1: Ground Movements due to Hillside Creep.

Tomlinson also reports hillside creep in London clay slopes above 10° but no information has been found on creep in clay fills.

As a result of this concern, much recent research work has been undertaken to better understand the correlation between slope stability, pore water pressure and embankment movement.

Amongst this work was a report commissioned from **Mott MacDonald** which concluded:

1. That old clay fill embankments are currently at risk of deformation and failure.

2. That this is a new area of soil mechanics in which the influence of vegetation is a key issue.

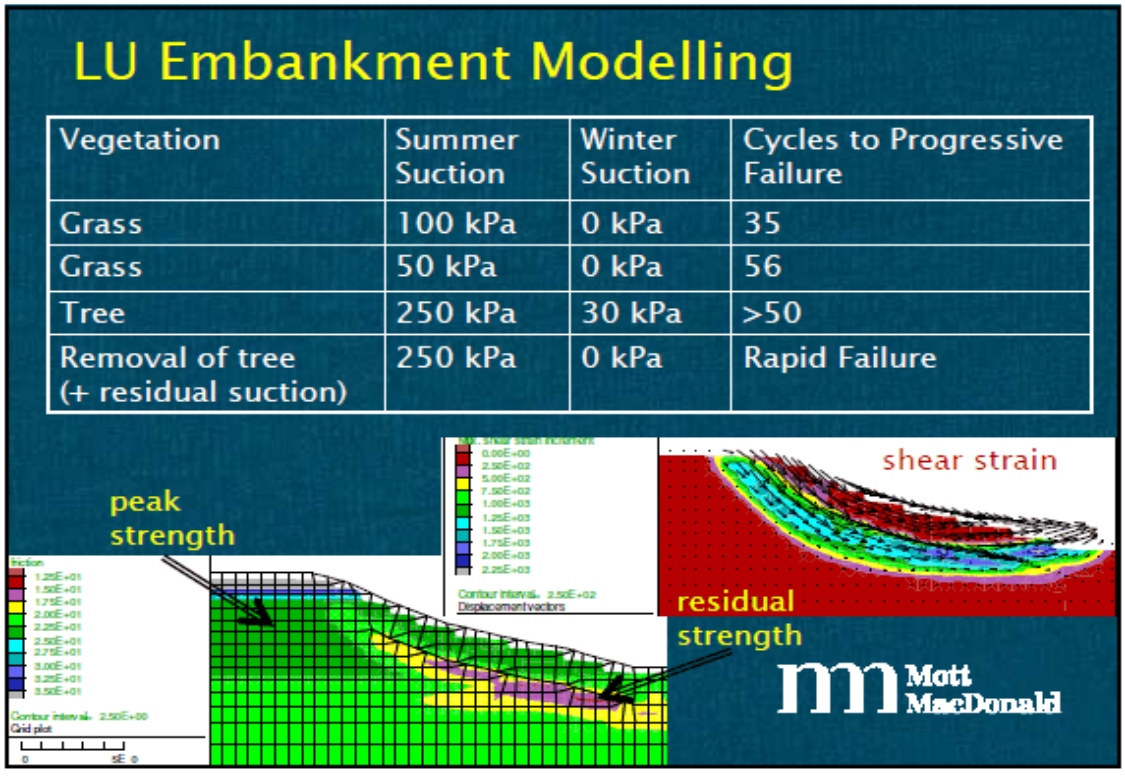
3. Climate change is probably increasing this risk.

4. And finally, that as old clay fill embankments form such a vital part of the UK transport infrastructure further multi-disciplinary research is needed.

But the most alarming fact emerging from this study was that, in embankment modelling work carried out for London Underground, the loss of soil suction associated with the ***complete*** removal of trees rapidly leads to embankment failure. (fig. 3)

Figures 1 & 3 of this report are taken from the Mott MacDonald report which is comparatively non-technical and can be read here:
http://cliffs.lboro.ac.uk/downloads/obrien%20loveridge.pdf

**Figure 3**



There is an extensive body of research on this topic, most of it very technical, and the conclusions are all the same. Problems with stability within these old clay embankments is getting worse but that the removal of trees and other vegetation is ***not*** going to solve the problem but ***make it worse.***

As David H. Barker states in the preface to reference 3 it is not only in sand dune areas that vegetation was **traditionally** used as stabilisation, but during the 20th century much of this knowledge has been lost. There is now an element of rediscovery of this lost knowledge. He also states that the current perception of the engineering functions of plants has not been accepted uncritically or without considerable scepticism by some engineers despite the evidence of accelerating rates of erosion, incidents of down-slope movements and downstream siltation after their removal.

At this symposium in his keynote address Donald H. Gray of the University of Michigan states that vegetation affects both surficial and mass stability of slopes in significant and important ways. He states that the protective role of vegetation in the stability of slopes has gained increasing recognition and he lists the beneficial effects as root reinforcement, soil moisture depletion, buttressing and arching and surcharge. He goes on to consider the consequences of vegetation removal and mentions the work conducted by Bishop and Stevens (1964) in logged areas in south-east Alaska and the significant increase in both frequency and size of landslides after clear-cut logging. Subsequent studies by other investigators have reinforced these findings.

## Embankment failures as a result of Network Rail's clearance policy

The Rail Accident Investigation Branch RAIB report that there was a failure at Kemble in the Network Rail maintained clay railway cutting slope. Annual inspections were carried out because the cutting slope was adjudged to be in the high risk category but **after removal of the vegetation** it was moved into the medium risk category with inspections scheduled every five years. **The slope failed shortly afterwards.**

In the investigation report no mention was made of the contribution of vegetation to enhancing slope stability. The report is also interesting because it reveals information on an algorithm developed by Network Rail to guide track-side inspectors in the procedure to be followed in assessing the condition of cuttings and embankments. It does not give any guidance on the inspection of vegetation on slopes but only warns of the possible deleterious effects of trees on neighbouring land.

Could it be that the algorithm was designed by management to give them the answers they wanted to hear? The report can be read here:

http://www.raib.gov.uk/publications/investigation_reports/reports_2008/report252008.cfm

## London Underground's solution to the problem

As a result of this and other new knowledge, **London Underground** has adopted a different approach for the clay embankments under their care. This involves the maintenance of deciduous trees gradually cutting them back at the same time as inter-planting with other less aggressive species of tree i.e. evergreens with lower seasonal variations in moisture demand and negligible leaf fall. Over a period of time deciduous trees close to the permanent way can be gradually eliminated but only as the root systems of the replacement planting becomes established.

Again the report is reasonably non-technical and can be read here

http://www.railwaystrategies.co.uk/article-page.php?contentid=5571&issueid=206

In January 1994 there was a deep seated catastrophic failure in the LU clay fill embankment on the Northern Line in Colindale. The side slopes were vegetated with poplar trees but the failure was in a 23 metre section **that was treeless.** The failure was repaired using sheet piles. More information can be found on p.54 of Reference 2.

## What are the alternatives?

**It is acknowledged that it is in this country's environmental interest that as much heavy freight as possible is moved by rail or canal and therefore it is important that Network Rail, in maintaining the network, do everything possible to strengthen embankments and structures to permit the transport of heavier loads.**

The route availability (RA) system is used by Network Rail is a measure of a railway vehicles axle load on the scale of 1 to 10. Each Network Rail route has an RA number but unfortunately the Wikipedia link to Network Rail's web site to find the RA number of the Hertford loop is no longer available.

But, by intimation, Network Rail have said the RA classification of this section of the line needs to be raised if possible.

**However the planting scheme proposed by Network Rail does not, in the author's opinion, strengthen the embankment but lead to a gradual erosion of the embankments capacity to carry load, as moisture levels slowly build up within the clay.**

Sheet piling either side of the railway, either tied or anchored, is a remedial system frequently employed by Network Rail to repair a slope following a slip but again, in the author's opinion, will do nothing to raise the RA number of this embankment.

The permanent way will continue to be supported on six or so metres of poorly compacted clay. Rainwater will continue to penetrate the railway ballast and any ash overlying this clay with nowhere to go. Gravity will take this water down behind the sheet piling where it can enter the clay through millions of passages left by the old tree roots. The clay will gradually soften as it absorbs this moisture and the load carrying capacity of the clay will gradually reduce.

Gabions (i.e. rock filled wire baskets forming a mass retaining wall) are again often used but once again they will not control moisture entering the clay. A further problem with using gabions is providing a good foundation at the toe of the embankment in a region of potential failure ( see Appendix A figs A1 & A2)

A combination of sheet piling & gabions will not solve the problem of water getting into the clay fill.

Stabilisation of the clay fill using lime, cement or pulverised fuel ash is also impracticable because of the impossibility of mixing these stabilisers into the embankment and also the high sulphate content of London clay.

Electro-kinetic stabilisation is at a too early stage of development to be considered.

**The most economic short and long-term solution, in the author's opinion, would be to enlist the help of Mother Nature by replanting trees the roots of which will remove this moisture and help to stiffen the clay.** Evergreen species can be planted close to the rail line so as to avoid as far as possible the detrimental effects of autumn leaf fall. Evergreens also have the benefit of a much smaller seasonal variation in moisture demand reducing as far as possible the weakening effects caused by these fluctuations.

But doubts will remain for many years as to whether this replanting will recover the severe damage caused by the felling of the trees ***before*** a major slip occurs.

## Conclusion

The reasons advanced by Network Rail for tree removal are almost devoid of technical merit. Network Rail appears to understand very little about the contribution of vegetation & root systems to slope stability and of the potentially catastrophic consequences of vegetation removal.

The reasons/excuses have one word which is consistent throughout. This word is “safety". This risk to safety is always based on surveys recommendations and reports that Network Rail insist on keeping confidential on the grounds that they are internal documents not for release into the public domain.

If embankment stability were in doubt it would be essential to undertake a programme of subsoil investigation and monitoring to determine the nature and extent of the problem.

No evidence has been found of any such work being carried out and the fact that Network Rail has cut down all the trees with the resulting known deleterious effects on embankment stability again points to the conclusion that the stability problem was much less then they indicated.

There is still much further research required on the strengthening affects of vegetation and root systems on clay embankments. Soils engineers have concentrated almost exclusively on the measurement of soil suction and/or pore water pressure in assessing the strength of clays and virtually no work has been undertaken to quantify the strengthening affects that root systems provide as fibre reinforcement to the soil.

Network Rail, as a corporate policy, withholds information from the public. The reasons for this can only be to provide large grey areas in public knowledge from which they can produce the excuse "safety".

**Network Rail, as a matter of policy, appear to have chosen the option of the cheap short-term solution without fully considering the long-term consequences thereof.**

But I cannot believe Network Rail is so technically incompetent. It is far more likely that they are carrying out the works without disclosing their true intentions.

**Since the removal of root systems severely weakens clay it is important that, if the embankment is to be returned to a more stable condition, replacement planting is quickly carried out in the hope that the soil weakening has not developed to the point where line closure and emergency strengthening work by much more expensive means is required.**

These replacement trees will also provide a simple visual monitoring of slope movement together with the permanent way level monitoring normally carried out.

Other soil monitoring on the slopes of the embankment should be carried out and piezometers installed to monitor soil suction and pore water pressure so that as much as possible can be learnt of the devastating consequences of complete vegetation removal on this type of embankment.

## References


1 Tomlinson M. J. **Foundation Design and Construction.** 7th Edition. Prentice Hall 2001

2 Perry J. Pedley M. & Reid M. **Infrastructure Embankments. Condition Appraisal & Remedial Treatment.** CIRIA report C592 London 2003

3 D. H . Barker (Editor)b **Vegetation and Slopes**, stabilisation, protection and ecology. Proceedings of the international conference held at the University Museum, Oxford. 29-30 September 1994


## Disclaimer

This report is compiled without the benefit of track maintenance records (and how this embankment compares with other similar embankments in the network), lineside inspection reports and the results of soil investigations, if any, carried out on this and similar embankments.

## About the author

**Peter Johns**

Mr Johns was awarded a Bachelor's degree in civil engineering from the University of Birmingham in 1967. He is a former Chartered Engineer, Member of the Institution of Civil Engineers and Member of the Institution of Structural Engineers.

His professional experience spans more than 30 years of work in the UK and overseas on a wide range of civil and structural engineering projects.

He has always maintained a keen interest in the field of soil mechanics from the late sixties where he worked as a resident engineer on two major site investigations for Ove Arup and Partners through to the nineties where he was retained as a soil mechanics consultant to Frankipile Zambia, and to the Zambia Consolidated Copper Mines.

His continuing professional development has included one year of evening classes studying soil mechanics under Sidney Rosenak at the Regent Street Polytechnic and a course on foundation design in tropical and residual soils at Imperial College London.

He is now retired.

## About the N21 Rail Action Group

The N21 Rail Action Group was set up by local residents living in Grange Park and Winchmore Hill, within the London N21 postcode, following the wholesale clearance of vegetation by Network Rail in January 2010, which has literally left a devastating blot on the landscape, in the heart of this leafy North London suburb.

We are campaigning:

1. To gain a better understanding of why such radical clearance of vegetation was necessary.

2. To have proof that proper environmental audits were conducted in this area of established woodland prior to the commencement of the work;

3. To ensure that there is a proper restoration of the site on completion of the work, with the replanting of mixed native species, to recreate a woodland.

4. Finally, to help kick-start a national campaign, to lobby government to examine Network Rail’s powers as a statutory undertaker, which enable them to operate in this manner, without resource to the normal consultative processes, the environmental impact of its work or the communities in which it operates.

Further information about the N21 Rail Action Group can be found on www.n21online.com

## APPENDIX A

Diagrammatic figures to illustrate potential failure mechanisms.

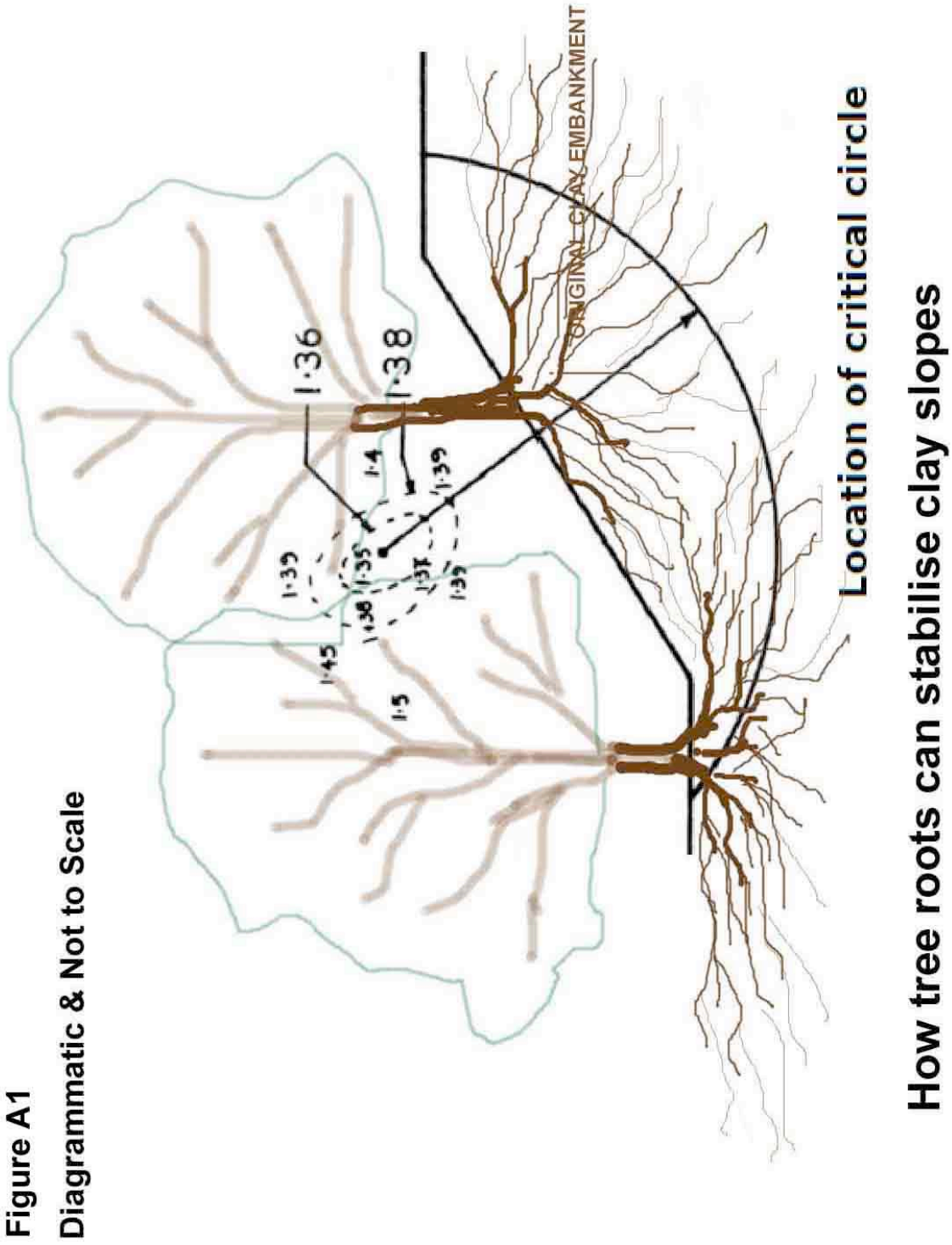
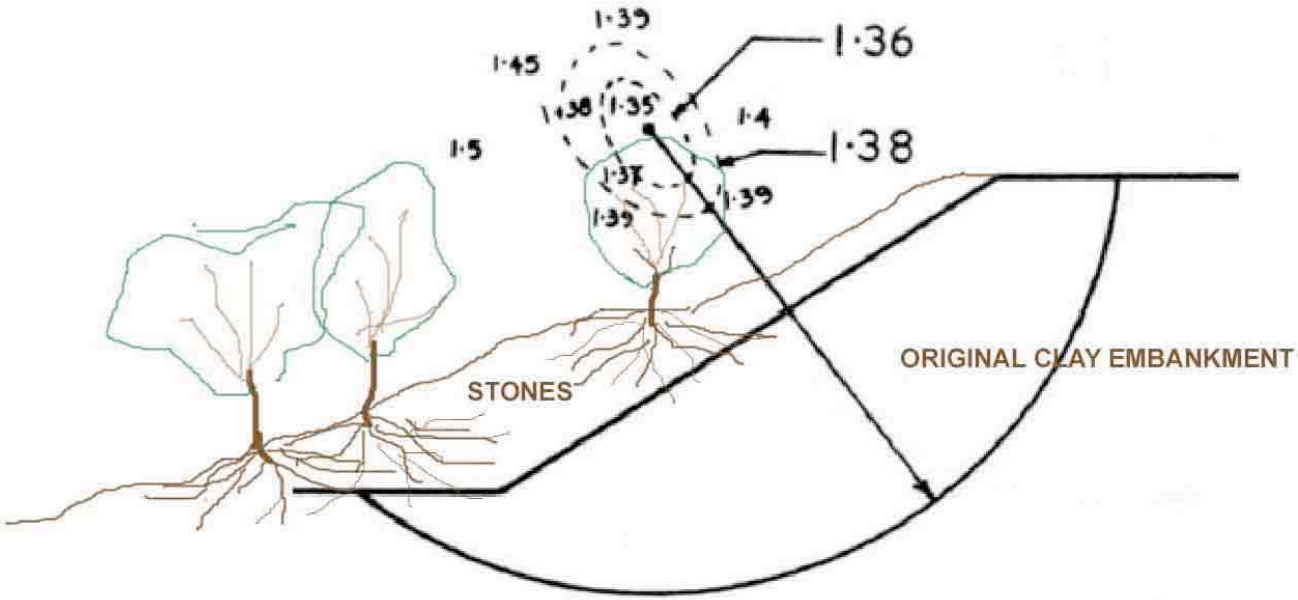



Figure A1
Diagrammatic & Not to Scale

**Figure A2**

**Diagrammatic & Not to Scale**




## Network Rail Proposals

**Note the lack of roots now anchoring the potential slip surface within the embankment**