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REPORT ON

TREHIR LANDFILL SITE
ASSESSMENT OF LANDFILL SLOPE STABILITY

Submitted to:

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1.0 INTRODUCTION

Trehir Development Company Limited (TDC) requested Golder Associates (UK) Limited (Golder) to carry out an assessment of the slope stability at Trehir Landfill. The scope of the work is identified in Golder's proposal ref. P02523476/1/V.0 dated 18 July 2002 and TDC's fax dated 3 September 2002.

This report summarises the work carried out for the stability assessment, presents the results of the stability analyses and discusses the effect of leachate levels on the stability of the site.

2.0 BACKGROUND

2.1 Site Location and Topography

Trehir Landfill is located approximately 1 km south southeast of Llanbradach, within the Rhymney Valley, approximately 0.4 km east of the River Rhymney (NGR ST 155 897) and approximately 2 km north of Caerphilly. Access to the site is acquired from a signposted exit from a roundabout on the A469, along a track which crosses the River Rhymney at Pandyford. The site location is shown in Figure 1.

2.2 Site Operation

Landfilling activities at the site commenced in August 1988. Planning permission and licensing for the site was obtained based on an attenuate and disperse principle. Currently the landfill has an approximate surface area of 7 Ha. MJ Carter (Reference 1) report the basal level of the site to be stepped from 107 mAOD in the west to approximately 147 mAOD in the southeast.

The site is due to close in 2005, after which it will be capped and restored. Phase 1 of the capping and significant changes to the drainage system, to segregate leachate and surface waters, are due to take place during early 2003. Part of the site is already completed with a temporary soil cover of about 0.3 to 0.5 m thickness and temporary slope drainage.

The current site layout is shown in Figure 2.

2.3 Waste Input

To date the site has principally received municipal wastes comprising domestic and commercial and industrial waste of a similar nature. In addition, inert waste comprising spoil, clay, shale, earth, hardcore and other similar material has been accepted at the site and used for cover, engineering material and for the construction and maintenance of haul roads.

2.4 Site Engineering

TDC describe the site engineering as follows:

The base of Phase 1 was lined with 3 m of quarry filler dust obtained from the ARC Craig-yr-Hesg Quarry. In the Phase 2 area the site has been lined with a geomembrane lining system. This area has three separate but integrated lining systems determined by the nature of the backslope. Area A is the major long slope, Area B is the smaller reducing slope and Area C is a vertical wall to the southeast.

In Area A the lining system comprises a protective heavy duty geotextile placed against the re-profiled quarry face with a 1 mm thick, low permeability HDPE geomembrane liner. The upper surface of the liner is protected by a heavy duty geotextile secured in the same anchor trenches as the HDPE liner. This is further protected by covering with selected loads of domestic waste carefully placed during landfill operations.

The lining system for Area B comprises a fin drain that is placed against the re-profiled quarry slope. The fin drain consists of a cuspated (dimpled) HDPE core with a drainage side and a flat side. The drainage side of the fin drain faces the slope and serves to collect groundwater flowing from the adjacent ground. Geotextile is bonded to the core on the drainage side in order to prevent the ingress of fines. Groundwater is collected from the fin drain by drainage pipes that are present on the intermediate benches of the re-profiled slope and connect into the drainage in Area A.

The flat side of the fin drain acts as a leachate and gas barrier. A 300 mm thick layer of clean granular fill is placed between the fin drain and the waste. This layer acts as a protector to the fin drain and as a leachate drainage and gas-venting medium. Leachate is collected by a drainage pipe at the base of the slope within the layer of the clean granular fill. As with the groundwater the leachate drainage system drains to the North.

The lining system in Area C comprises a fin drain that is placed against the trimmed quarry slope. As with the system employed in Area B, the fin drain consists of a cuspated HDPE core with a drainage side and a flat side. However, in Area C the drainage side of the fin drain faces the waste. Here it serves to form a barrier to leachate and gas migration and to collect leachate that flows towards the perimeter of the landfill.

As in Area B, a 1 m thick layer of clean granular fill is placed between the fin drain and the waste. This layer protects the fin drain from the waste and also acts as a leachate drainage and gas venting medium. Leachate collected within the granular fill layer and the fin drain is collected by the site perimeter drainage pipe that in this area is located in the small berm cut into the quarry slope. The leachate collected drains in either direction through the perimeter pipe to the leachate discharge chamber.

2.5 Leachate Management System and Site Drainage

TDC describe the leachate management system and site drainage as follows:

At present there are a number of drainage systems constructed on and around the landfill site. These systems, either individually or combined, collect the leachate generated by the landfill, water from the groundwater sump, water from the on site wheel wash, surface water runoff from the tip itself, surface water runoff from the haul road and water from associated amenities. The system ultimately discharges to the sewer.

The existing drainage system is illustrated in Figure 2. A summary of the development of the drainage system based on information obtained from site reports and documentation, is given in Table 1 below.

Date	Engineering Works to Leachate Collection System
1988	Toe drain / interceptor drains/sewer connection installed
1990-1991	Installation of interceptor drains/sump
1993	Extension of toe drain in northerly direction including leachate collection sump
1994	Extension of sump trench
1994-1995	Extension of leachate interception trench on southern boundary
1999-2000	Leachate collection drains installed on inside of liner and connected to existing drainage system
2002-2003	Planned improvements to segregate leachate and surface water drainage

Table 1: Summary of leachate collection system.

A series of basal and perimeter drains control the egress of leachate generated within the landfill. Drains are located at the base of the quarry face at the northern, eastern and southern sides of the landfill. Irregularly spaced leachate drains are installed on the top of the basal layer of quarry filler dust and connected to a drain that runs southwards along the length of the toe of the western edge of the landfill. The drain turns westwards and follows the site access road beneath the railway embankment then turns northwards to a leachate collection manhole.

It is understood that drains within the waste mass are formed from half slotted pipes in aggregate fill which drain into the perimeter drain. The perimeter drain is currently formed by two 225 mm diameter perforated pipes in an aggregate filled trench. No CQA information is available for this design and installation.

150 mm leachate collection drains are installed at various layers along the internal face of the geomembrane to the rear site extension. These link into the existing perimeter leachate collection system at both sides of Phase 1 of the site. This is shown on the CQA plan of the liner installation contained in the CQA report.

The groundwater collection chamber adjacent to the compactor shed also discharges to the leachate toe drain. To date no contamination problems have been observed or detected during monitoring and it has been agreed with the Environment Agency that this flow can be redirected to the surface water ditch behind the compactor shed.

On the southern edge of the landfill another similar perimeter leachate drain discharges to the chamber at the southern end of the toe collector drain. This drain is laid in the base of the old quarry at the foot of the rock face that formed the edge of the quarry. A gravel drain has been raised over the drain against the rock face to the ground surface as waste was placed. This stone drain is exposed at ground surface along the southern boundary of the landfill and collects some surface water as well as venting gas. An impermeable geosynthetic drain material was placed against the rock face over the eastern half of this drain run. No CQA or design diagrams are available for this structure.

The basal and perimeter leachate drains flow away from the site down towards the traffic lights on Pandy Lane and then to the sewer/surface water discharge point.

A groundwater cut-off system is installed down gradient and some 30 m below the base of the landfill. This has been developed progressively. In May 1989 a pump was installed in Borehole 2 to investigate the feasibility of groundwater pumping. A groundwater cut-off trench and sump was subsequently installed with pumping devices which intercept the flow of groundwater down gradient from the site. The cut-off trench has since been extended. The pumping system discharges into the leachate drainage system.

The leachate drain running to the sewer is a 375 mm diameter concrete pipe. It also currently picks up the surface water from the access road gulley system and the discharge from a short length of groundwater cut-off drain. A field drain also connects to this system adjacent to the sewer entry point. This mixture of leachate, surface water and groundwater discharges to the sewer.

The consented amount that is permitted to run to sewer is 3 l/s. If the discharge exceeds this amount the system automatically surcharges to the River Rhymney. Concentrated leachate is diluted in the drainage system by the entry of surface water to produce a less concentrated but larger volume of leachate contaminated water. This can increase the volume to such an extent that leachate contaminated water surcharges to the River Rhymney during periods of high flow.

Works are about to be undertaken in order to segregate the surface water and leachate collection systems, which will minimise the risk of leachate surcharging to the river. The design for the system will be submitted to the Environment Agency for approval prior to construction.

2.6 Capping and Restoration

In 2003 it is intended to construct a landfill cap over Phase 1 to limit infiltration to the waste mass and therefore leachate production. In 2005 it is intended to cap Phase 2 of the site. Due to the lower run-off potential of Phase 2, it is anticipated that an improved cap specification will be needed to meet Agency requirements.

2.7 Previous stability assessment

A previous stability assessment of the site was carried out by Card Geotechnics in February 1998 (Reference 2), and determined the sensitivity of the proposed design to changes in strength parameters and assumed groundwater levels. This report concludes that instability of the landfill is unlikely to occur; this is based on the assumption that leachate seepages in the waste slope face at 16 m above the landfill base are a result of perched leachate and do not reflect continuous leachate from the base to this level.

The Card report also states that for the slope to become marginally stable (with a calculated factor of safety less than 1.2) the leachate levels must reach a height of 14.5 m. It is understood that this criterion has been taken by the Environment Agency as a condition in the site waste management licence.

The approved restoration profile has changed since the previous stability assessment was completed and the revised profile has been used in the current assessment.

3.0 STABILITY ASSESSMENT

3.1 Conceptual model

The computer code Slope/W has been used to establish the factor of safety against slope instability for this assessment. Two types of failures mechanisms have been analysed. Firstly, global circular failures within the waste mass have been investigated using a circular search routine and Bishop's method on analysis. Secondly, the possibility of a translational failure of the waste along the geosynthetic materials using Janbu's method of analysis has been carried out. Further details of the geometry, material properties and leachate levels are given in the subsequent sections.

3.1.1 Geometry

Three cross-sections have been used to assess the stability of the site and the location of these are shown on Figure 2. The bottom of the landfill was taken from John Vincent Surveys Ltd Drawing No. 211A/01 and the top of the landfill for the typical case was the approved pre-settlement contours taken from John Vincent Surveys Ltd Drawing No. 215/1/01. These cross-sections are considered to be representative of the conditions at the site. In addition to this profile, two other top of landfill profiles were assessed for cross section B-B; the approved post-settlement levels (from John Vincent Surveys Ltd Drawing No. 246/2A/01) and a surface created that was 3 m higher than the approved pre-settlement levels.

3.1.2 Material properties

Four main materials have been modelled in the stability analyses: capping soils, waste, sub-grade and geosynthetic interfaces. The materials properties used in the stability assessment are summarised in the Table 2 below.

Material	Unit Weight (kN/m^3)	Shear strength
Capping soils	18	$c' = 3$ kPa, $\phi' = 20°$
Waste	12	$c' = 5$ kPa, $\phi' = 25°$
Sub-grade	19	$c' = 0$ kPa, $\phi' = 30°$
Geosynthetic interfaces	-	$\alpha' = 0$ kPa, $\delta' = 10°$ (peak) $\alpha' = 0$ kPa, $\delta' = 5°$ (residual)

Table 2: Summary of material properties used in the stability analyses.

It is understood that the capping soils will comprise uncompacted soils and therefore low shear strengths have been assumed in the analyses. Since the waste placed at the site is mainly domestic, the shear strength has been taken from the suggested design line given by

Jones *et al.*, 1997 (Reference 3). The sub-grade material comprises a mixture of in situ bedrock, in situ glacial till, granular fill and filler dust and a conservative estimate of shear strength has been used in the analyses. The geosynthetic interfaces comprise: geotextile/quarry face, geotextile/smooth geomembrane, fin drain/quarry face, fin drain/geotextile and fin drain/granular material. The weakest of these interface is the geotextile/smooth geomembrane interface which can have a peak friction angle as low as 10°, and a residual friction angle as low as 5° (Jones & Dixon, 1998 - Reference 4) and these values have been used in the analyses.

3.1.3 Leachate levels

Leachate levels within the waste are monitored within the following boreholes (see Figure 2 for locations):

- Near base of slope: M2/1, M2/2, M1/1 and M1/2
- Mid slope: M1/5, M1/4, M1/3, M2/5, M2/4 and M2/3

These boreholes are located within Phase 1, towards the lower end of the landfill slope. We are not aware of any leachate monitoring within Phase 2. The above boreholes are used to control the leachate as well as for monitoring levels and of these boreholes, only M2/1, M2/2, M1/2 and M1/5 are not pumped. It is therefore not possible to establish a definitive leachate profile for the site.

A summary of leachate levels for the period August 2001 to July 2002 is given in Appendix 1. The leachate levels in the vicinity of the three cross sections are also given in Appendix 1.

In the stability analyses, the maximum recorded leachate levels at the three cross-sections have been used to assess the stability of the final waste profile. Since there is some uncertainty over the leachate levels (due to the boreholes being pumped), the effect of increasing leachate levels has been investigated.

3.2 Results

3.2.1 Section A-A

A summary of the results of the Slope/W runs for Section A-A is given in Table 3 below and computer outputs are given in Appendix 2.

Ref	Description	Factor of Safety
aa_01	Circular failure, leachate: 4m at M1/2, 8m at M1/4	1.60
aa_02	Circular failure, leachate: 5m at M1/2, 9m at M1/4	1.46

Ref	Description	Factor of Safety
aa_03	Circular failure, leachate: 6m at M1/2, 10m at M1/4	1.31
aa_04	Circular failure, leachate: 7m at M1/2, 11m at M1/4	1.15
aa_05	Circular failure, leachate: 4m at M1/2, 10m at M1/4	1.53
aa_06	Circular failure, leachate: 4m at M1/2, 12m at M1/4	1.40
aa_07	Circular failure, leachate: 4m at M1/2, 14m at M1/4	1.23
aa_08	Circular failure, leachate: 4m at M1/2, 14m at M1/4, 16 upslope	1.19
aa_09	Translational failure, leachate: 4m at M1/2, 8m at M1/4, δ=10°, r_u=0.1	1.81
aa_10	Translational failure, leachate: 4m at M1/2, 8m at M1/4, δ=10°, r_u=0.3	1.64
aa_11	Translational failure, leachate: 4m at M1/2, 8m at M1/4, δ=5°, r_u=0.3	1.36

Table 3: Summary of Slope/W runs for Section A-A

The calculated factor of safety for the initial condition, i.e. the highest recorded leachate levels, is 1.60. The factor of safety decreases with increasing leachate levels. If leachate is considered to rise in 1 m increments at both monitoring boreholes M1/2 and M1/4, a factor of safety less than 1.3 is obtained for leachate levels greater than 6 m and 10 m at M1/2 and M1/4 respectively. However if the leachate level at the toe of the slope (M1/2) is maintained at 4 m, then the level at M1/4 can rise to around 13 m before the factor of safety reduces below 1.3.

Translational failure of the waste along the liner in the upper section of landfill is considered unlikely with a calculated factor of safety of 1.36 using pessimistic values for geosynthetic interface friction and pore water pressure at the interface.

3.2.2 Section B-B

A summary of the results of the Slope/W runs for Section B-B is given in Table 4 below and computer outputs are given in Appendix 3.

Ref	Description	Factor of Safety
bb_01	Circular failure, leachate: 3m at M2/2, 10m at M2/5	1.57
bb_02	Circular failure, leachate: 4m at M2/2, 11m at M2/5	1.51

Ref	Description	Factor of Safety
bb_03	Circular failure, leachate: 5m at M2/2, 12m at M2/5	1.44
bb_04	Circular failure, leachate: 6m at M2/2, 13m at M2/5	1.35
bb_05	Circular failure, leachate: 7m at M2/2, 14m at M2/5	1.25
bb_06	Circular failure, leachate: 8m at M2/2, 15m at M2/5	1.15
bb_07	Circular failure, leachate: 3m at M2/2, 14m at M2/5	1.49
bb_08	Circular failure, leachate: 3m at M2/2, 16m at M2/5	1.42
bb_09	Circular failure, leachate: 3m at M2/2, 18 at M2/5	1.35
bb_10	Circular failure, leachate: 3m at M2/2, 20m at M2/5	1.27
bb_11	Circular failure, leachate: 3m at M2/2, 22m at M2/5	1.18
bb_12	Translational failure, leachate: m at M2/2, 8m at M2/5, δ=10°, r_u=0.1	2.46
bb_13	Translational failure, leachate: m at M2/2, 8m at M2/5, δ=10°, r_u=0.3	2.30
bb_14	Translational failure, leachate: m at M2/2, 8m at M2/5, δ=5°, r_u=0.3	2.01
bb_01a	Post-settlement profile, circular failure, leachate: 3m at M2/2, 10m at M2/5	1.69
bb_05a	Post-settlement profile, circular failure, leachate: 7m at M2/2, 14m at M2/5	1.32
bb_01b	Pre-settlement profile +3m, circular failure, leachate: 3m at M2/2, 10m at M2/5	1.57
bb_05b	Pre-settlement profile +3m, circular failure, leachate: 7m at M2/2, 14m at M2/5	1.25

Table 4: Summary of Slope/W runs for Section B-B

The calculated factor of safety for the initial condition, i.e. the highest recorded leachate levels, is 1.57. The factor of safety decreases with increasing leachate levels. If leachate is considered to rise in 1 m increments at both monitoring boreholes M2/2 and M2/5, a factor of safety less than 1.3 is obtained for leachate levels greater than 7 m and 14 m at M2/2 and M2/5 respectively. However if the leachate level at the toe of the slope (M2/2) is maintained at 3 m, then the level at M2/5 can rise to around 20 m before the factor of safety reduces below 1.3.

Translational failure of the waste along the liner in the upper section of landfill is considered unlikely with a calculated factor of safety of 2.01 using pessimistic values for geosynthetic interface friction and pore water pressure at the interface.

3.2.3 Section C-C

A summary of the results of the Slope/W runs for Section C-C is given in Table 5 below and computer outputs are given in Appendix 4.

Ref.	Description	Factor of Safety
cc_01	Circular failure, leachate: 3m at M2/1, 7m at M2/4	1.90
cc_02	Circular failure, leachate: 4m at M2/1, 8m at M2/4	1.89
cc_03	Circular failure, leachate: 5m at M2/1, 9m at M2/4	1.86
cc_04	Circular failure, leachate: 6m at M2/1, 10m at M2/4	1.83
cc_05	Circular failure, leachate: 8m at M2/1, 12m at M2/4	1.76
cc_06	Circular failure, leachate: 10m at M2/1, 14m at M2/4	1.67
cc_07	Circular failure, leachate: 12m at M2/1, 16m at M2/4	1.51
cc_08	Circular failure, leachate: 14m at M2/1, 18m at M2/4	1.34

Table 5: Summary of Slope/W runs for Section C-C

The measured leachate levels in the vicinity of Section C-C are relatively low compared to the other two cross-sections and this is seen in the higher calculated factors of safety. The factor of safety against a circular failure within the waste body for the initial condition is 1.90 and this decreases with increasing leachate levels to 1.34 for 14 m and 18 m of leachate at M2/1 and M2/4 respectively.

Due to the limited extent of the liner in this area and the geometry of the final waste profile, translational failures along the liner are not considered likely and have not been analysed.

3.3 Discussion

3.3.1 General

The stability analyses has demonstrated that the leachate levels within the site are critical to the stability of the site. If the levels monitored in the boreholes are representative of the leachate within the site, then the factor of safety against failure of the waste slope is in excess of 1.3 and therefore generally considered to be satisfactory. However, it is likely that in the vicinity of the boreholes that are currently being pumped, the leachate levels may be higher than the measured values and this will have a detrimental effect on the stability. It is not possible to establish the actual stability of the waste slope without knowledge of the actual leachate profile.

3.3.2 Haul road

It is understood that the haul road that currently crosses the front face of the site will be moved as part of the Phase 1 capping works. Excavating into the waste slope to form a new haul road will adversely affect the stability of the slope since it will involve locally steepening the waste slope gradient. Any such excavation should be minimised to reduce the risk of instability, in particular it is recommended that no such excavation should be carried out in areas where there are high leachate levels. Detailed analysis of the effect of the proposed haul road on waste stability should be carried out as part of the capping design once the exact location of the new haul road is known.

3.3.3 Post-settlement profile

As the waste settles with time, the final profile of the site will tend towards the agreed post-settlement profile; this reduces the height of the waste slope and slackens the angle of the front face. Stability analyses have been carried out for Section B-B to investigate the effect of the post-settlement profile on the waste slope stability. This has the effect of increasing the factor of safety with the initial condition increasing from 1.57 to 2.17, and the case with 7 m leachate at M2/2 and 14 m leachate at M2/5 increasing from 1.25 to 1.88.

3.3.4 Seepages at front face

We understand that a number of leachate seepages have been observed at the front face of the waste, particularly in the southern corner of the site. Such seepages may be leachate locally ponding on low permeability layers or may be an indication that there is a significant quantity of leachate in that area. The stability analyses has shown that if leachate is present for the full depth and levels reach the front face, then the calculated factors of safety are below 1.3, e.g. file ref. aa_08.

3.3.5 Increased pre-settlement profile

As requested by TDC we have assessed the effect of increasing the approved pre-settlement profile vertically by 3 m in Phase 2 on the overall stability of the site. The analyses shows that there is no discernable effect on the most critical failure surface which is near the toe of the waste slope. However, increasing the pre-settlement profile may effect the local stability of the upper slope, but the factor of safety against such a failure will be higher than the critical failure mechanism.

4.0 CONCLUSIONS

It can be concluded that the stability of the site is predominantly controlled by the leachate levels within the site. At present, a definitive statement on the stability cannot be made since there is uncertainty over the leachate levels in the vicinity of the boreholes that are being pumped. If leachate levels between the pumped boreholes are found to be at, or close to, the levels within the boreholes, then the factor of safety would be in excess of 1.3 and therefore generally considered satisfactory. The stability of the site will, provided leachate is controlled, increase in the long-term as the waste settles reaches its post-settlement profile.

5.0 REFERENCES

1. MJ Carter Associates (2000).
'Risk Assessment of the Control of Landfill Gas and Leachate in the Area the Subject of Planning Permission Reference P/99/0603 at Trehir Landfill Site, Caerphilly.' May 2000.

2. Card Geotechnics (1998).
Trehir Landfill Site, Report on risk assessment of landfill slope stability, Ref. CG/112, Rev. 2, February 1998.

3. Jones, D.R.V., Taylor, D.P. & Dixon, N. (1997).
Shear Strength of Waste and its Use in Landfill Stability Analysis, *Proc. Geoenvironmental Engineering*, Cardiff University, Thomas Telford, London, pp. 343-350.

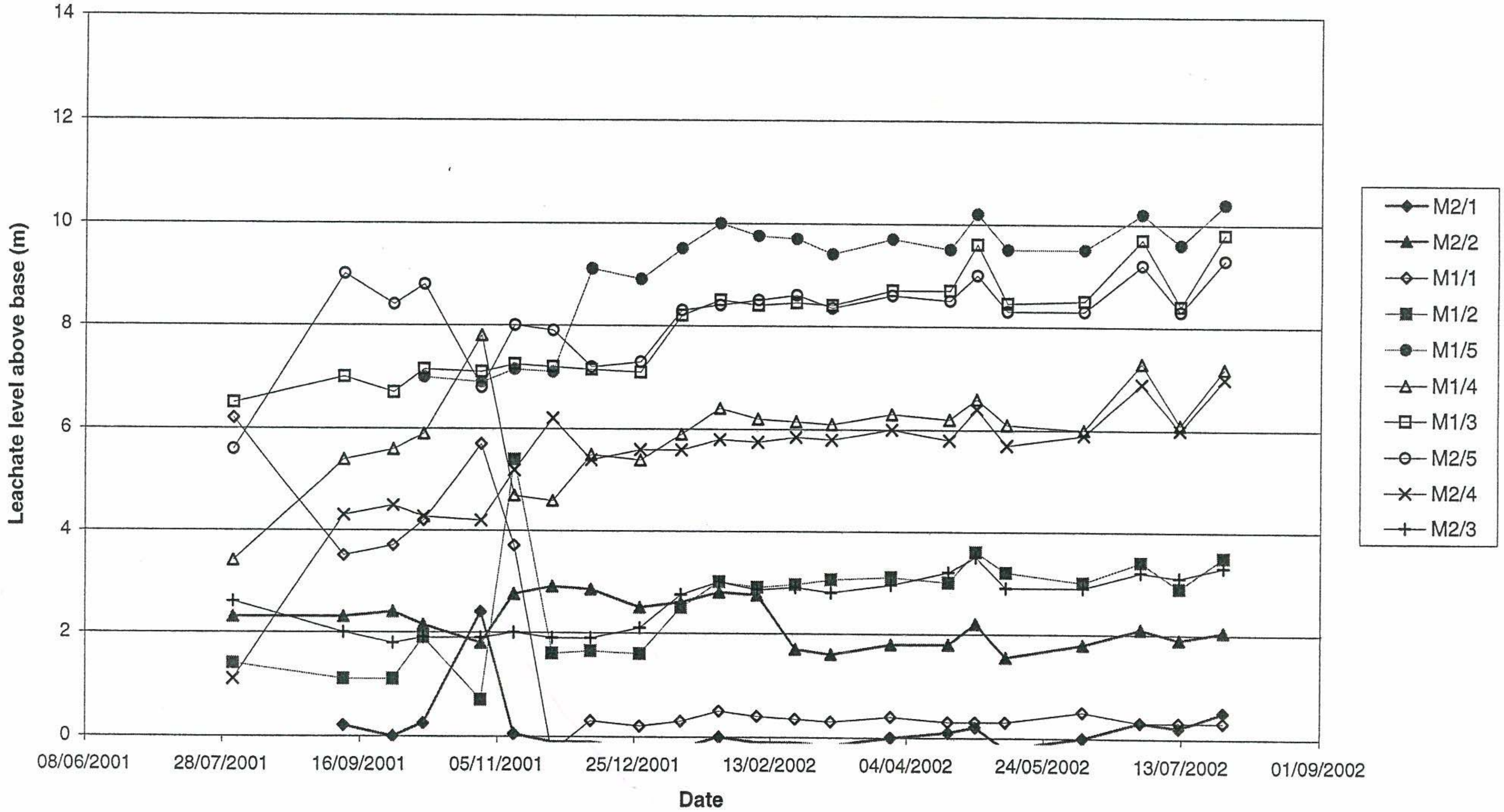
4. Jones, D.R.V. & Dixon, N. (1998).
The stability of geosynthetic landfill lining systems, *Geotechnical Engineering of Landfills*, Thomas Telford, London, pp. 99-119.

APPENDICES

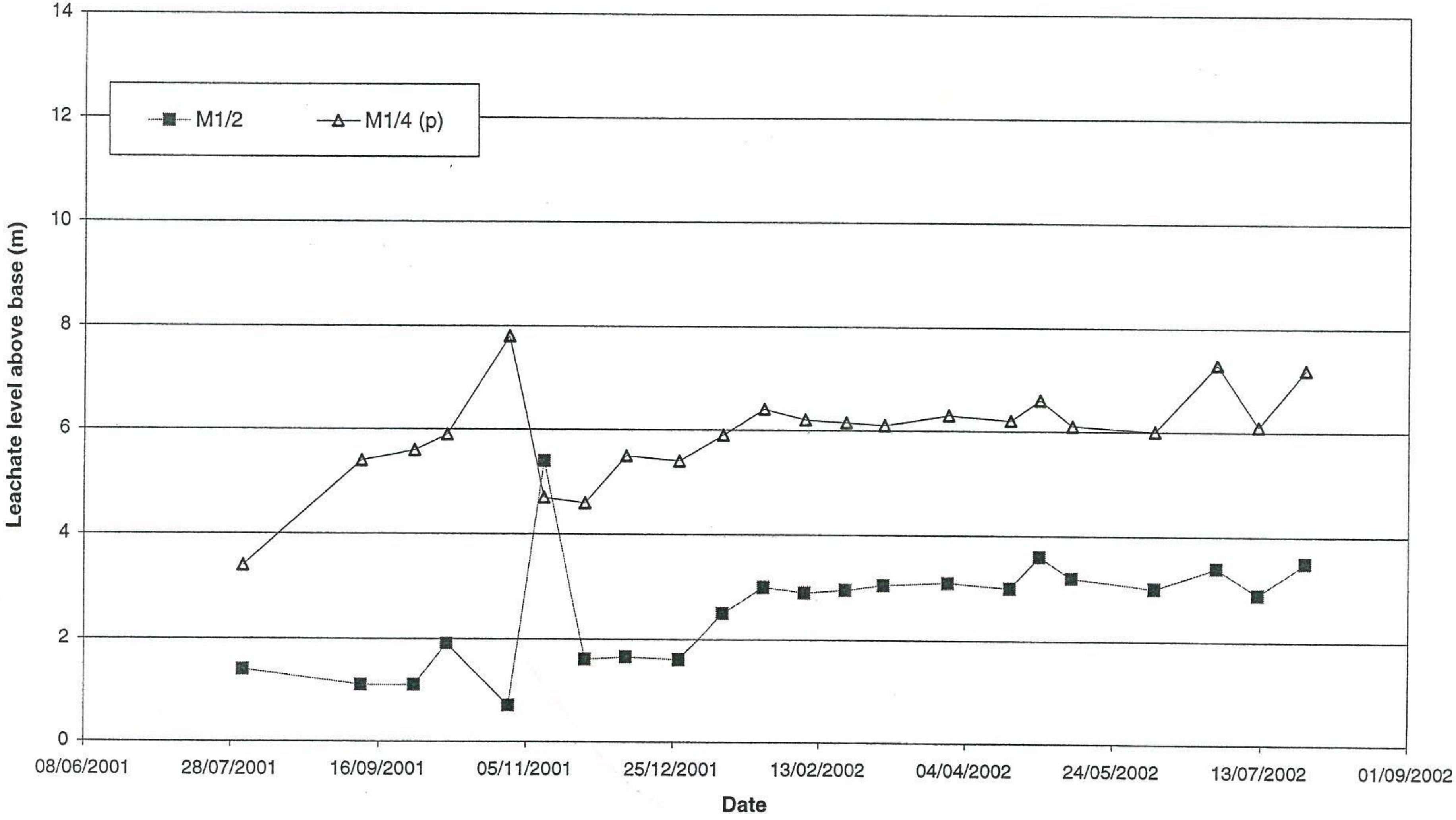
APPENDIX 1

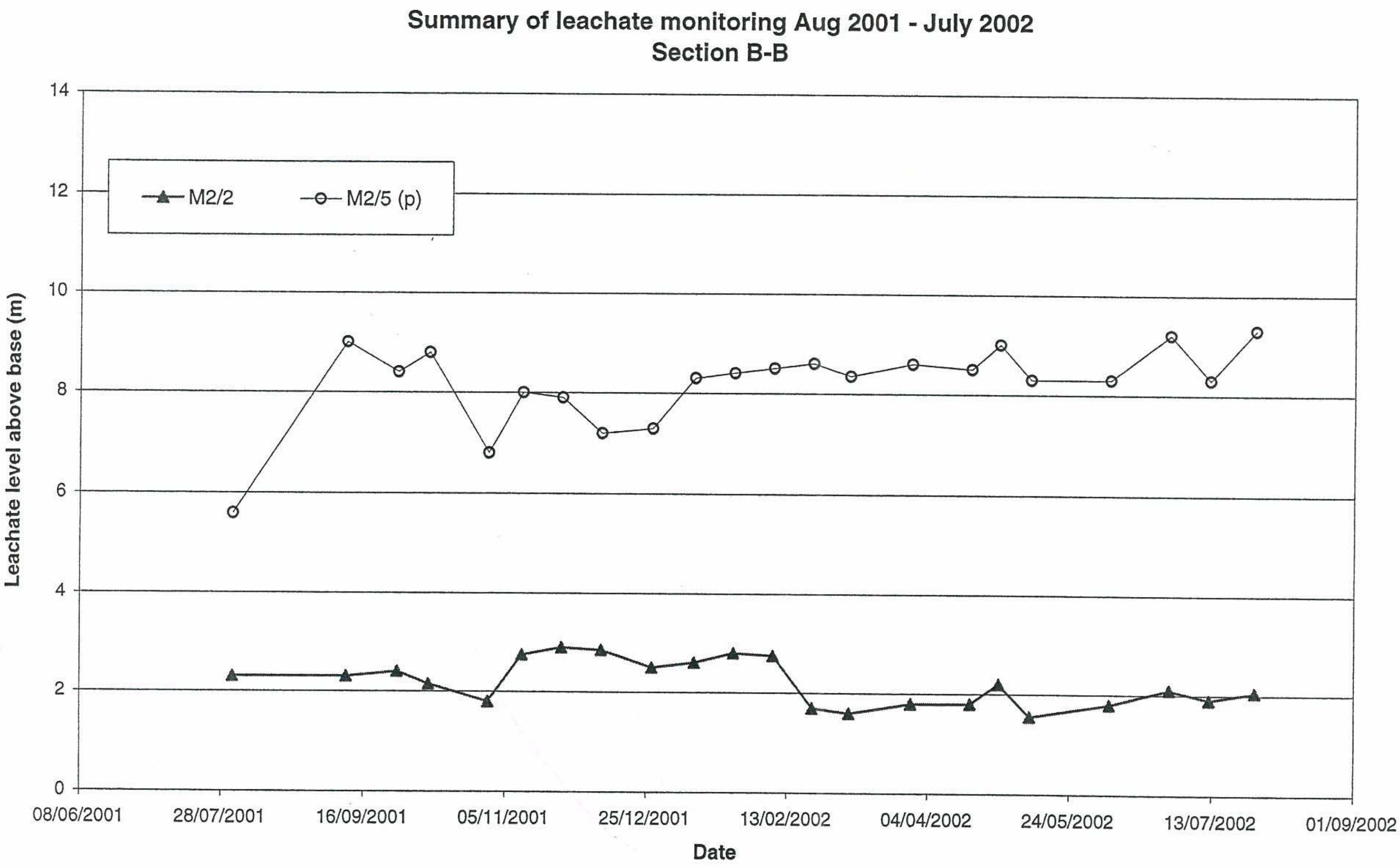
Summary of leachate levels August 2001 to July 2002

Summary of leachate monitoring Aug 2001 - July 2002

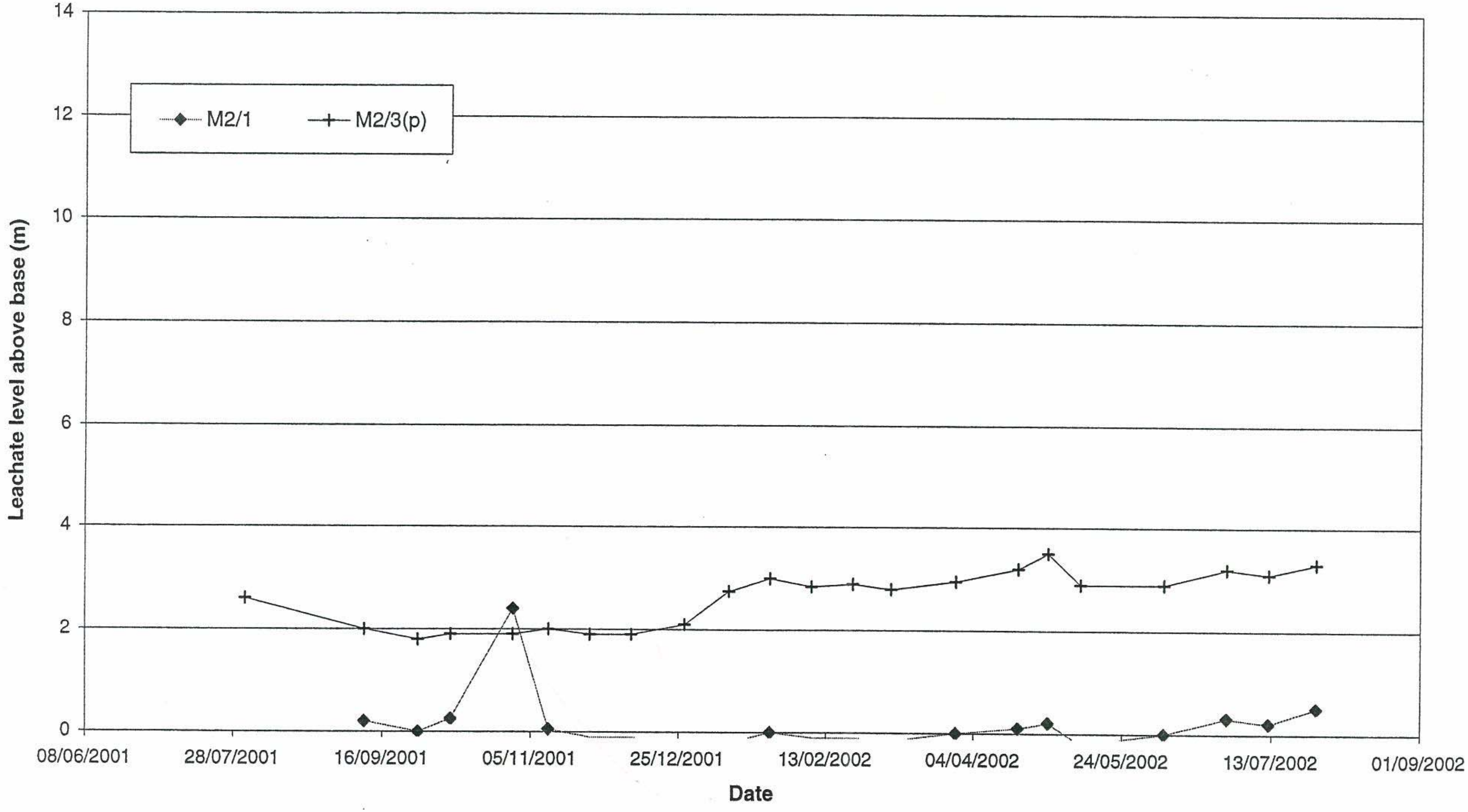


Summary of leachate monitoring Aug 2001 - July 2002
Section A-A



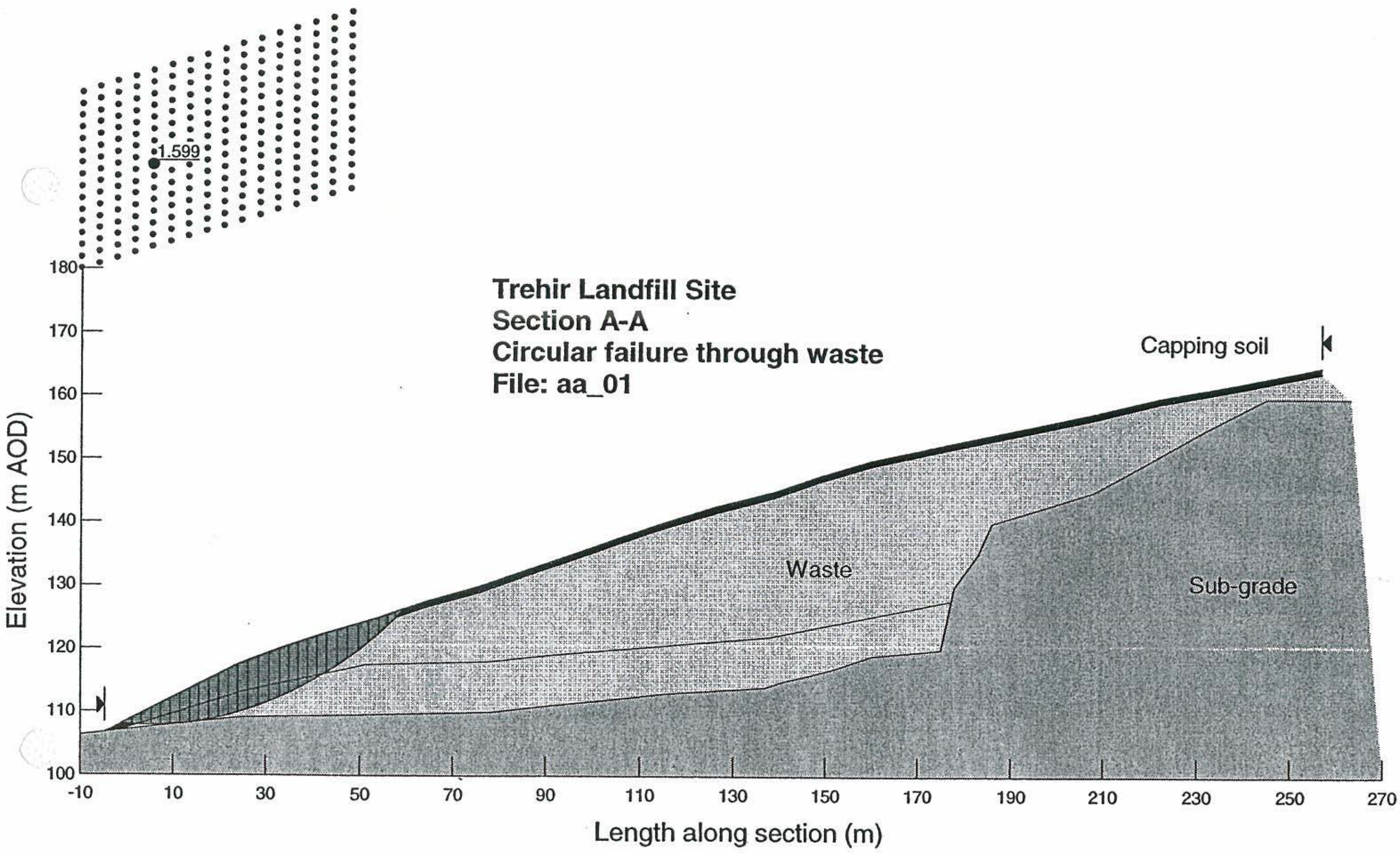

Summary of leachate monitoring Aug 2001 - July 2002
Section B-B
M2/2
M2/5 (p)
Leachate level above base (m)
14
12
10
8
6
4
2
0
08/06/2001
28/07/2001
16/09/2001
05/11/2001
25/12/2001
13/02/2002
04/04/2002
24/05/2002
13/07/2002
01/09/2002
Date

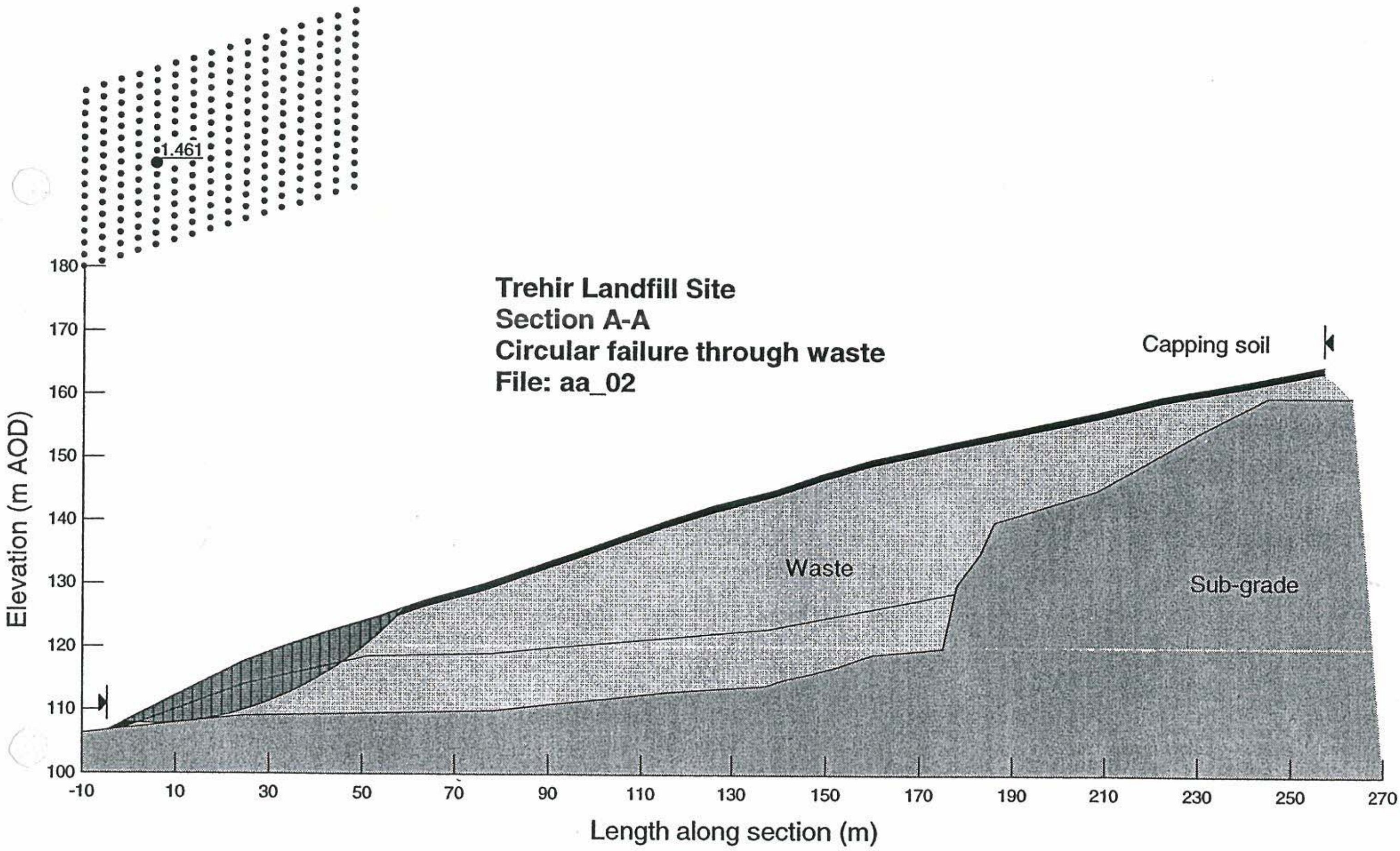
Summary of leachate monitoring Aug 2001 - July 2002
Section C-C



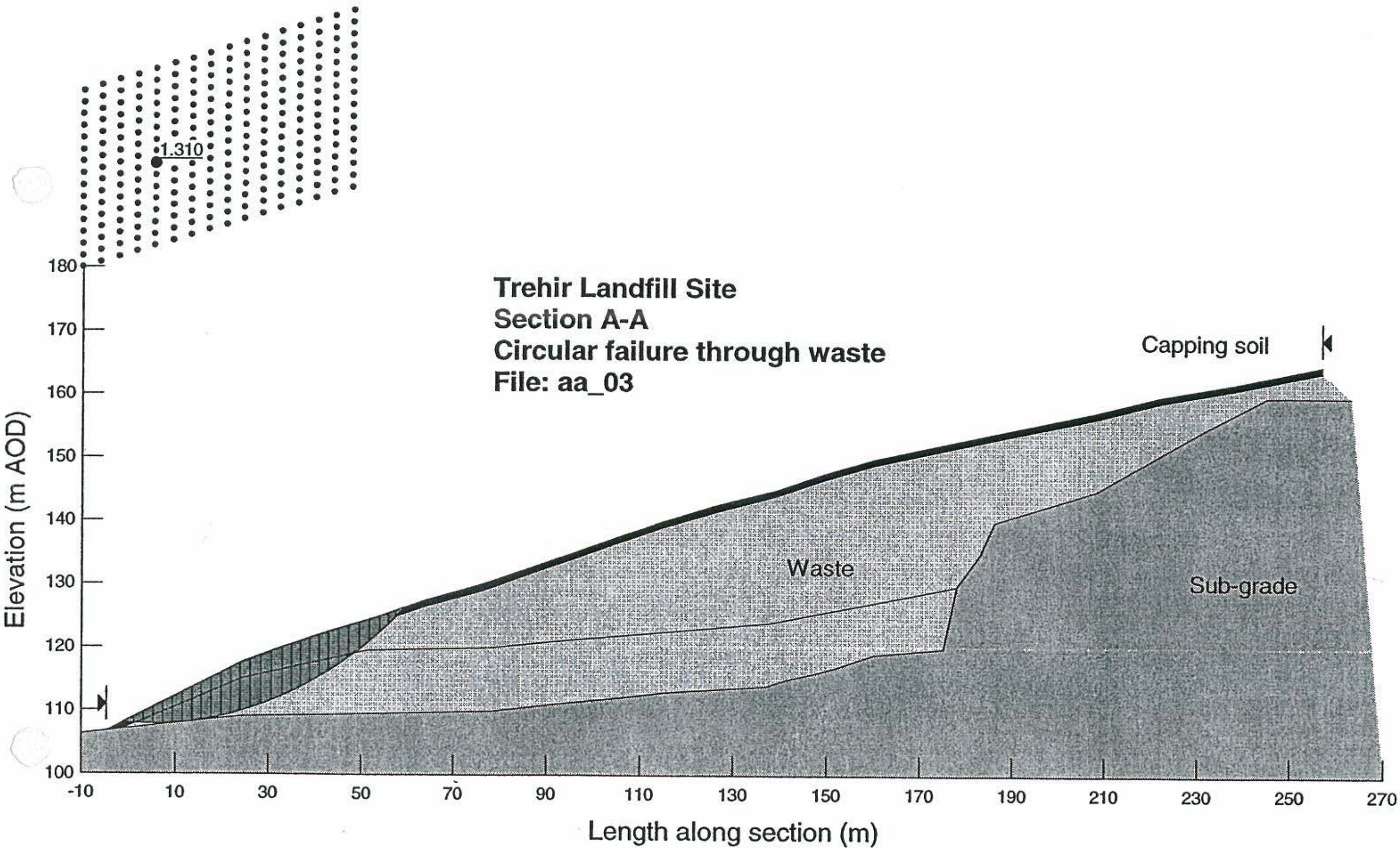
APPENDIX 2

Stability Analyses: Section A-A

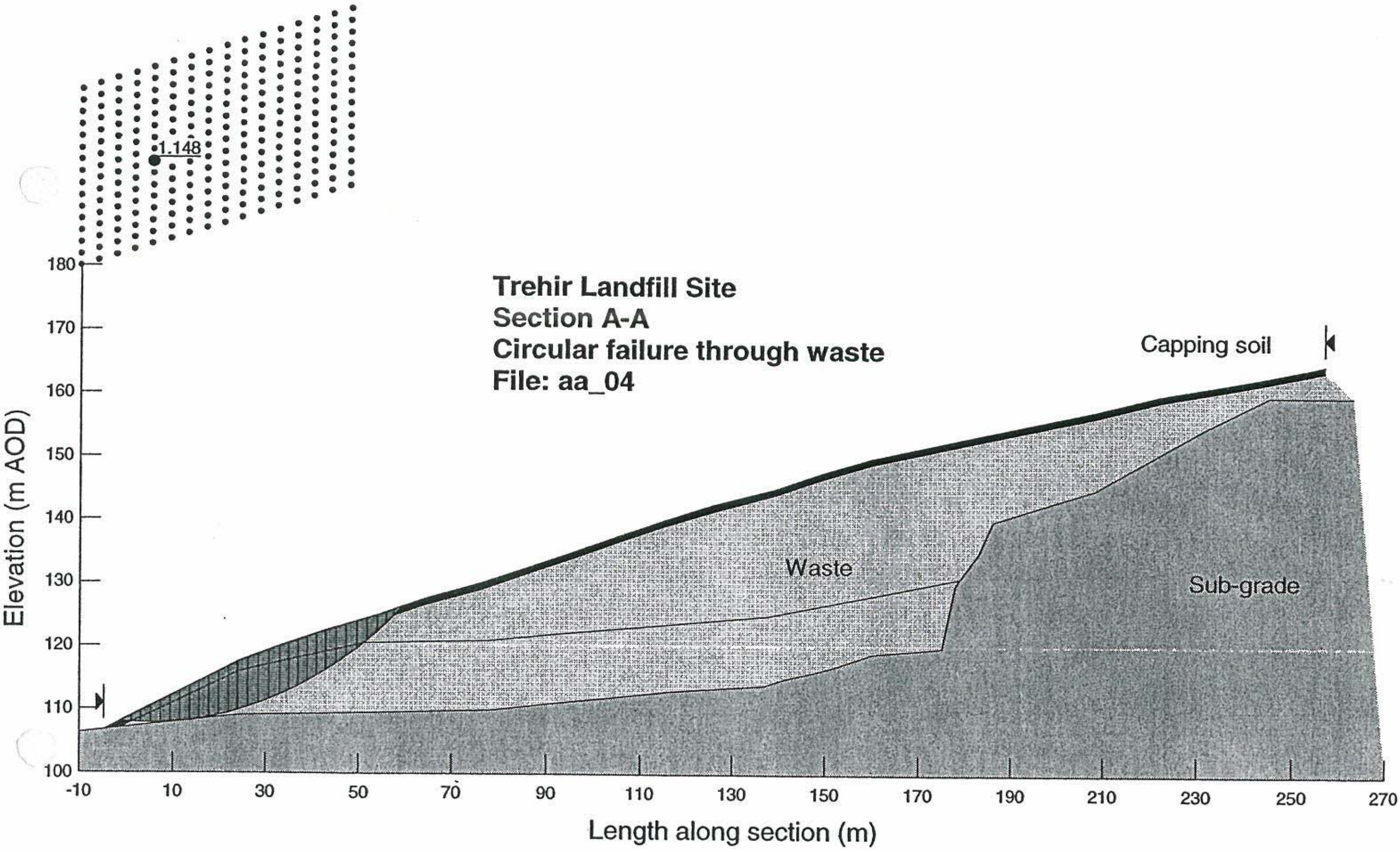

1.599
180
170
160
150
140
130
120
110
100
Elevation (m AOD)
Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_01
Capping soil
Waste
Sub-grade
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)



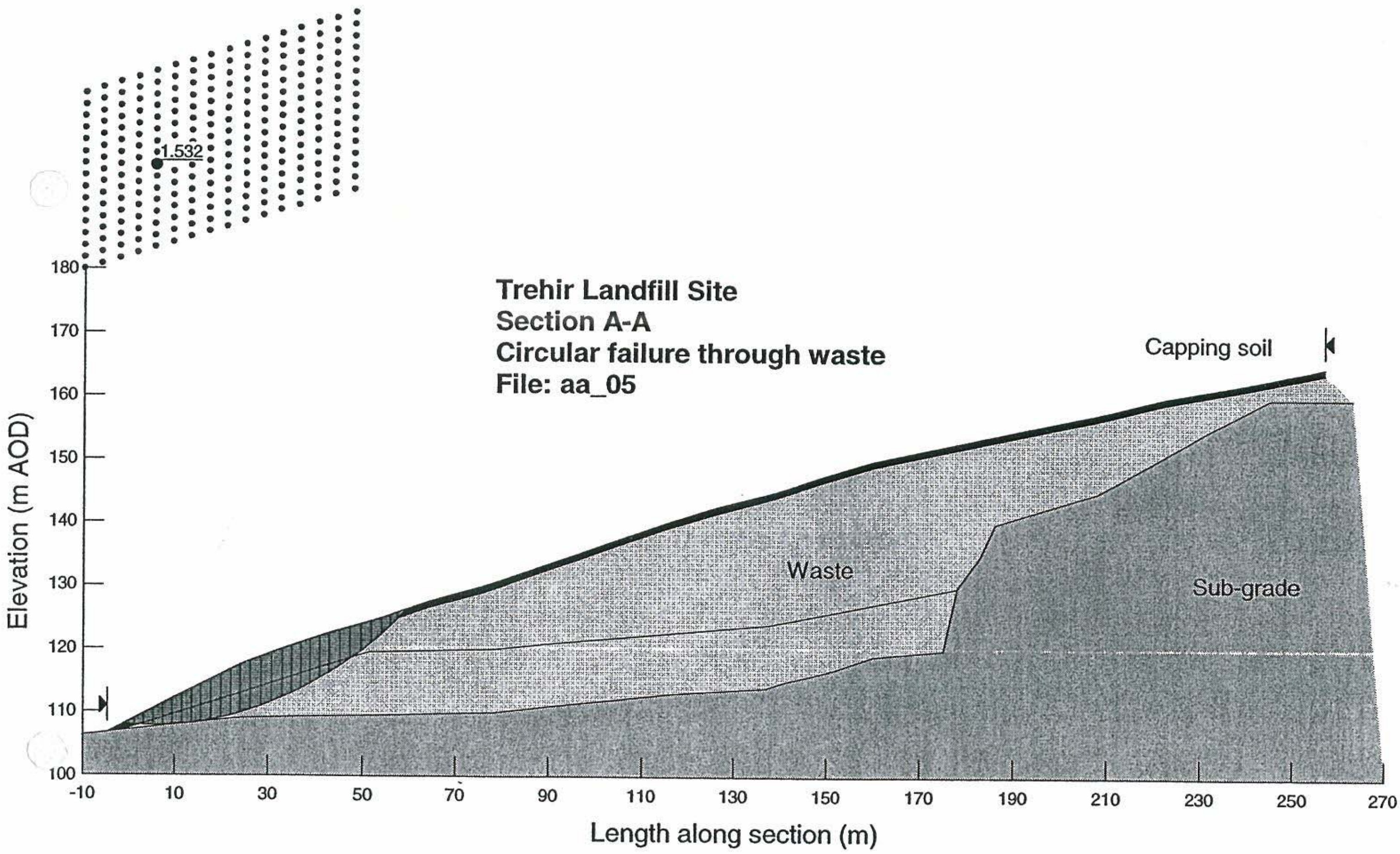
Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_02
1.461
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)



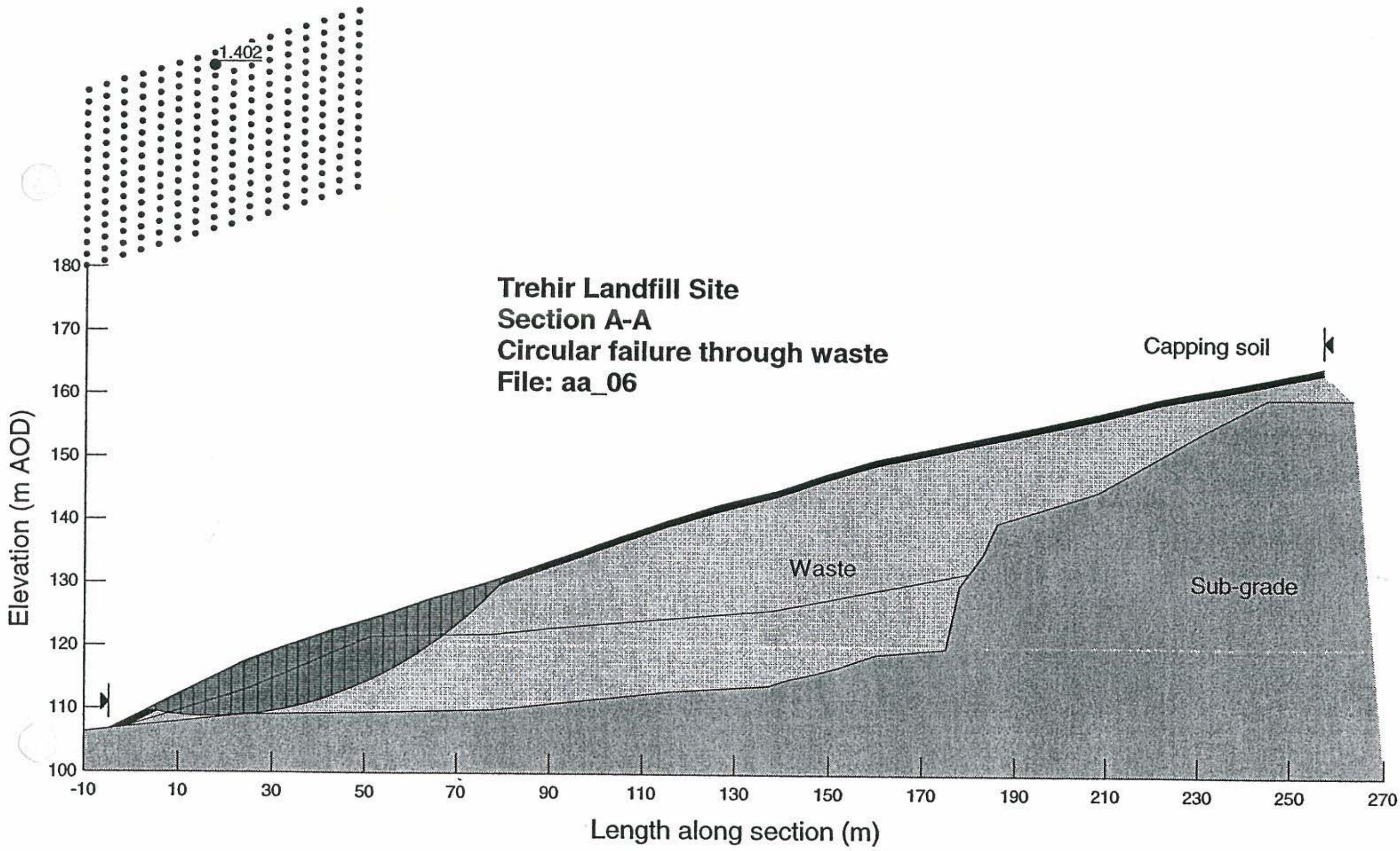
Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_03
1.310
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)

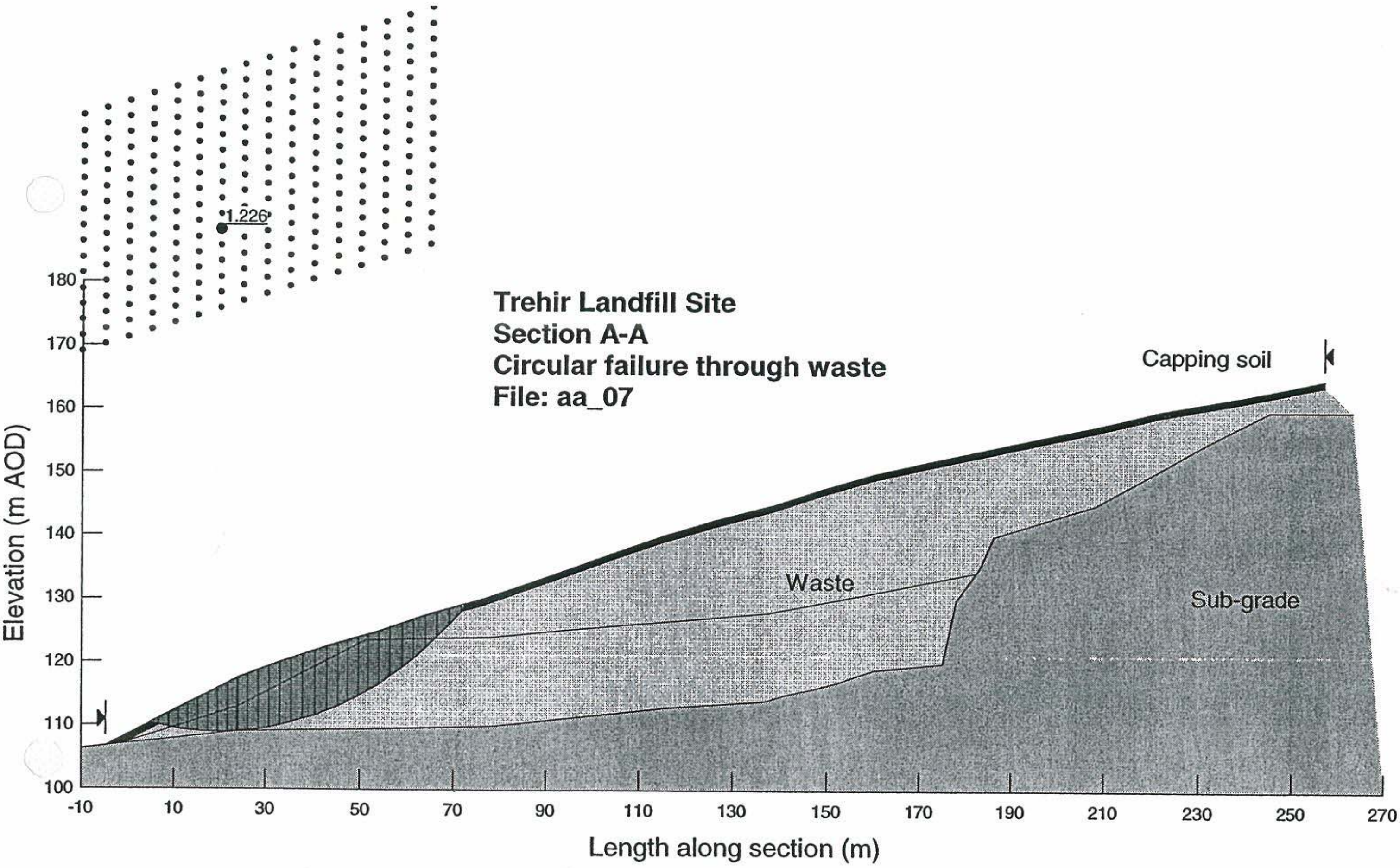


Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_04
1.148
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)



Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_05
1.532
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)


1.402
Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_06
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)



Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_07
1.226
Capping soil
Waste
Sub-grade
Elevation (m AOD)
Length along section (m)
180
170
160
150
140
130
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100
-10
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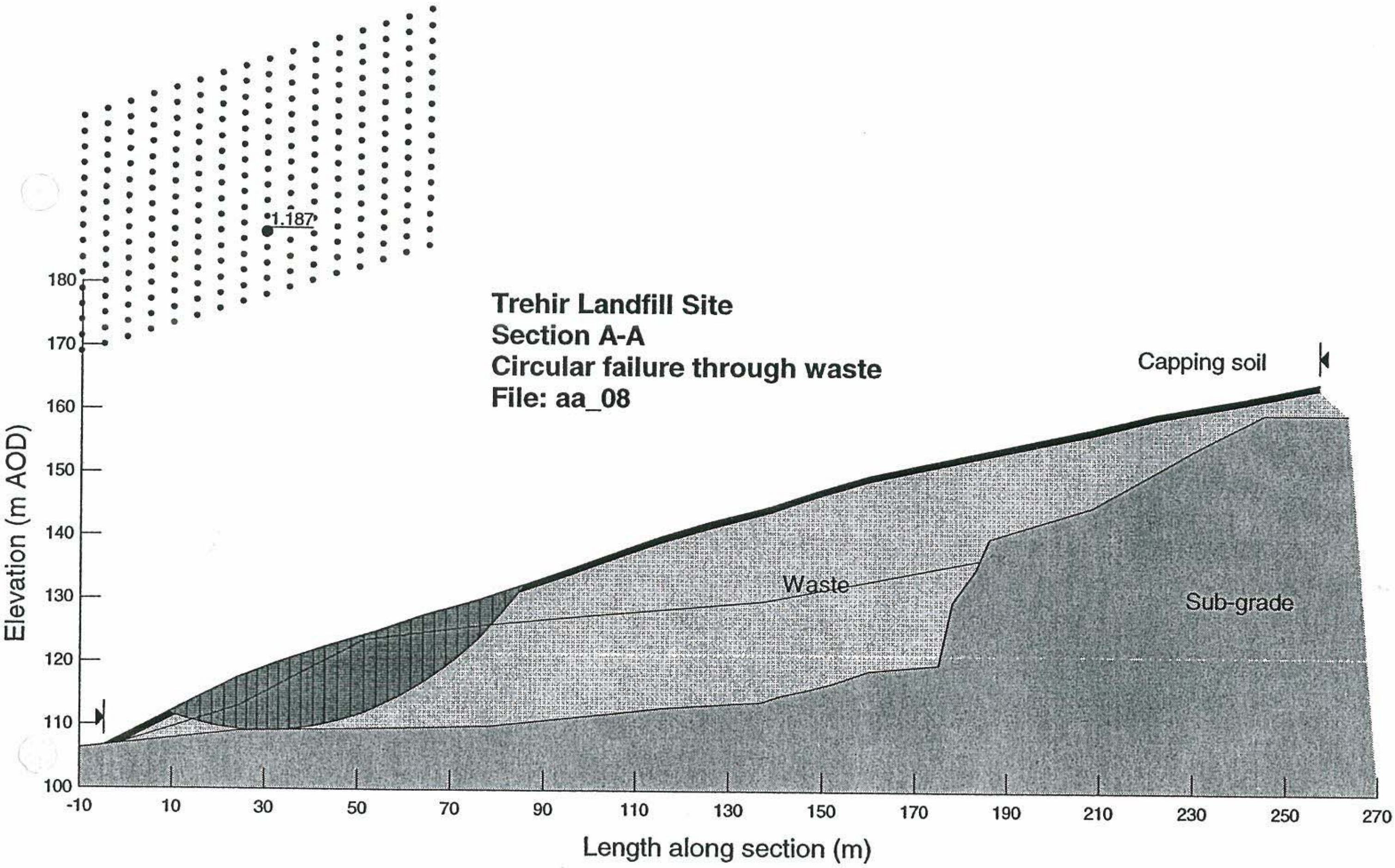
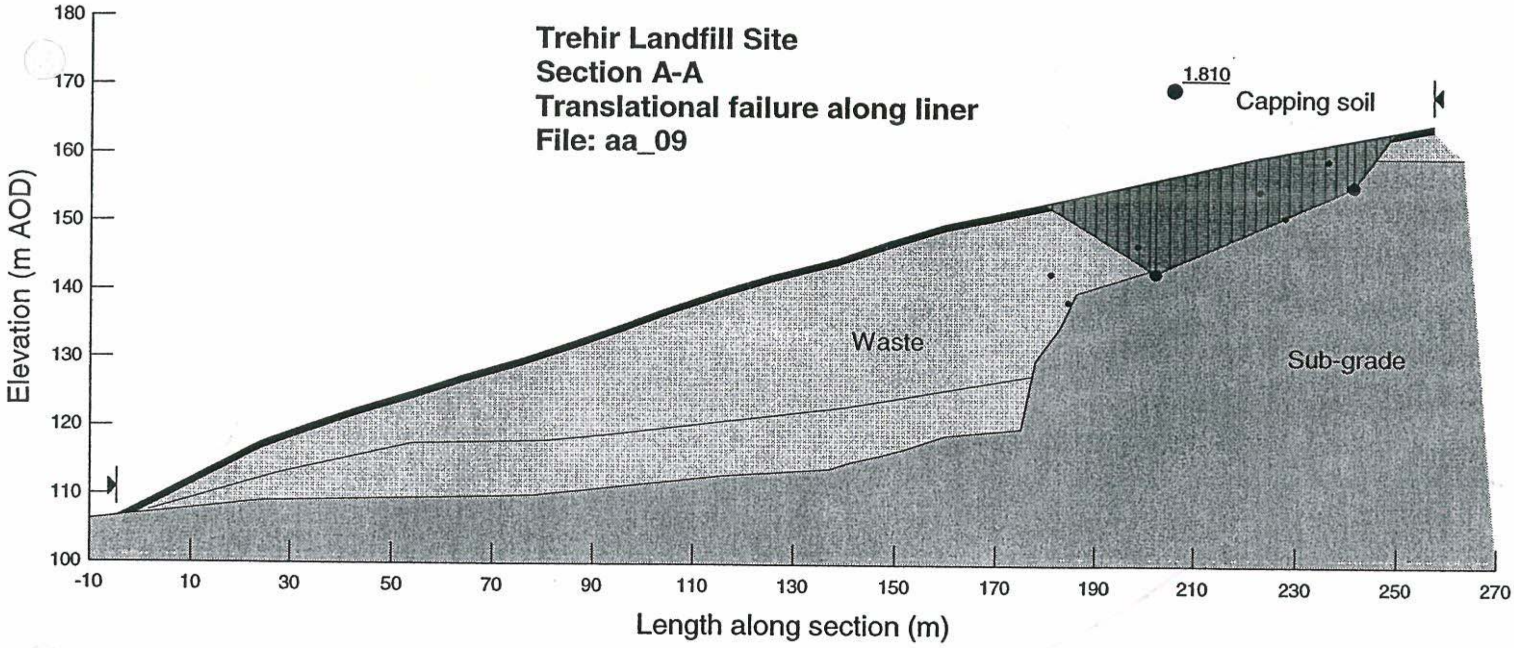
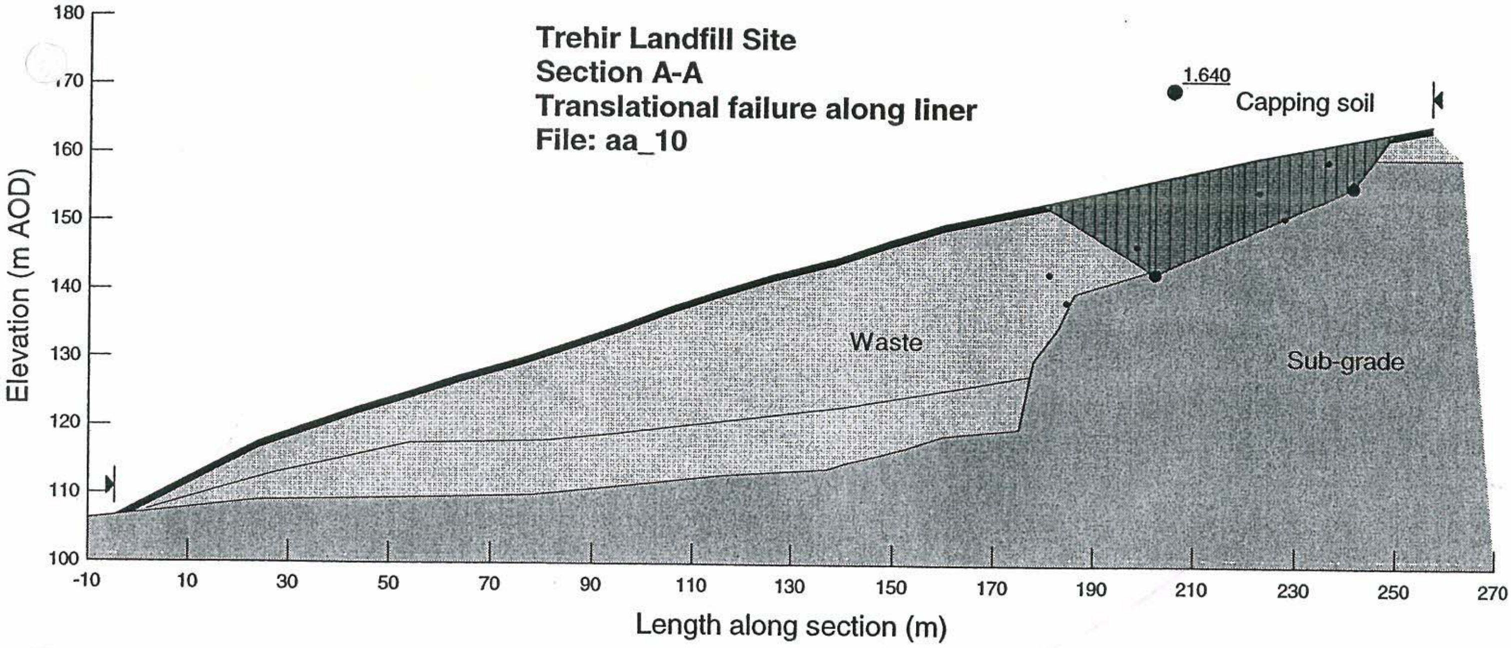
30
50
70
90
110
130
150
170
190
210
230
250
270



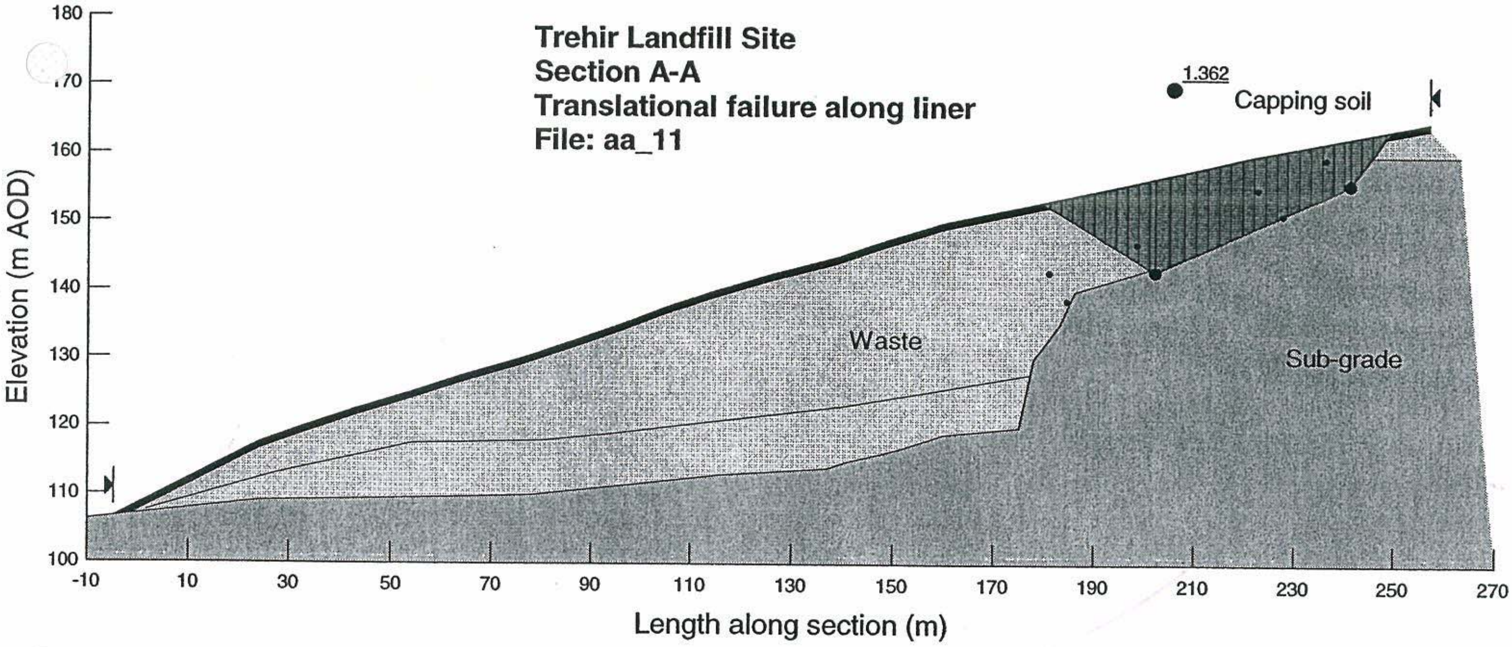
1.187
Trehir Landfill Site
Section A-A
Circular failure through waste
File: aa_08
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)



Trehir Landfill Site
Section A-A
Translational failure along liner
File: aa_09
1.810
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)

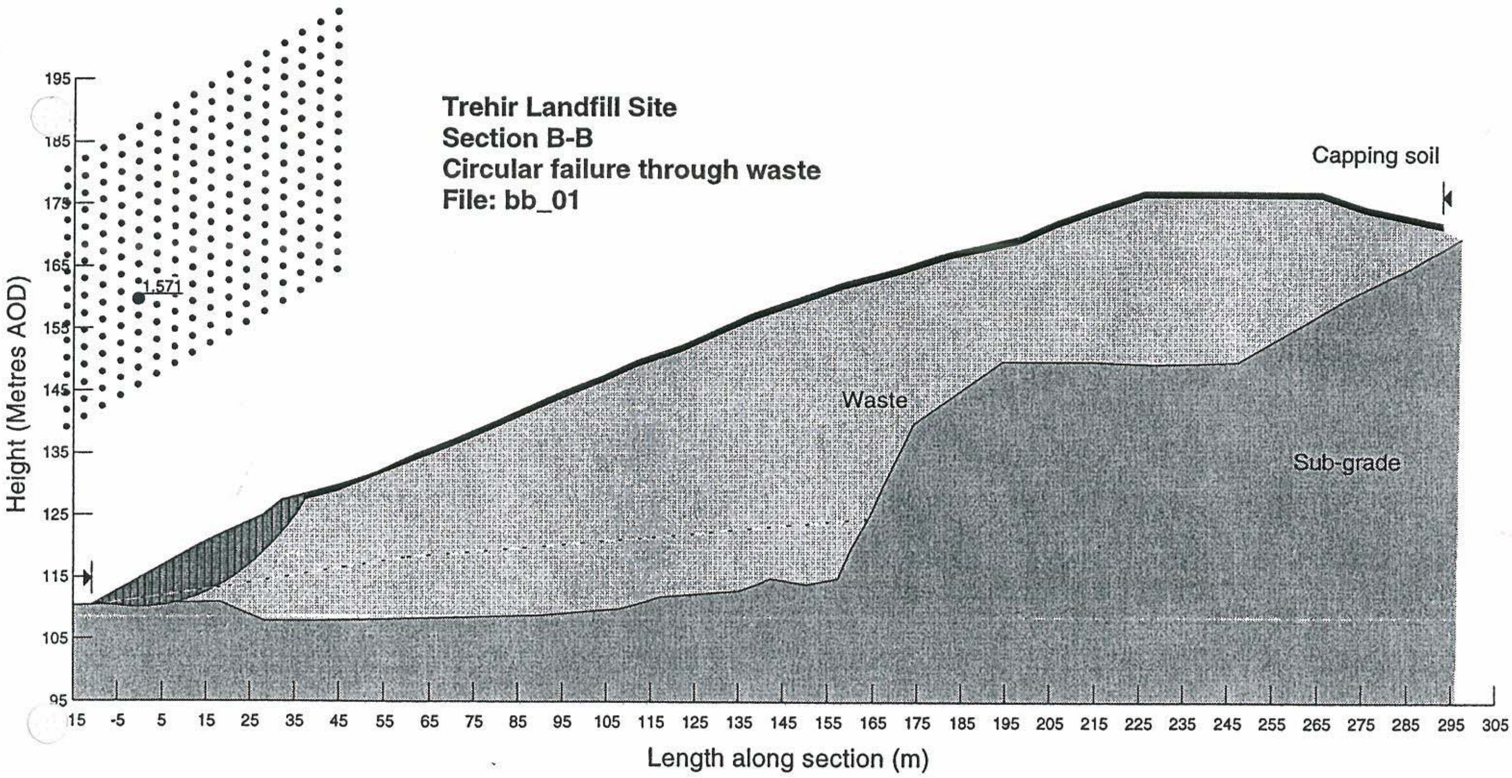


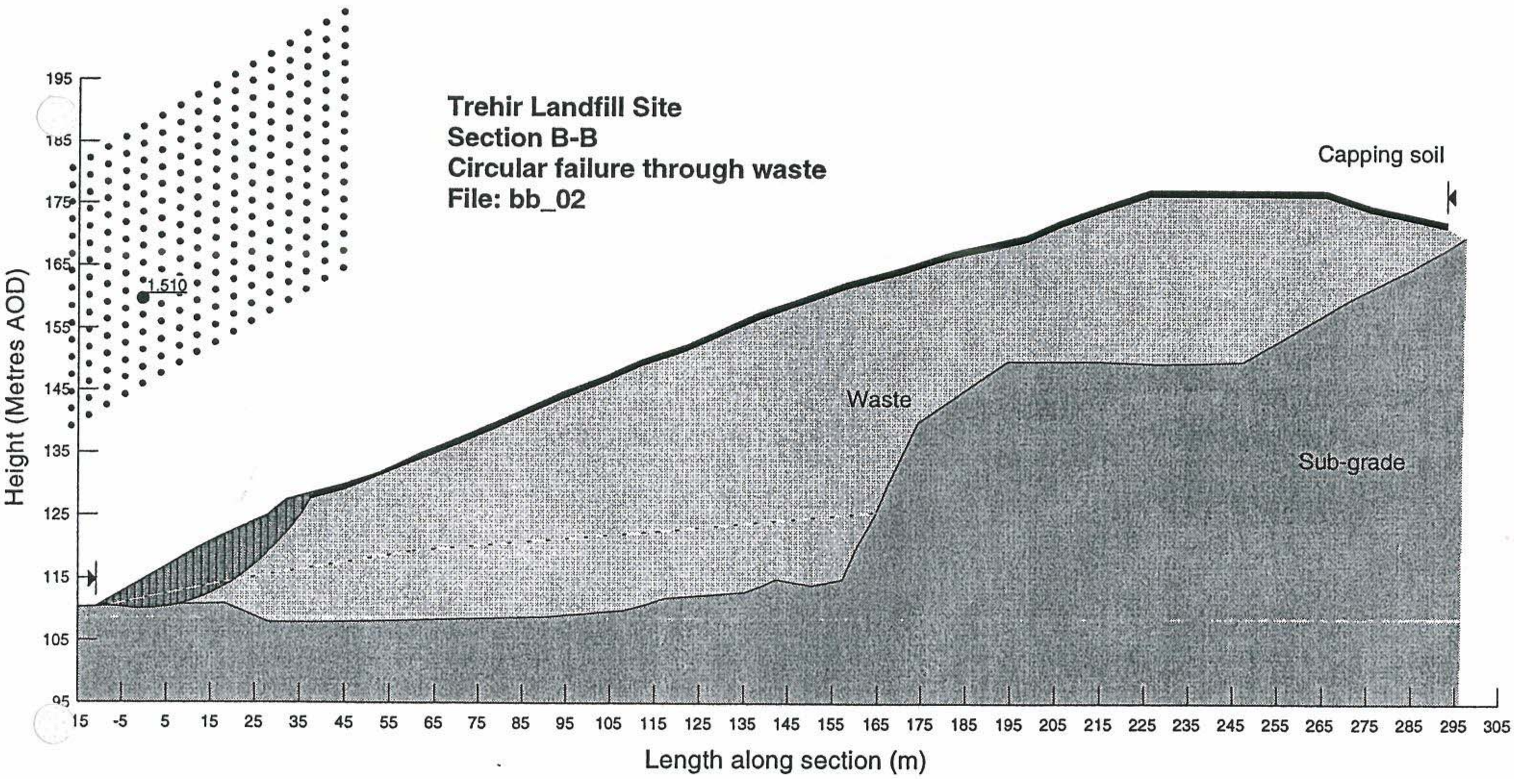
Trehir Landfill Site
Section A-A
Translational failure along liner
File: aa_10
1.640
Capping soil
Waste
Sub-grade
Elevation (m AOD)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
Length along section (m)


Trehir Landfill Site
Section A-A
Translational failure along liner
File: aa_11
1.362
Capping soil
Waste
Sub-grade
Elevation (m AOD)
Length along section (m)
180
170
160
150
140
130
120
110
100
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270

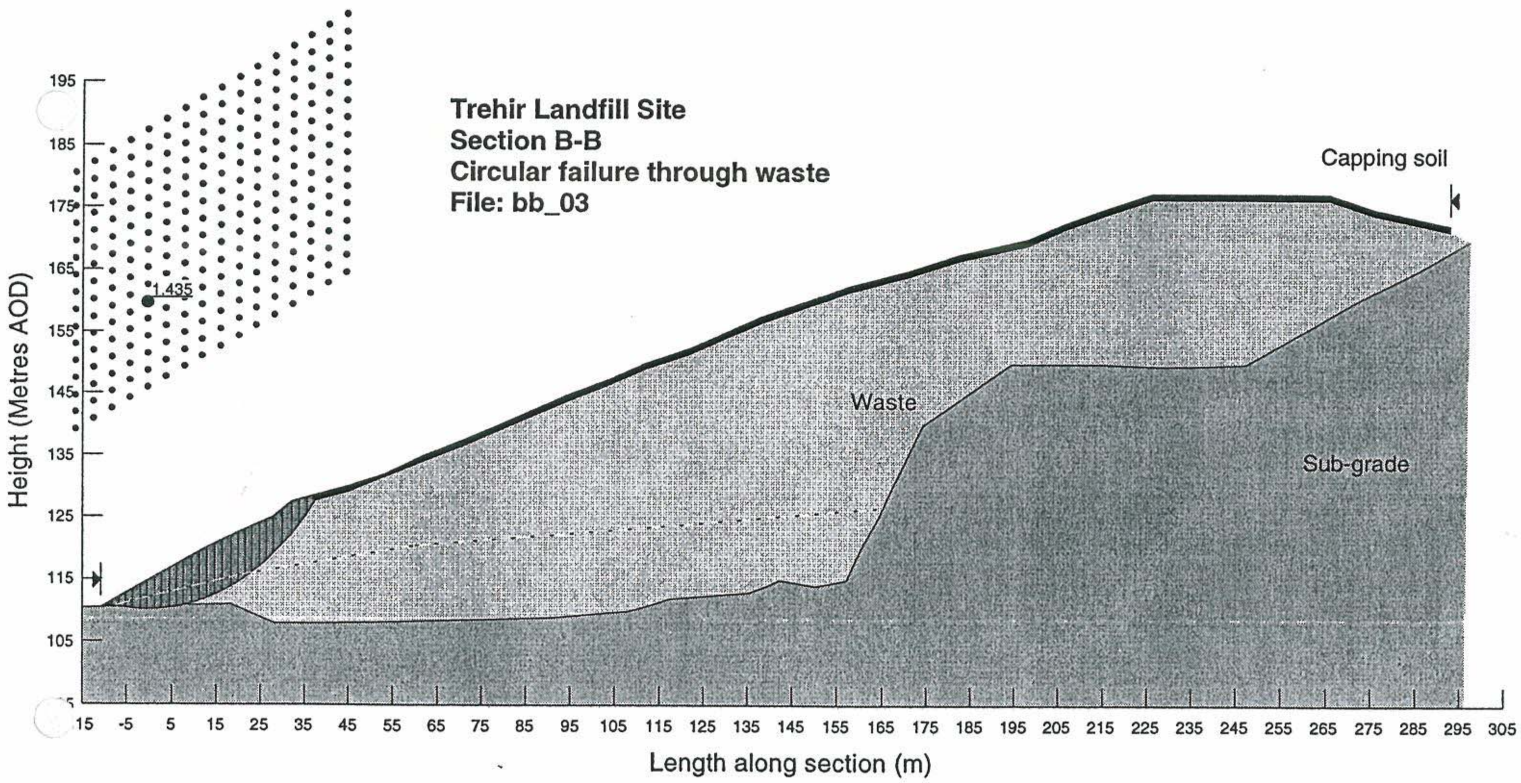
APPENDIX 3

Stability Analyses: Section B-B

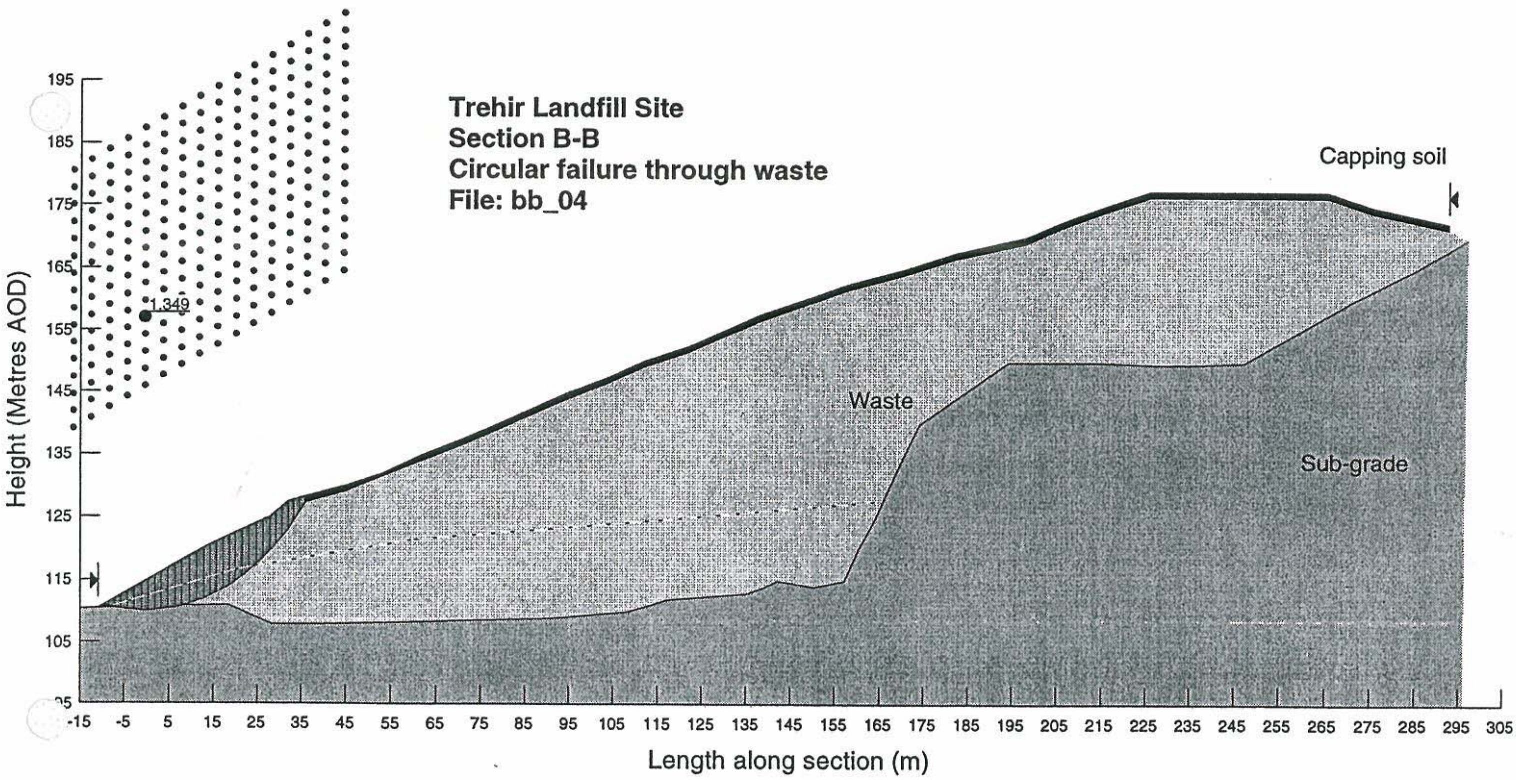

Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_01
Capping soil
Waste
Sub-grade
1.571
Height (Metres AOD)
Length along section (m)
195
185
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305



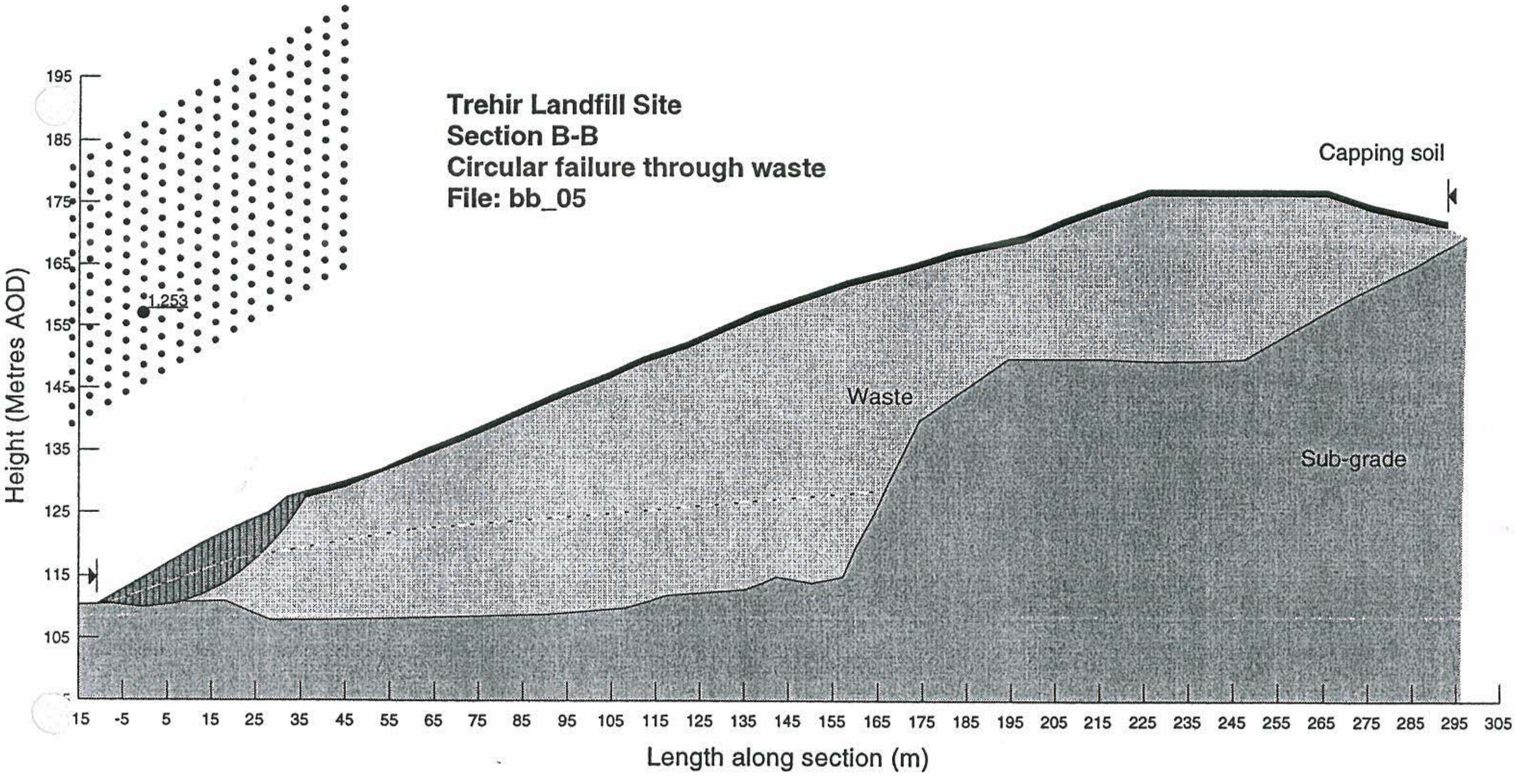
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_02
Capping soil
1.510
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

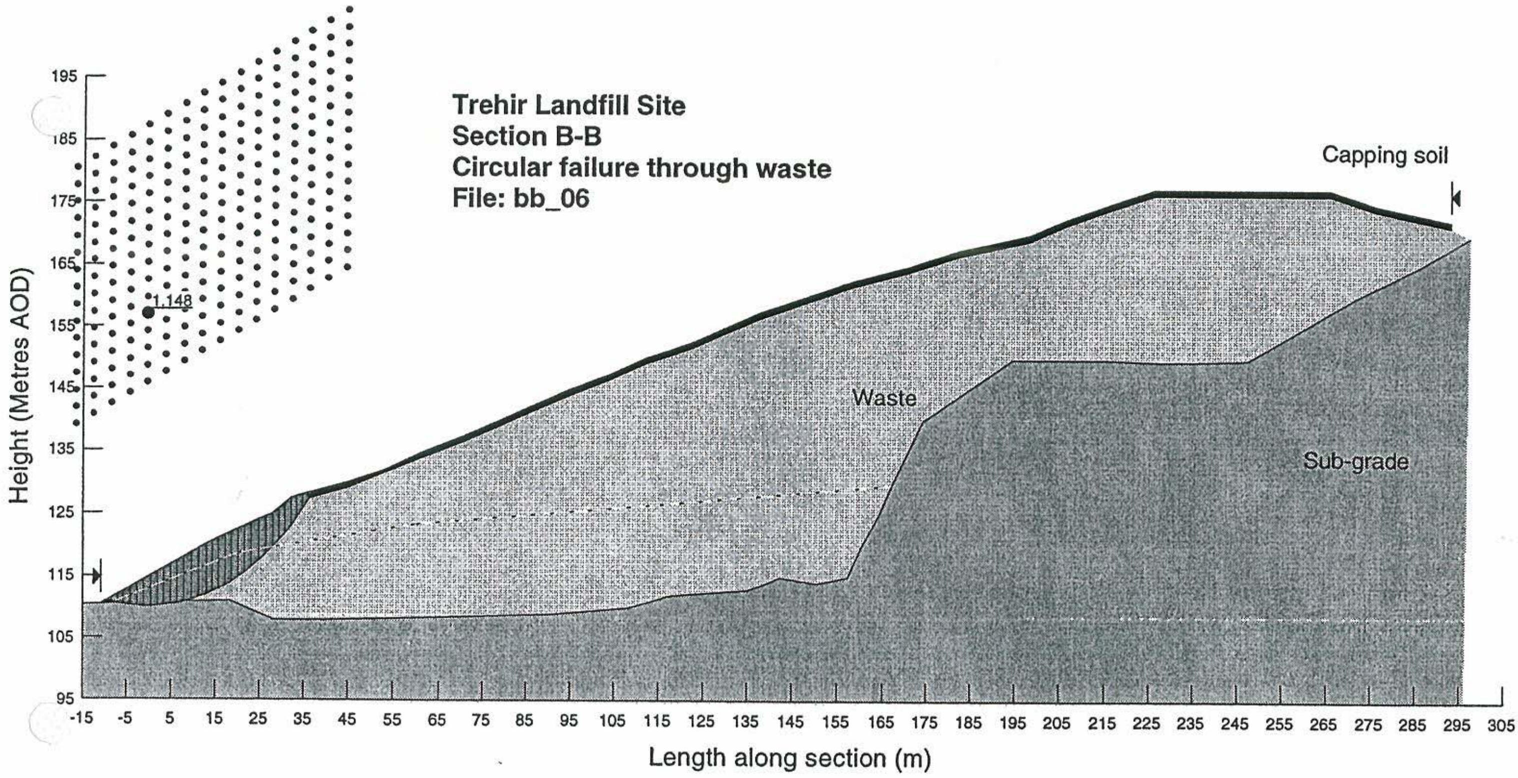


Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_03
Capping soil
1.435
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

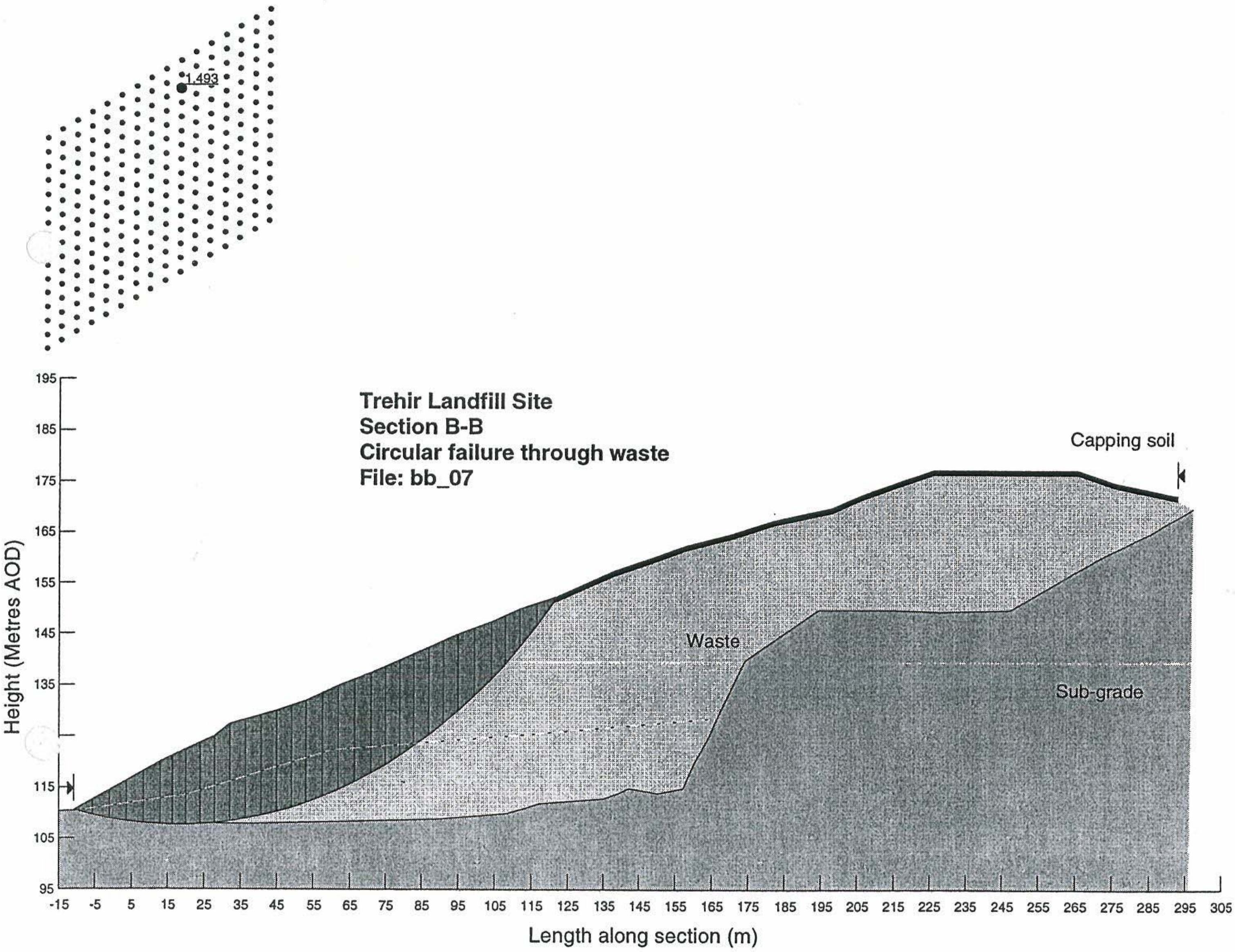


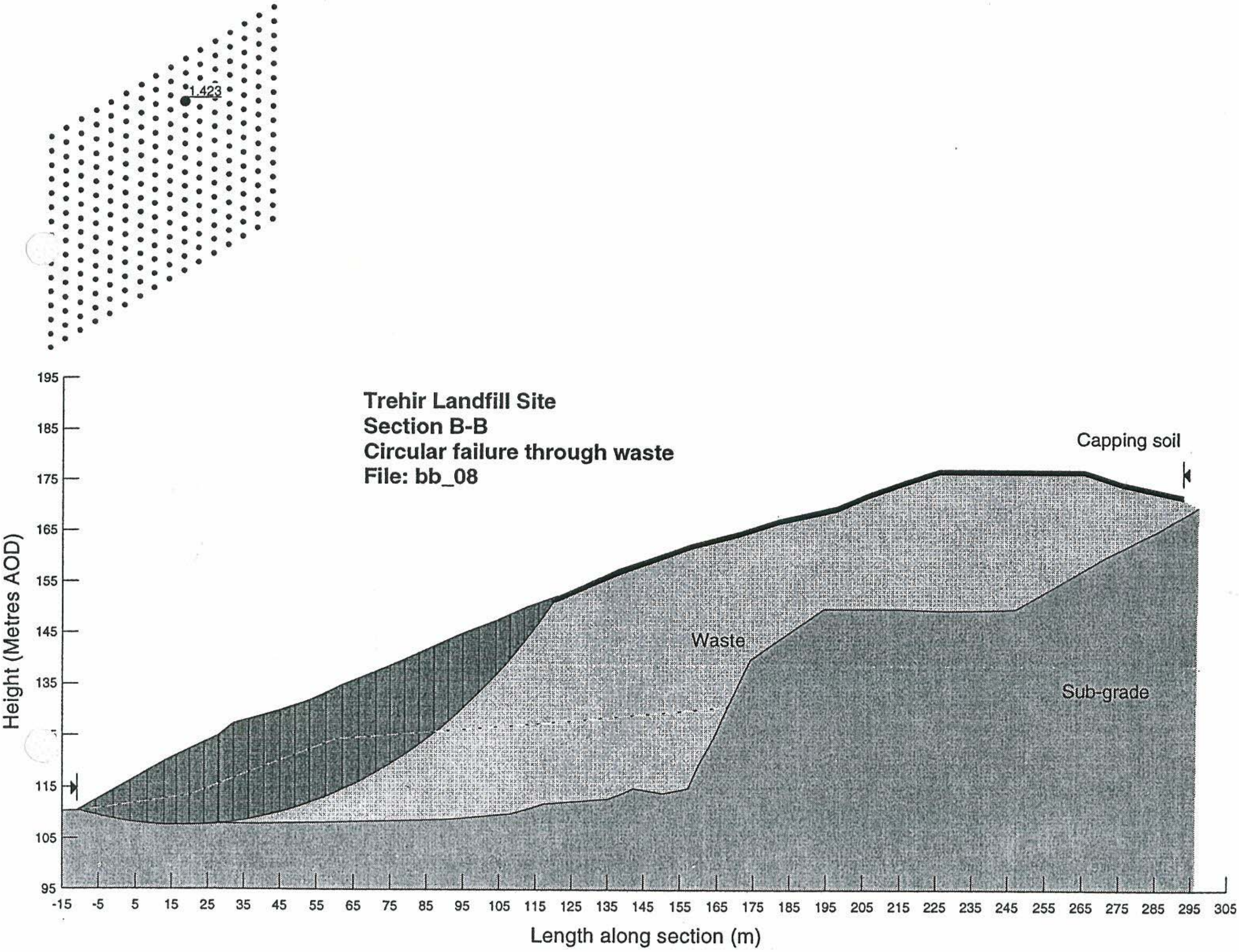
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_04
Capping soil
1.349
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305
Length along section (m)

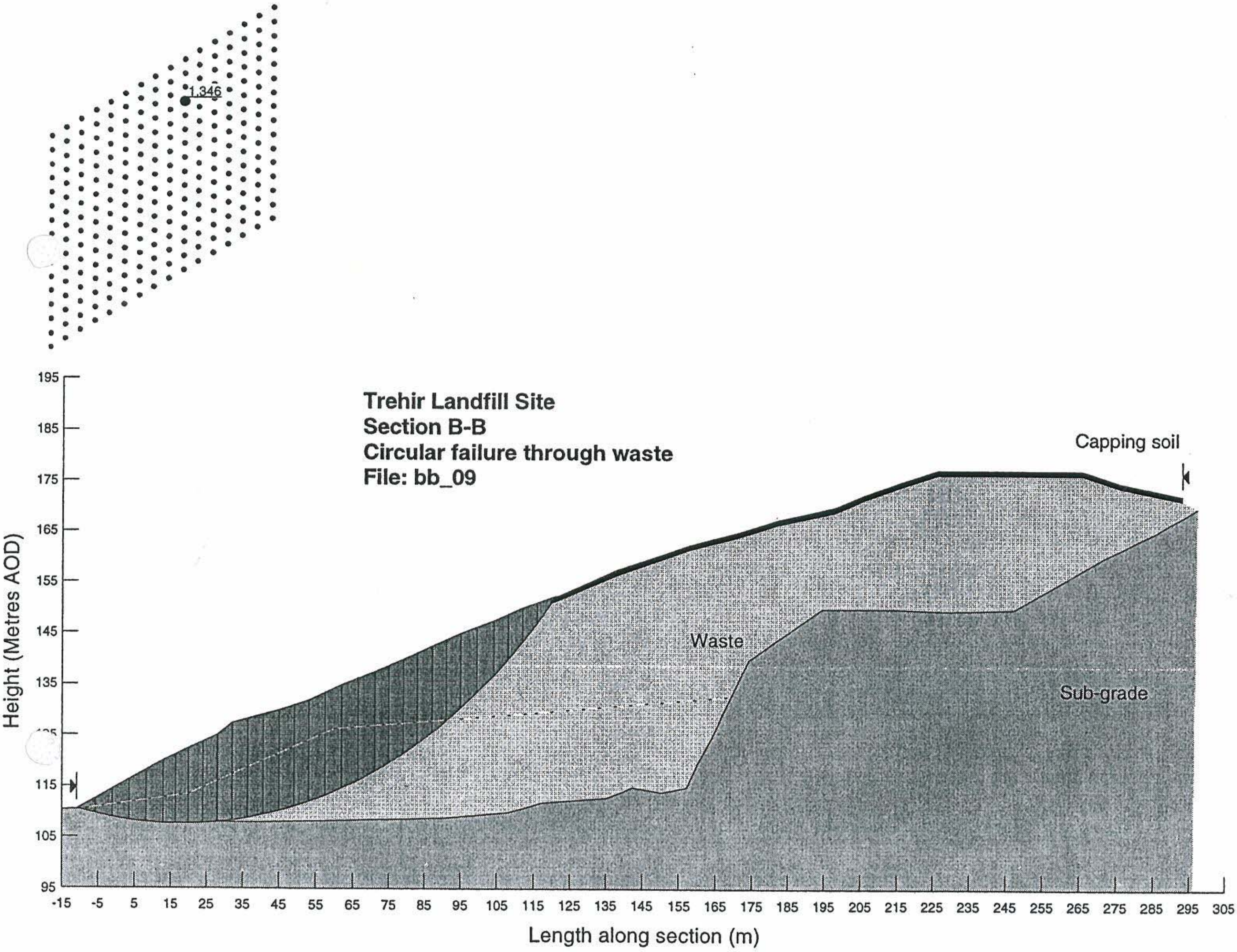

Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_05
Capping soil
Waste
Sub-grade
1.253
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)



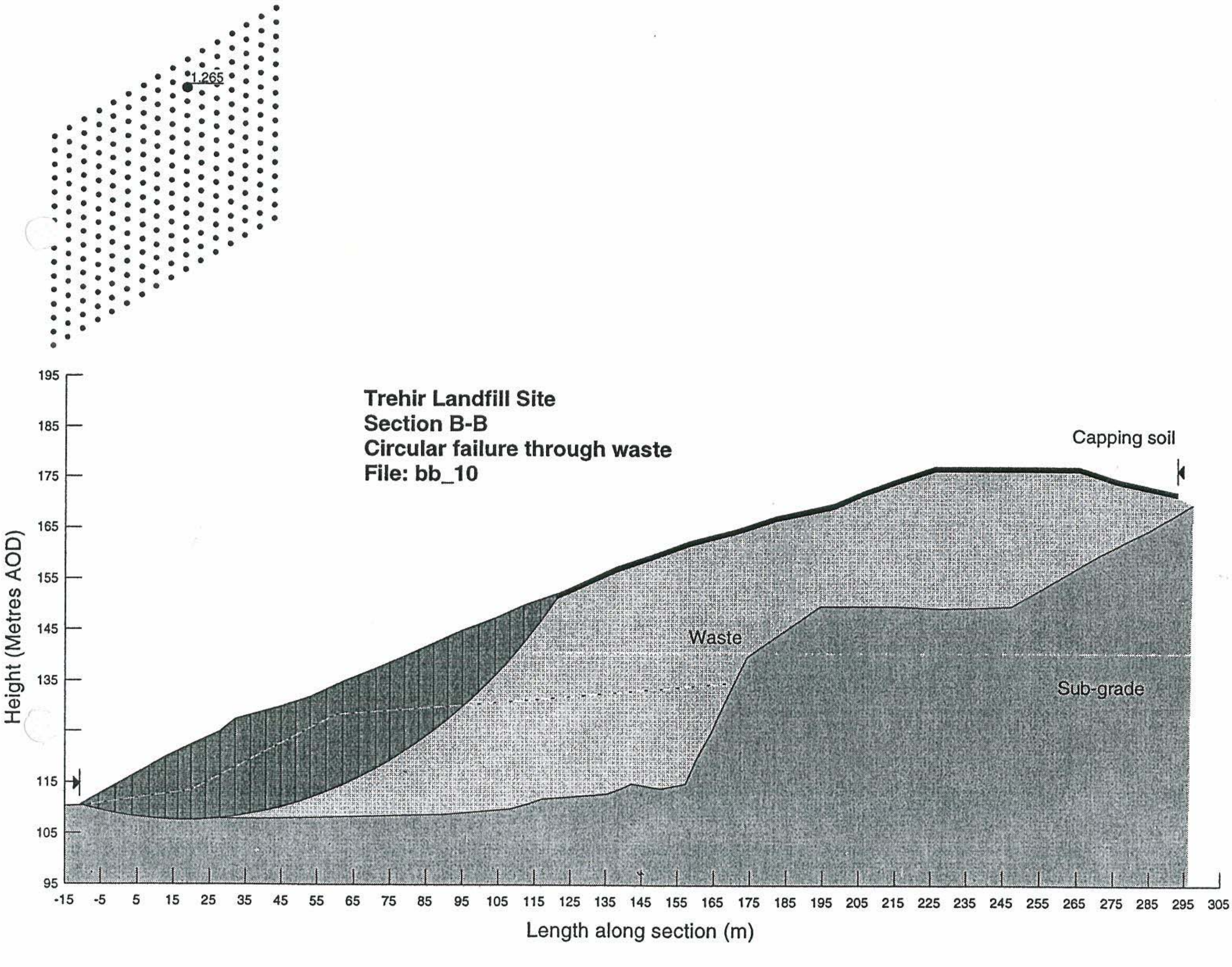
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_06
Capping soil
1.148
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305
Length along section (m)


1.493
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_07
Capping soil
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305
Length along section (m)

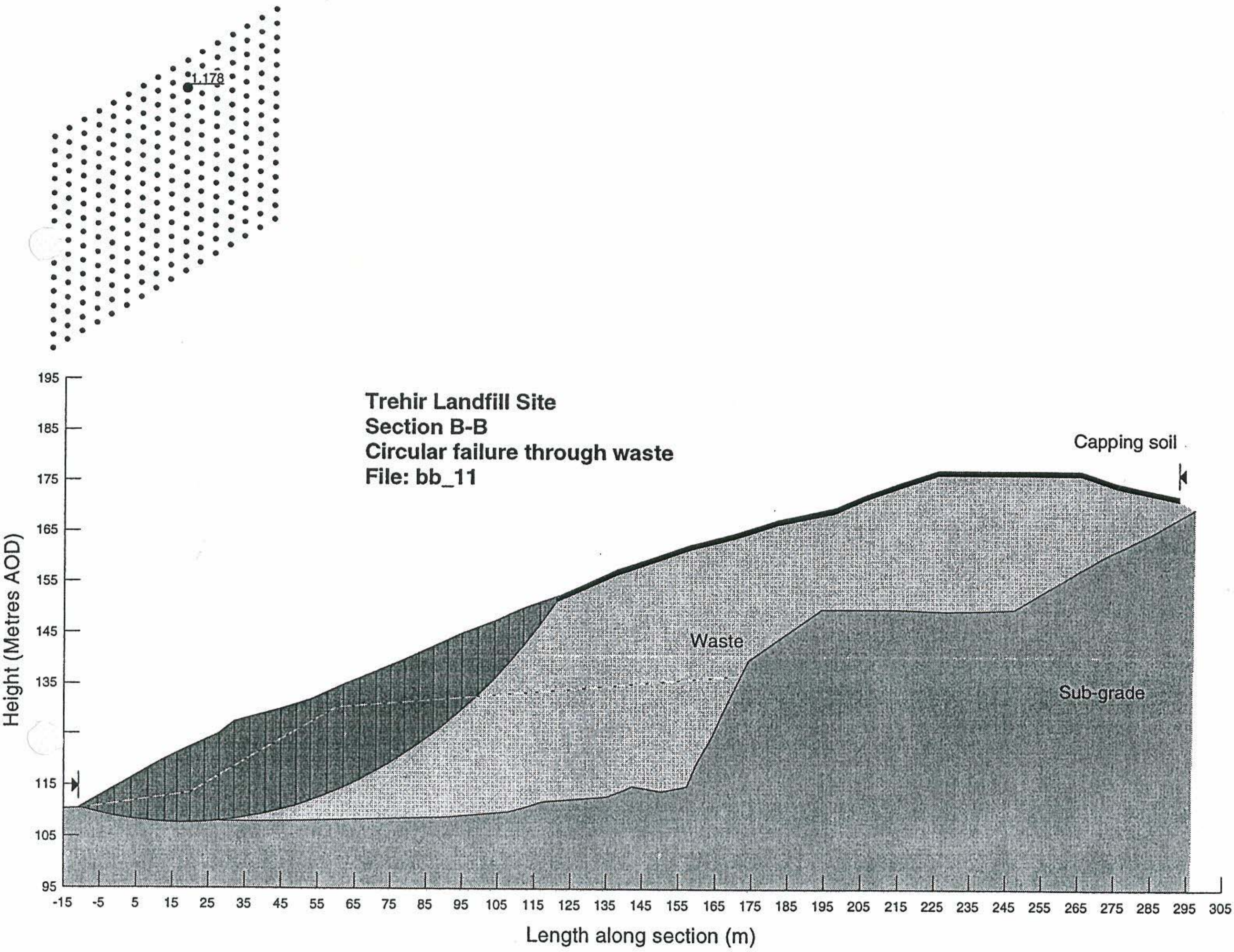

1.423
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_08
Capping soil
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)
195
185
175
165
155
145
135
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305



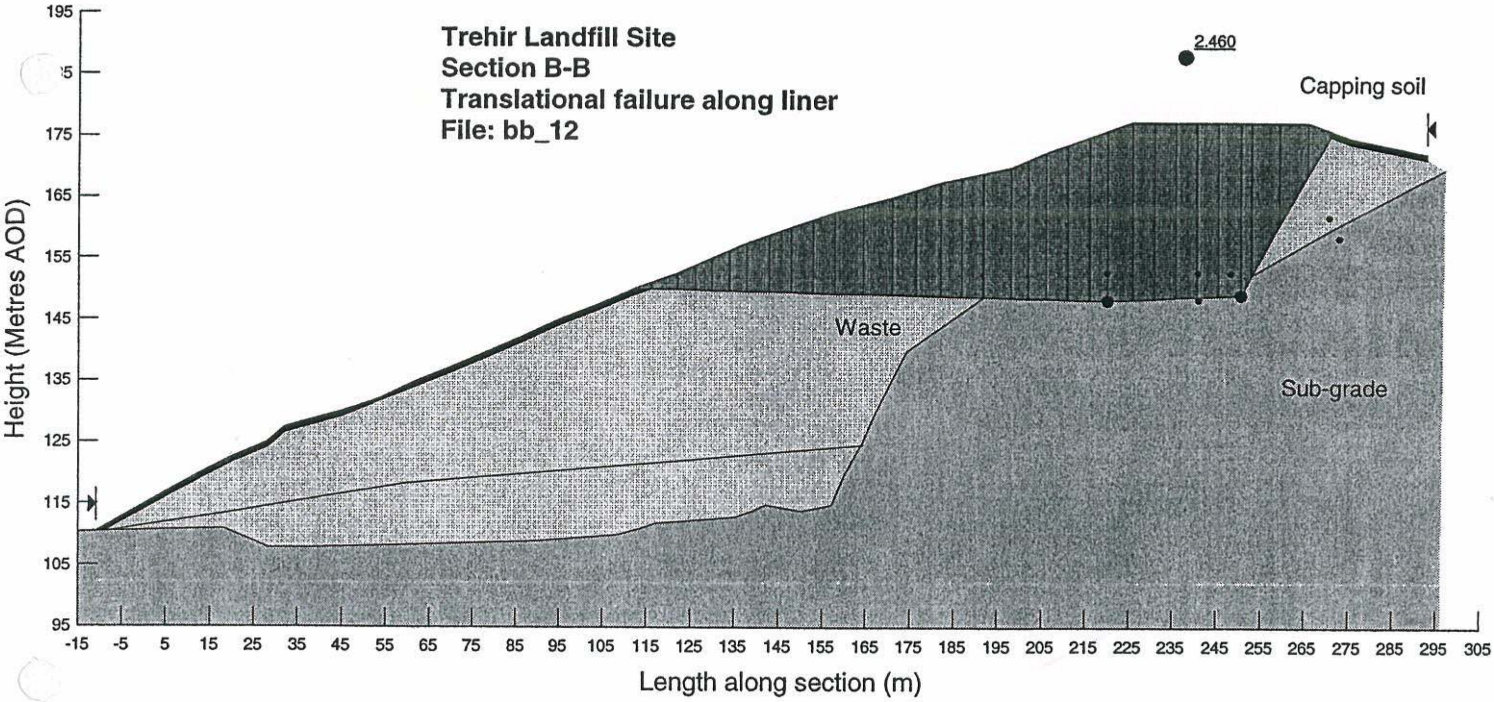
1.346
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_09
Capping soil
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

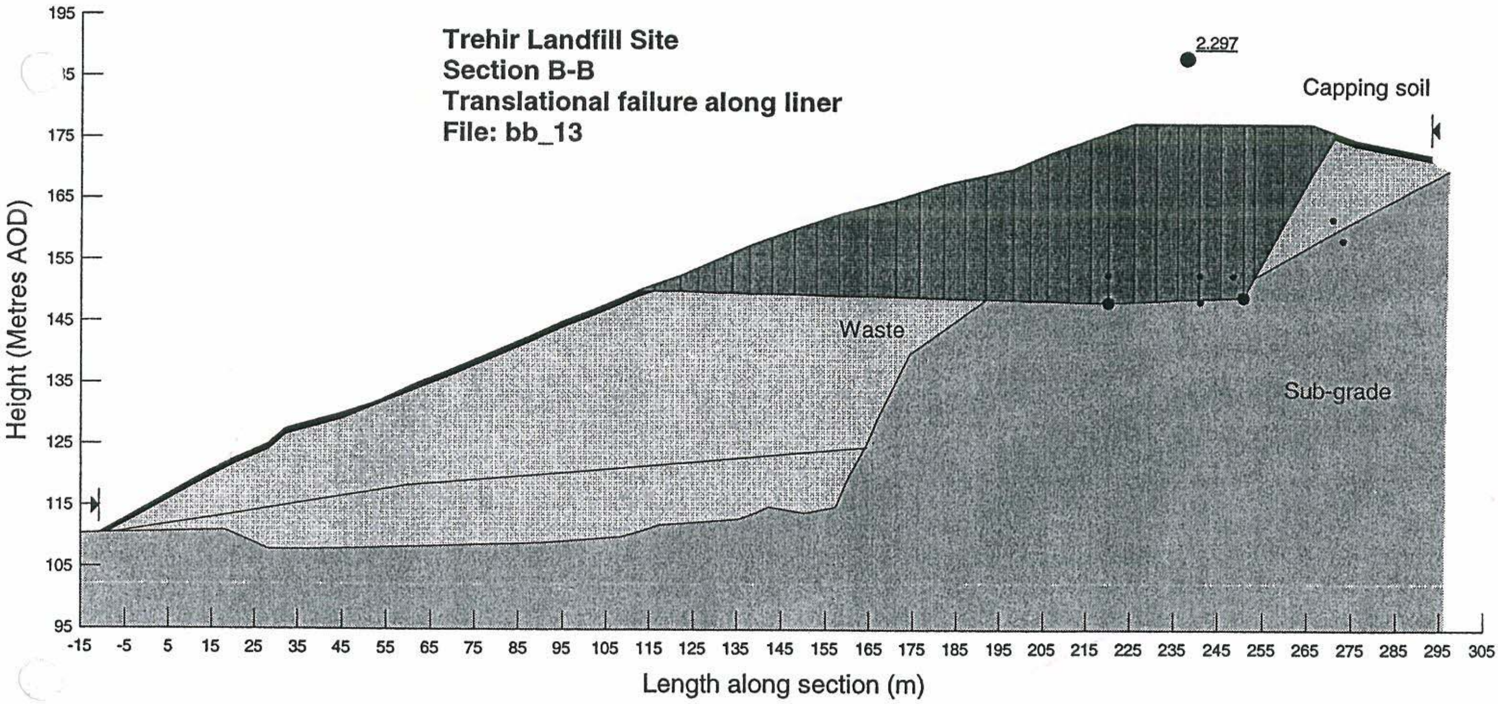


1.265
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_10
Capping soil
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305
Length along section (m)

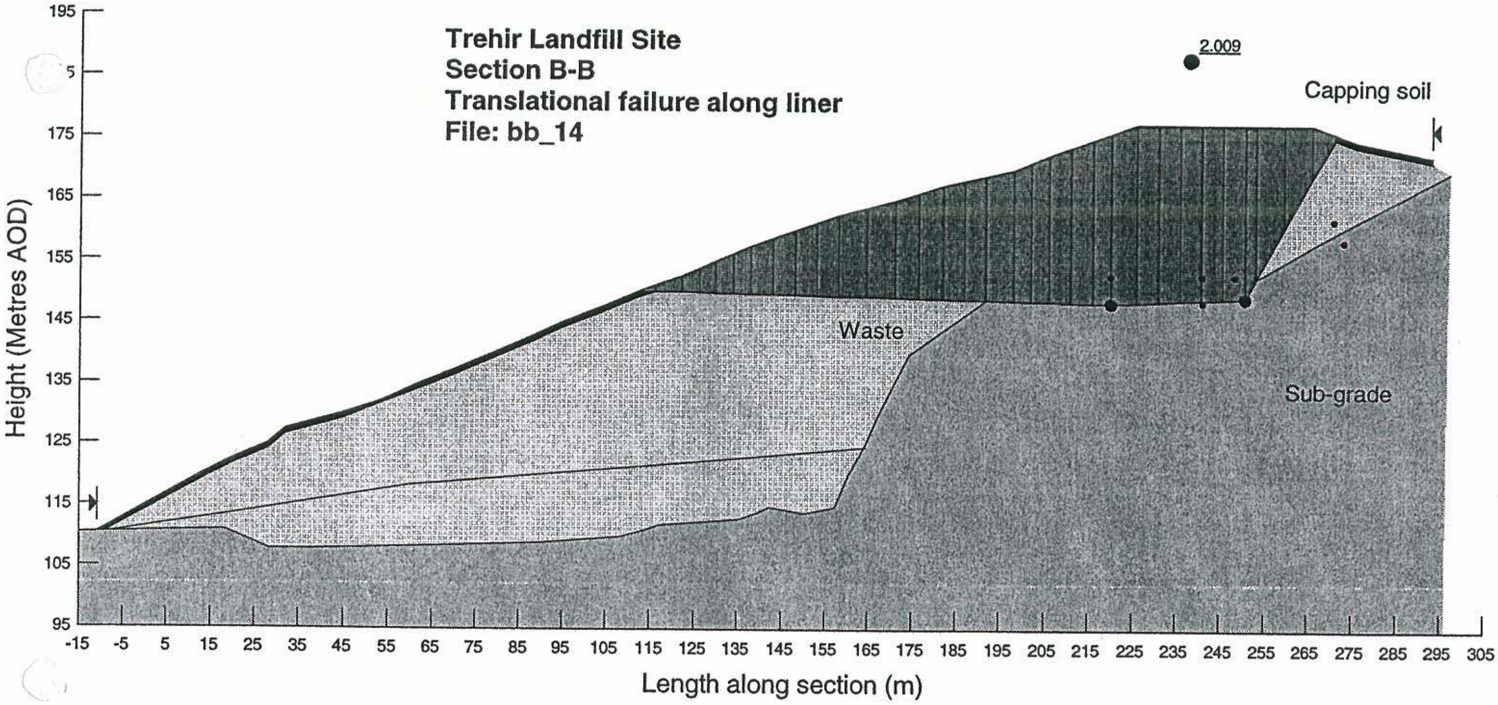


1.178
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_11
Capping soil
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305
Length along section (m)

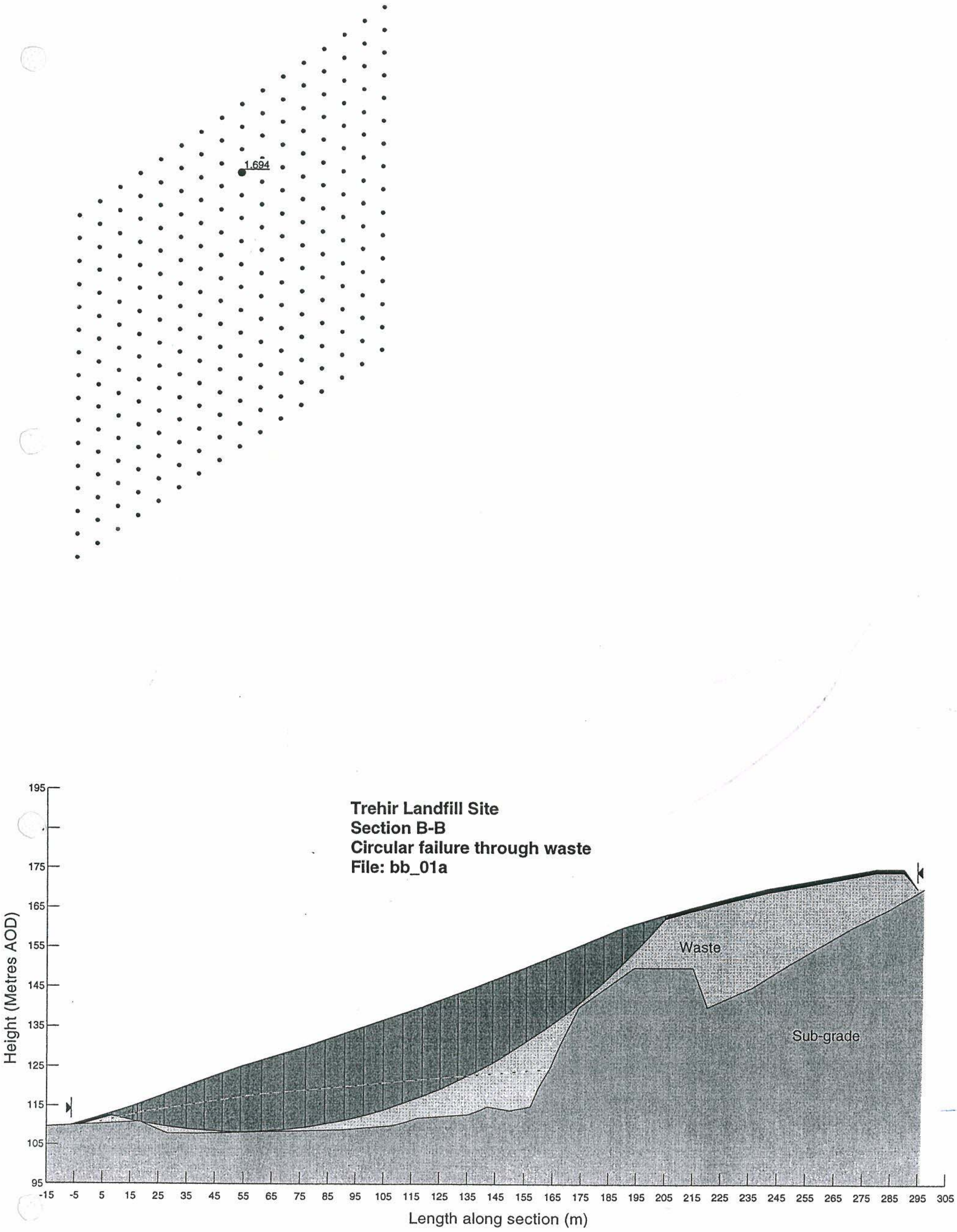

Trehir Landfill Site
Section B-B
Translational failure along liner
File: bb_12
2.460
Capping soil
Waste
Sub-grade
Height (Metres AOD)
195
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

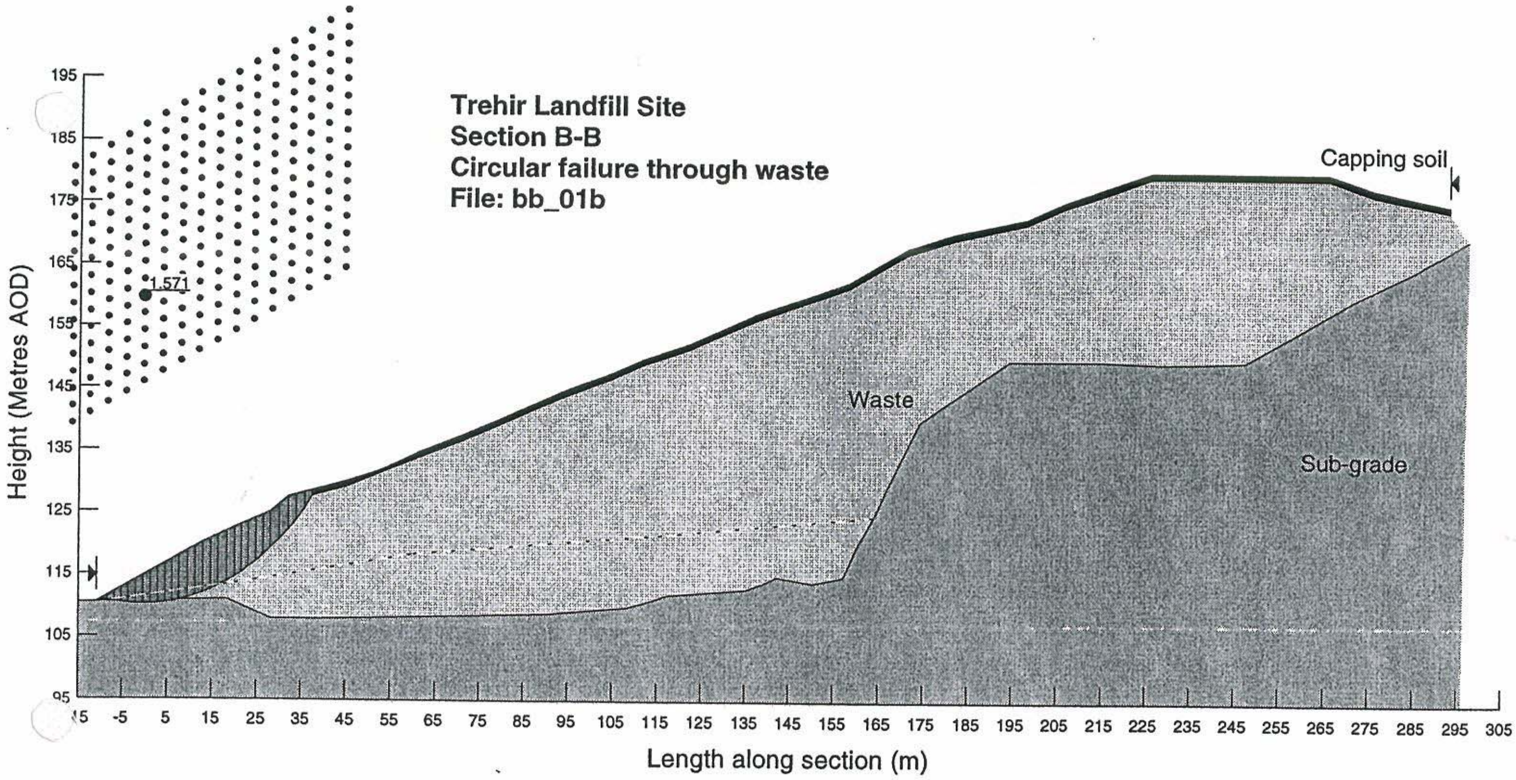


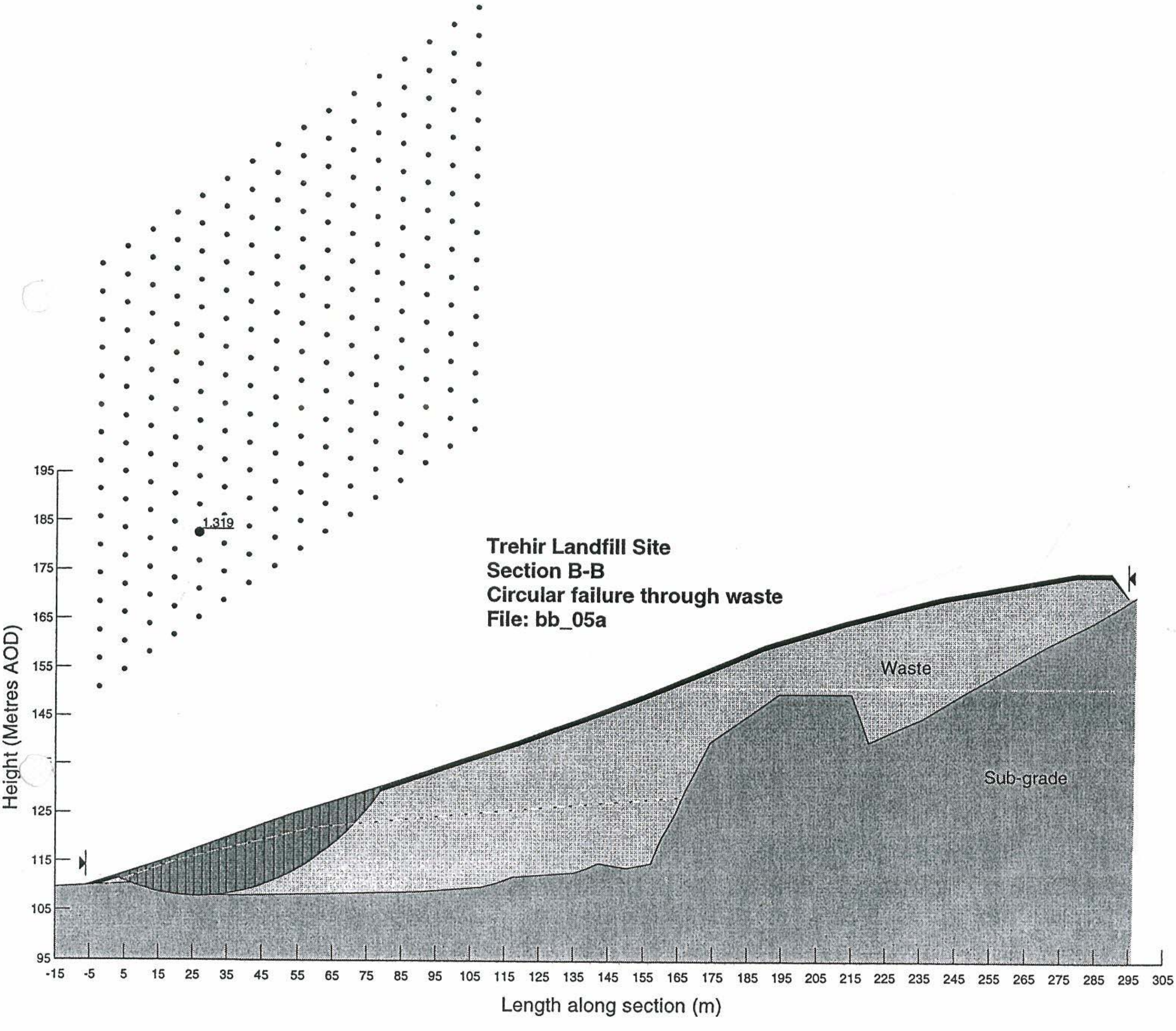
Trehir Landfill Site
Section B-B
Translational failure along liner
File: bb_13
2.297
Capping soil
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)
195
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305



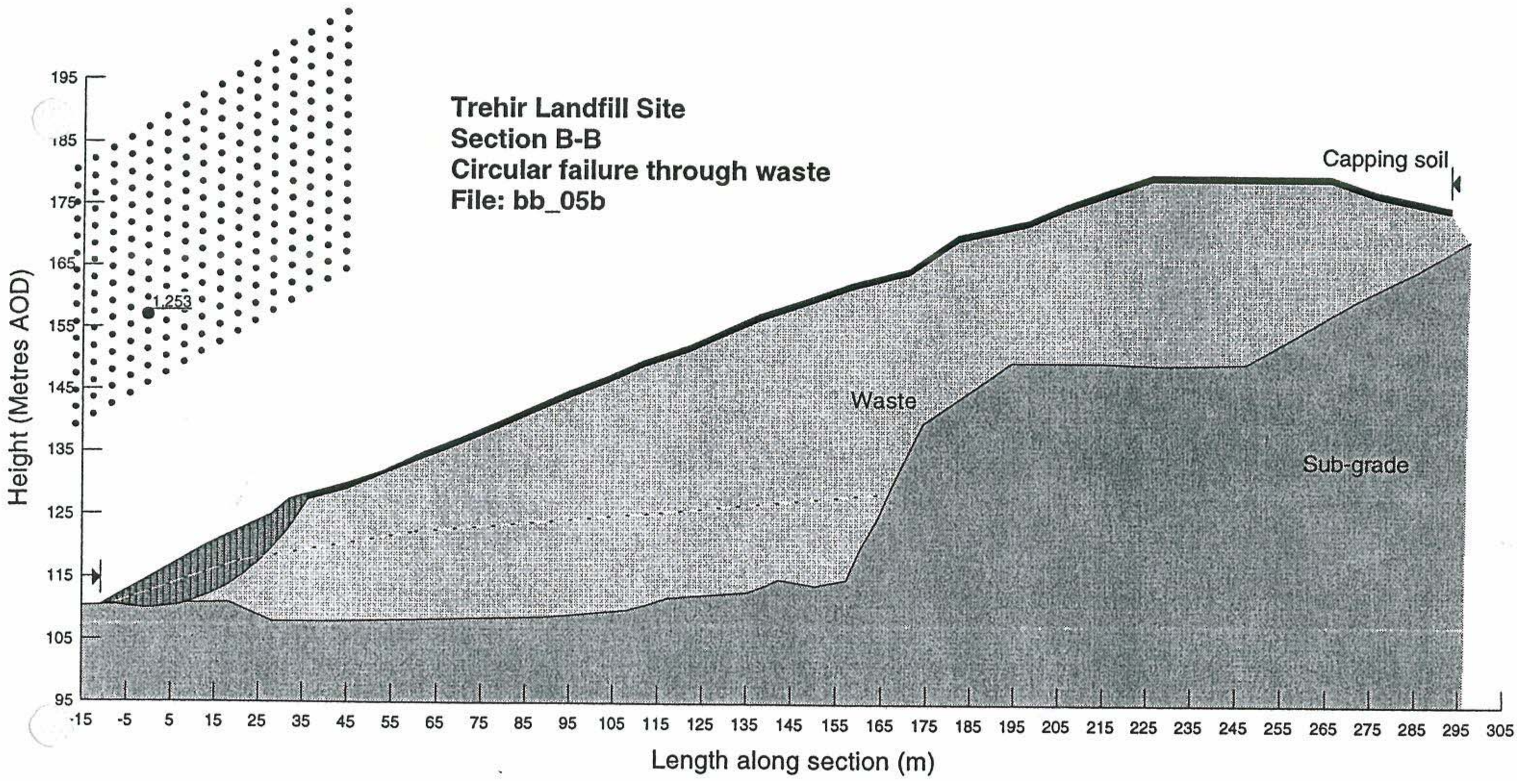
Trehir Landfill Site
Section B-B
Translational failure along liner
File: bb_14
2.009
Capping soil
Waste
Sub-grade
Height (Metres AOD)
195
175
165
155
145
135
125
115
105
95
-15 -5 5 15 25 35 45 55 65 75 85 95 105 115 125 135 145 155 165 175 185 195 205 215 225 235 245 255 265 275 285 295 305
Length along section (m)


1.694
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_01a
Waste
Sub-grade
Height (Metres AOD)
195
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)


Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_01b
Capping soil
1.571
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

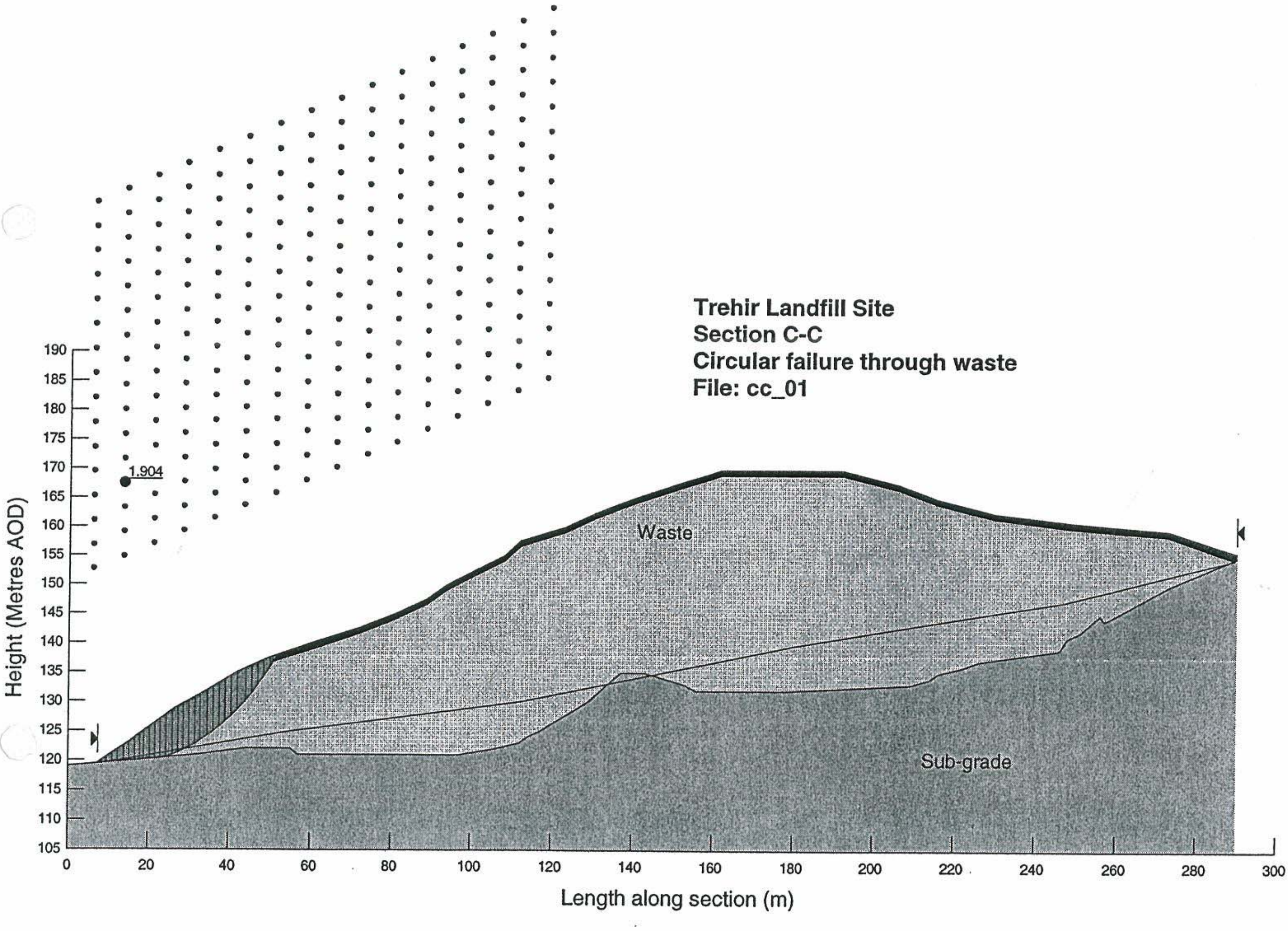


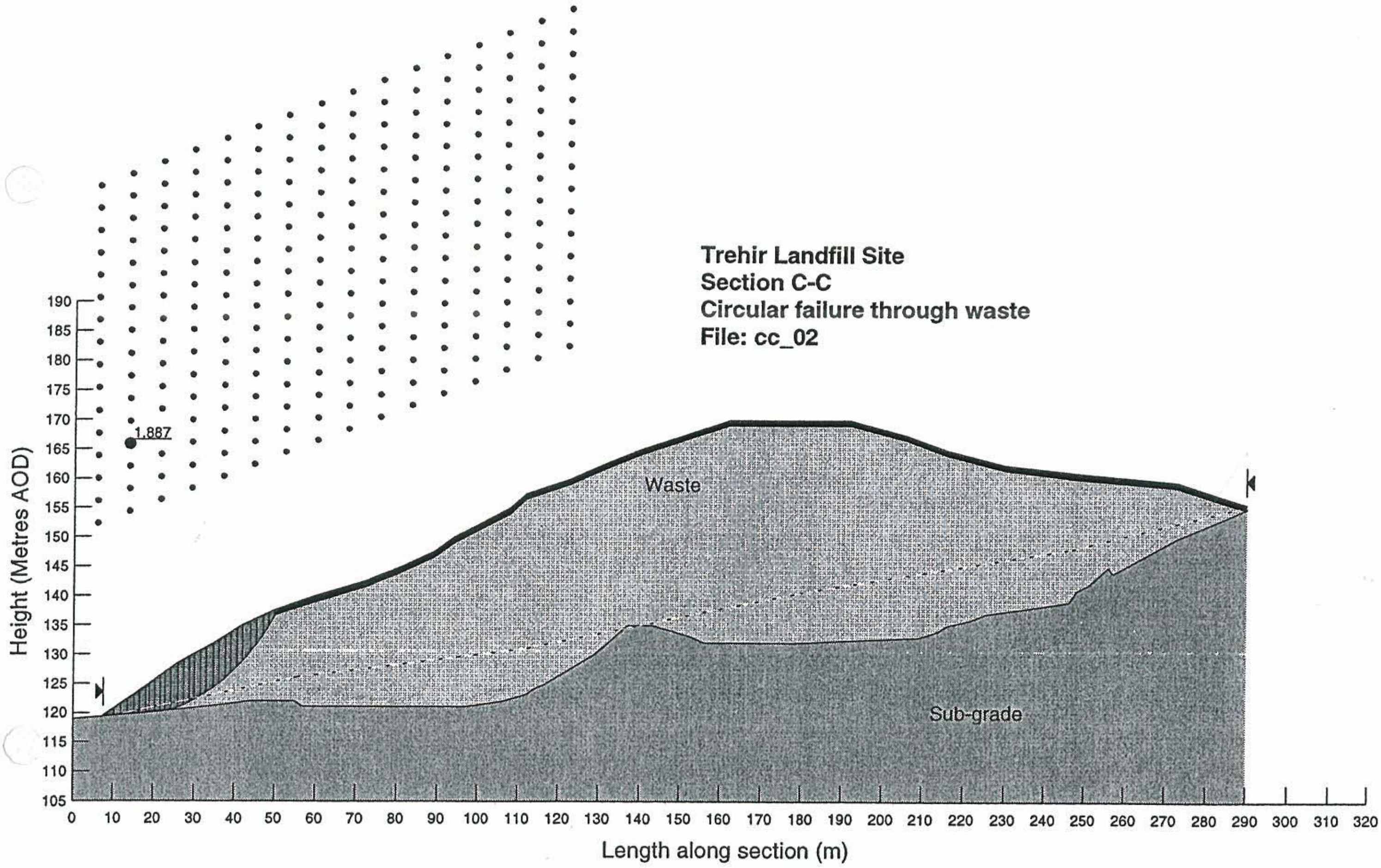
Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_05a
1.319
Waste
Sub-grade
Height (Metres AOD)
195
185
175
165
155
145
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

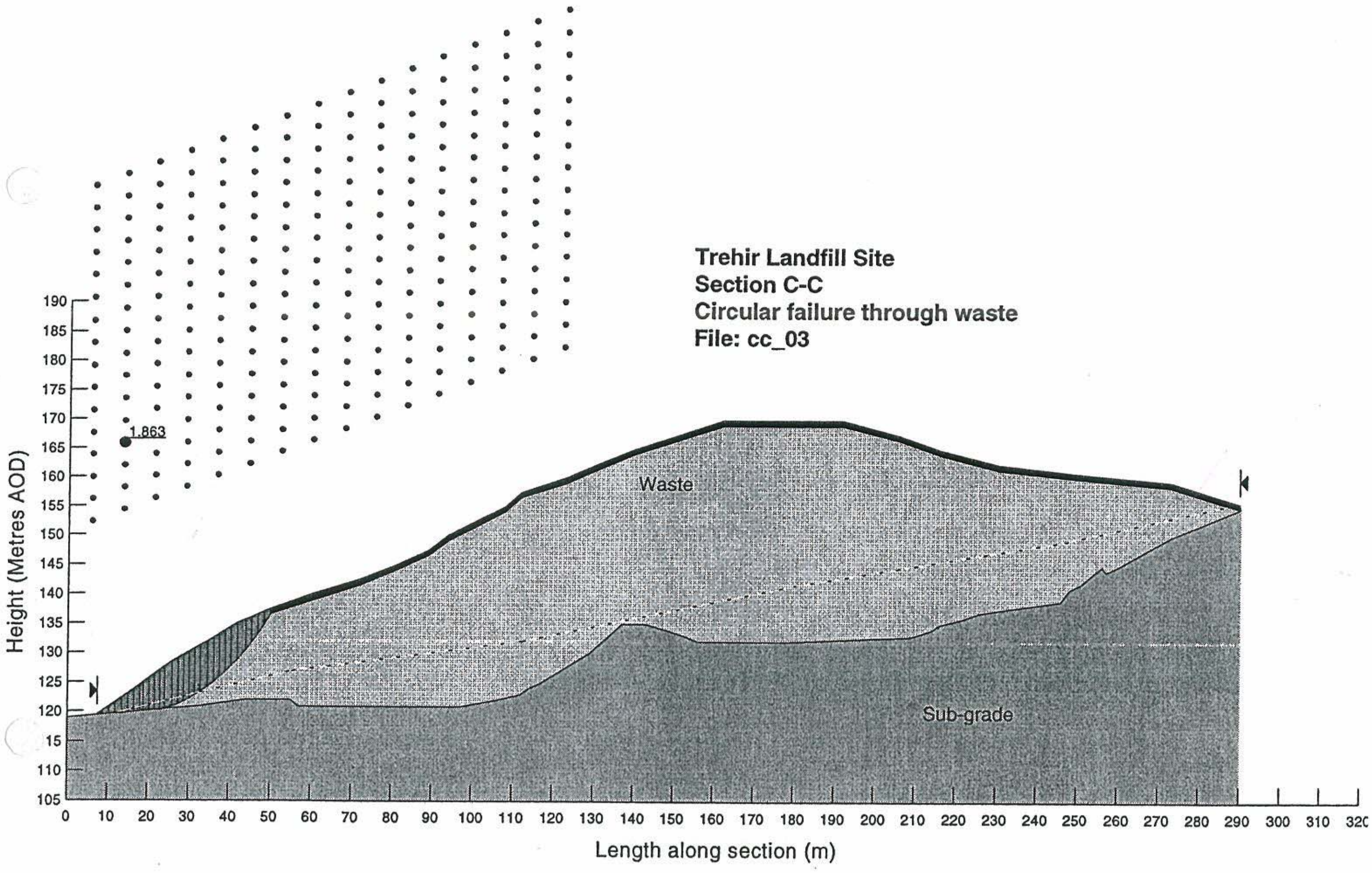

Trehir Landfill Site
Section B-B
Circular failure through waste
File: bb_05b
Capping soil
Waste
Sub-grade
1.253
Height (Metres AOD)
195
185
175
165
155
145
135
125
115
105
95
-15
-5
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
Length along section (m)

APPENDIX 4

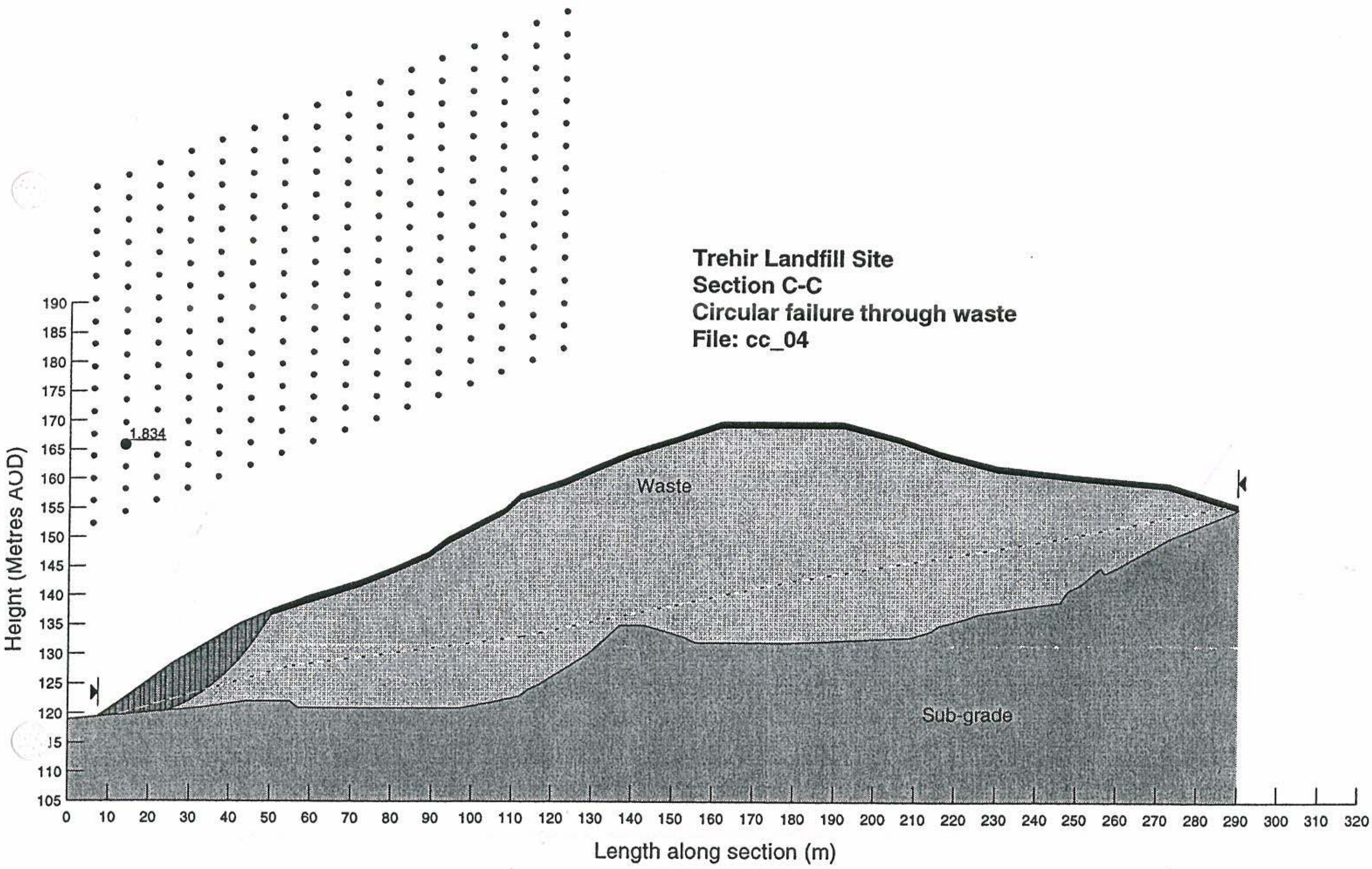
Stability Analyses: Section C-C


Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_01
1.904
Waste
Sub-grade
Height (Metres AOD)
190
185
180
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Length along section (m)

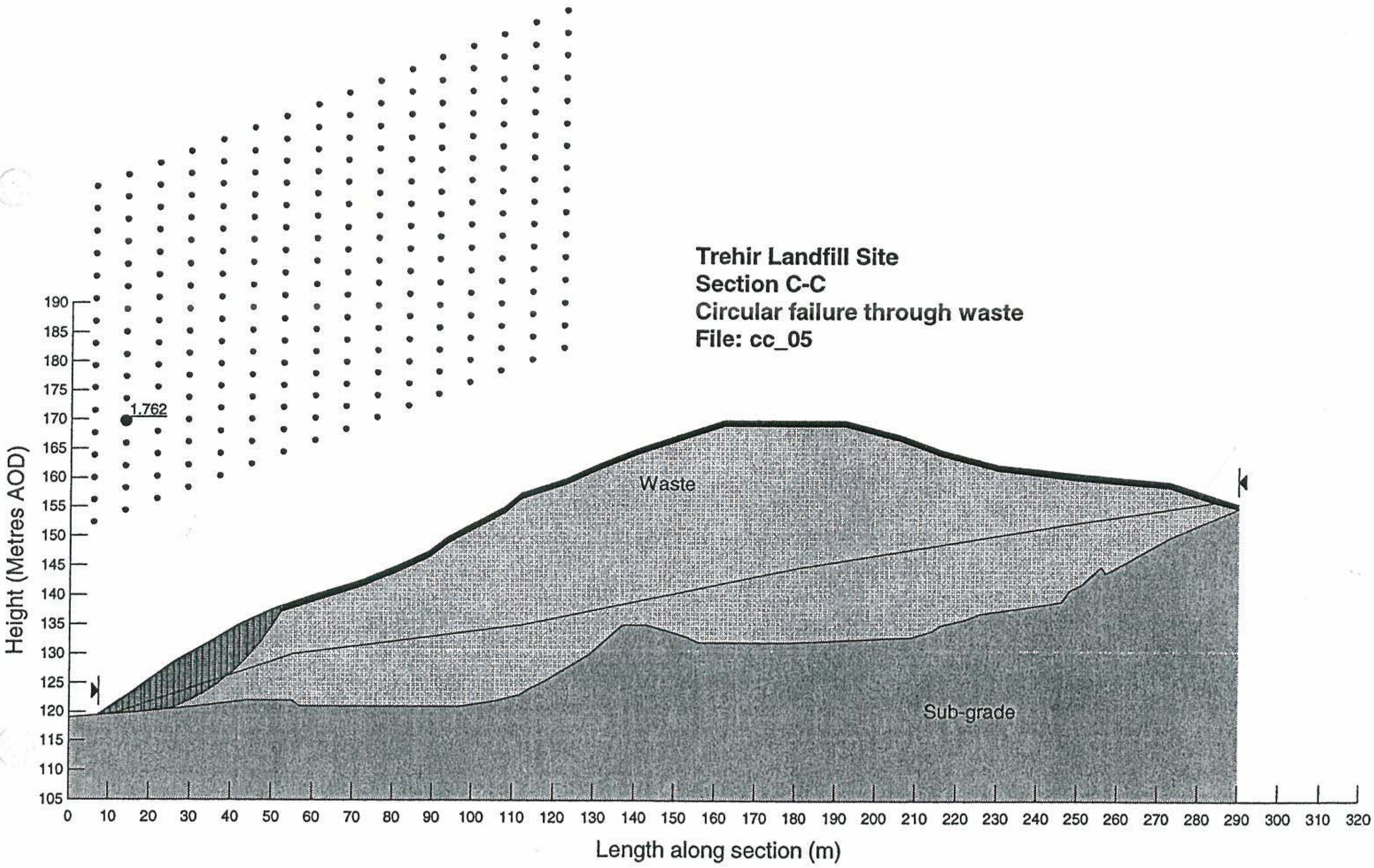

Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_02
1.887
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)
190
185
180
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320



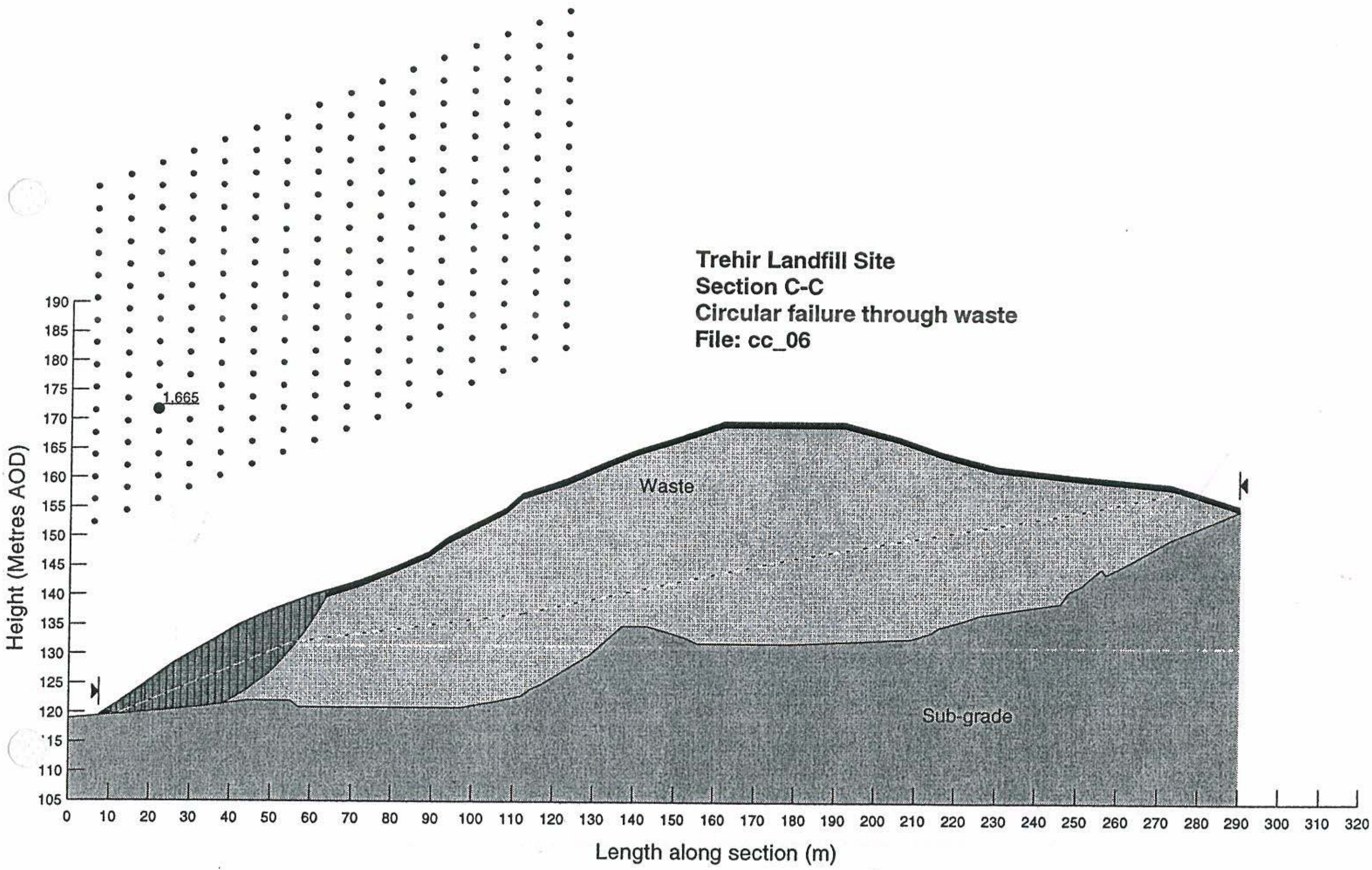
Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_03
1.863
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)



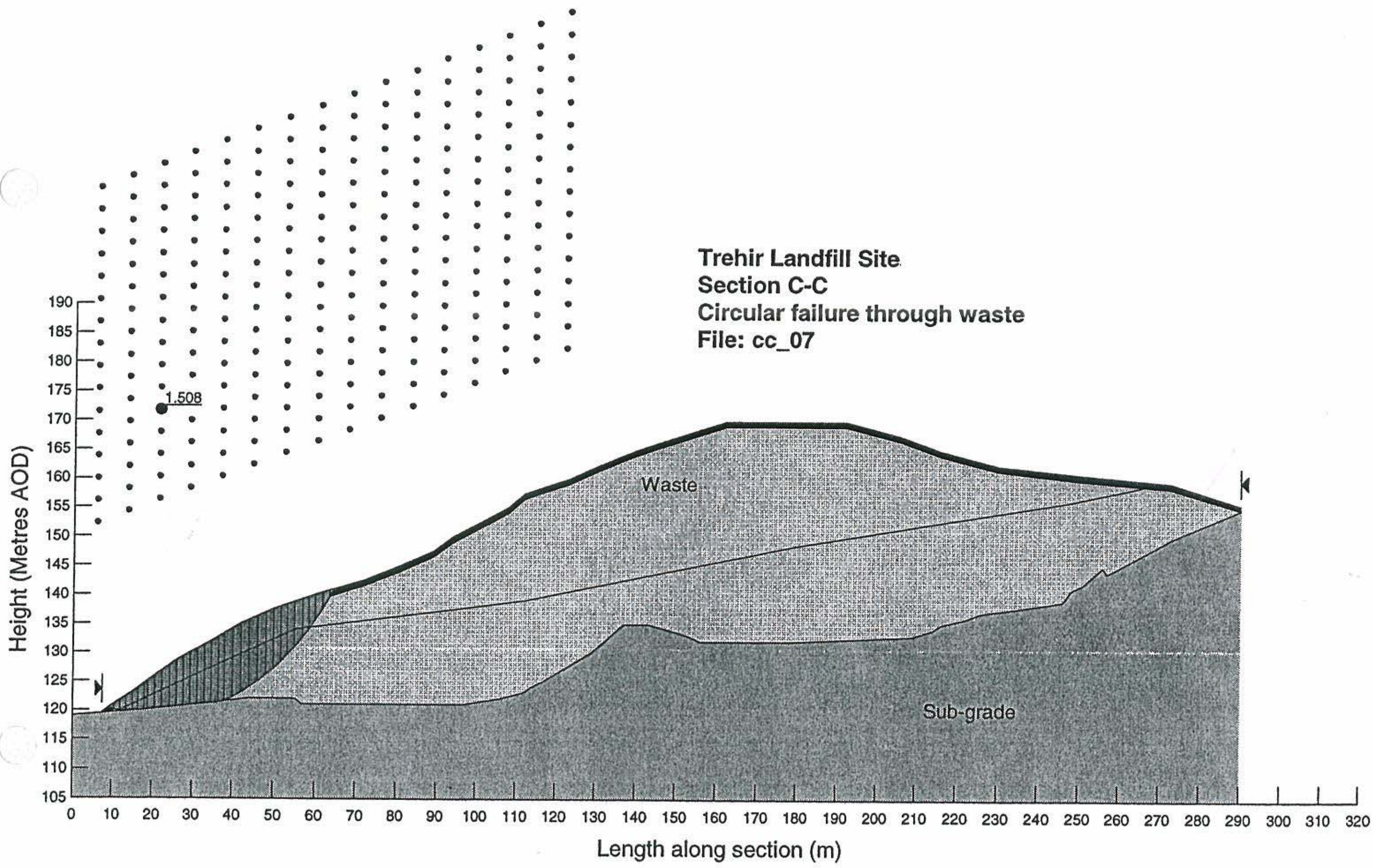
Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_04
1.834
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)



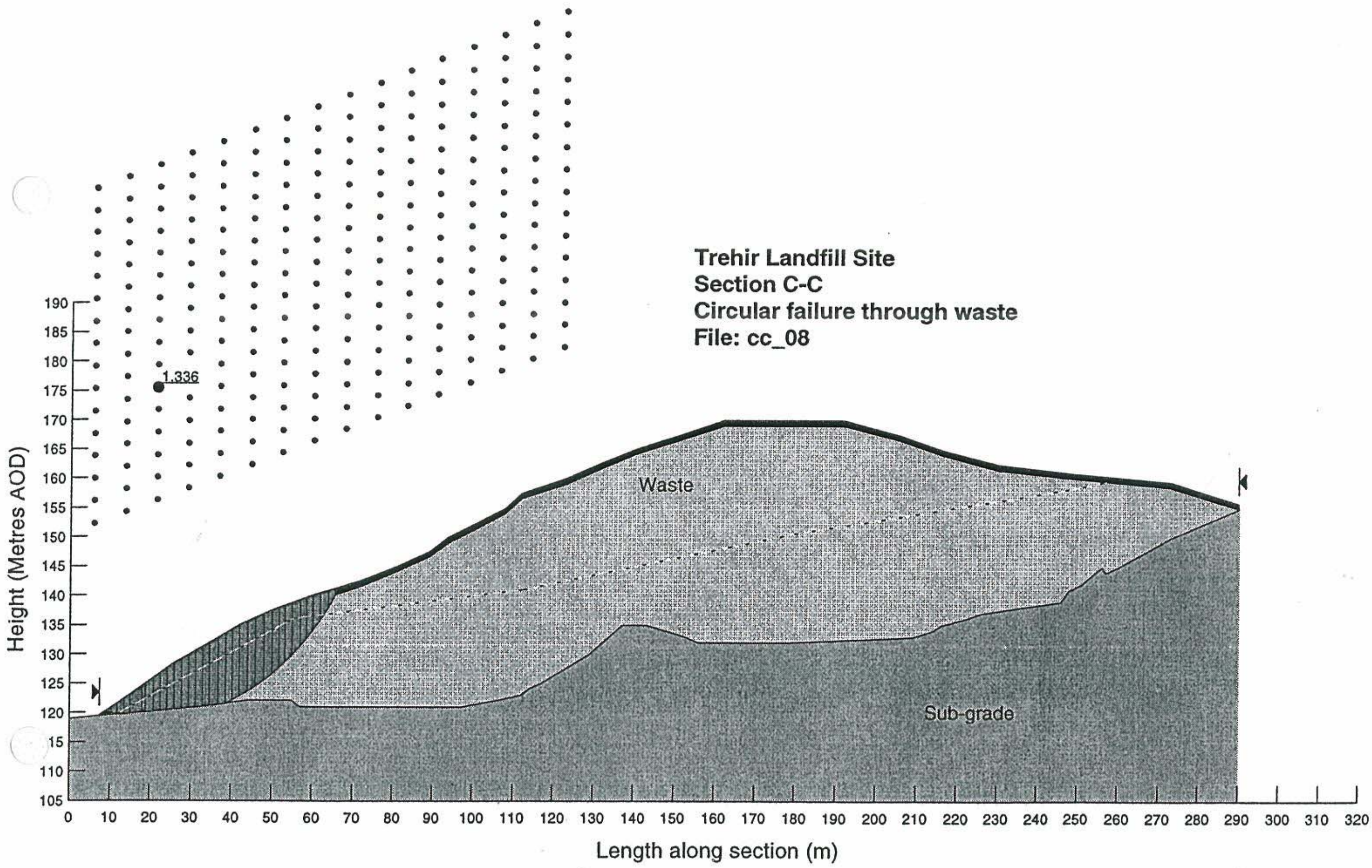
Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_05
1.762
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)
190
185
180
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320



Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_06
1.665
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)



Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_07
1.508
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)
190
185
180
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320



Trehir Landfill Site
Section C-C
Circular failure through waste
File: cc_08
1.336
Waste
Sub-grade
Height (Metres AOD)
Length along section (m)