RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Outline Design Briefing Report

December 2017

Prepared for Bristol City Council

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Limitations

AECOM Infrastructure & Environment UK Limited ("AECOM") has prepared this Report for the sole use of Bristol City Council ("Client") in accordance with the Agreement under which our services were performed **River Avon Tidal Flood Risk Management Strategy RESP1007626 (23/10/15) and Response to Tender Submission Clarifications (03/11/15) (the "Agreement")**. The report takes into account the particular instructions and requirements of the Client in accordance with the provisions of the Agreement. It is not intended for and cannot be relied upon by any third party. No liability is accepted by AECOM and no responsibility is undertaken to any third party.

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The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report. The work described in this Report was undertaken between February 2017 and November 2017 and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

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1 INTRODUCTION

1.1 Overview and purpose of this report

A preferred option of low and high defences in the city centre was identified in the River Avon Tidal Flood Risk Management Strategy Preferred Option Report dated October 2016. The decision was based on concept designs and high level cost estimates. Since that time the engineering designs for high and low defences have been developed further both in terms of alignment and construction type to enable a more robust cost estimate to be prepared.

The Strategy has developed engineering designs to a design stage consistent with the available information; some key information (e.g. detailed location specific ground condition information) was unavailable at this stage, limiting the level of detail. Additional development and refinement of the designs will be required when developing an Outline Business Case for any schemes that follow on from the Strategy, and to bring them to a state suitable for a planning application.

This report describes the methodology and assumptions used to generate the proposed engineering solutions along with the limitations of the approach and how these have been dealt with.

2 BASE DATA

2.1 Background

All engineering design relies on adequate data to be able to undertake the necessary analyses to ensure that a design is safe, functional and buildable. For this phase of the strategy we have been able to confirm the line (alignment) and the level (crest level to be achieved) of the proposed defences and suggest a form (the type of defence to be implemented) which has been used as the basis for costing.

In consideration of the stage of the project and the timescales for delivery of the designs have been based largely on existing information collected by Bristol City Council or the Environment Agency for other purposes. AECOM have used the provided information in good faith and have not carried out independent checks to confirm the validity of the data and recommend that this is undertaken in future phases.

Three reaches were identified where it was considered that the proposed solutions would have a significant impact on the total cost of the strategy. These are described further in section 3.1 below. For these reaches worst case cross sections were identified and analyses carried out based on available information to identify the key dimensions of structures that would be required. A single design was identified and applied along the whole reach and no optimisation was carried out to refine the design in any way. This provides a robust cost estimate and offers opportunities for value engineering / efficiencies during the outline design phase.

For all other reaches the proposed solutions are based on engineering judgement and no analyses have been carried out to confirm the sizes of the elements required.

2.2 Topographical Survey and LiDAR

LiDAR data at 2m resolution was available to assess ground levels across the whole of the site. The accuracy of LiDAR is quoted as being +/- 150mm in the vertical plane and due to the resolution and processing may not pick up all the relevant structures and ground levels to support a design.

Existing topographical survey data was provided which included the following areas:

- Bathymetric cross sections approximately every 200-400m Dated January 2010
- Topographical survey Cattle Market Road pre and post MetroBus works 2016
- Topographical survey Entrance Lock
- Topographical survey Cumberland Road
- Topographical survey Netham Lock
- Cross sections and topographic survey Totterdown north of Victor Street

Additional data was requested from the BCC surveyor to supplement the existing data at key locations including:

- Netham (Feeder Road)
- Entrance Lock (Hotwell Road tie in)

Where topographical survey was available this was compared to the LiDAR data. Discrepancies were found, as expected, close to buildings, at the edge of the river channel close to near vertical riparian walls and where there is significant tree or vegetation cover.

Ground levels quoted in this document are based on the best available information, and comprise survey data where available or LiDAR. Further topographical survey should be carried out prior to any further outline and detailed design being carried out.

2.3 Ground Investigation

No bespoke ground investigation was carried out for the strategy. A geotechnical desk based review was carried out by AECOM (see Appendix A) pulling together available information from previous site investigation reports provided by BCC and freely available borehole records from the British Geological Society. Ground parameters for use in the analyses of the reaches described in section 3.1 were also derived.

The review concluded that the geological sequence was generally characterised as follows:

- Made Ground
- Tidal Flat Deposits (silt or clay)
- River Terrace Deposits (sand or gravel)
- Partially or Completely Weathered Bedrock (clay, sand and gravel)
- Bedrock (sandstone, mudstone, siltstone or conglomerate)

Bedrock was encountered in some but not all boreholes and the depth at which it was found varied significantly across the length of the works, the shallowest was at the eastern end of Cumberland Road (4.5m below ground level) but at Bathurst Basin bedrock was not encountered until 38m below ground level.

Typical design ground parameters to be used for the sizing of elements in the key areas (see section 3 below) were estimated based on the boreholes available. These parameters were in some cases based on soil descriptions only or extracted from test results detailed in third party reports so their reliability would need to be confirmed prior to any further outline and detailed design.

The review included consideration of the implications of historic river bank slippages in the Cumberland Road and Clarence Road areas.

It is recommended that a bespoke site investigation is carried out prior to any further outline and detailed design.

2.4 Existing Structures

There are numerous existing riparian walls in the city centre of varying construction types and condition. Information relating to these walls was extremely limited and in most cases was anecdotal.

Determining whether these walls could provide the necessary foundation to the required raised tidal defences will be a key factor in the out turn cost of the strategy. In most cases it is difficult to demonstrate that historic walls will have an adequate factor of safety against failure to current design standards. However, the fact that many are standing without evidence of any movement or stress indicate that they are capable of carrying out the function for which they were constructed and are therefore not necessarily unsafe.

No assessments were carried out as part of the strategy to assess the capacity of existing structures to be raised or support new tidal defences. AECOM were not made aware of any structural investigations having been carried out to identify construction type, durability or residual life of any existing structures.

Based on the combined knowledge of the project team, including a design assumptions workshop held on 29 September 2016, the following approach was agreed:

Table 1. Existing Structures

Reach	Description	Existing Riparian Structure	Assumption for strategy
1	Entrance Lock	Masonry walls – assumed to be gravity retaining walls but no construction details available	Can be relied upon to support raised defences
1	Brunel Dam	Partially silted up sluice gate structure with concrete sub and superstructure	Replace structure in its entirety. No need to incorporate sluices

Reach	Description	Existing Riparian Structure	Assumption for strategy
2	Cumberland Road	Retaining wall at edge of highway of unknown construction, raised in some locations as part of MetroBus scheme. Secondary retaining wall supporting heritage railway and footpath (Chocolate Path) understood to be vaulted masonry structure. Recent and ongoing issues with settlement of the footpath suggest inadequate or deteriorating condition.	Design structure to retain and protect the highway but not the heritage railway or footpath if this is too onerous. Do not rely on structural support from either of the two lines of retaining structure.
3	Cumberland Road East	Heritage Railway Line in tunnel	Cannot apply additional loading to tunnel
4	Bathurst Dam	Mass concrete dam reinforced with steel railway tracks constructed in 1940's	Condition assessment showed unlikely to be able to be raised in current form without additional support.
4	Commercial Road	Masonry walls – assumed to be gravity retaining walls but no construction details available. In fair / poor condition with signs of movement behind the wall.	New wall to replace the retaining structure as well as provide raised tidal defence
5	Clarence Road	Masonry walls – assumed to be gravity retaining walls but no construction details available. Recent failure of part of wall repaired using mass concrete backfill.	New wall to replace the retaining structure as well as provide raised tidal defence
6	Cattle Market Road	Wing walls associated with Network Rail bridge extend only partway along proposed defence line before tying in to natural bank	No additional loading to be put on Network Rail bridge or wing walls.
7	Totterdown / St Phillips	No riparian structures - natural banks with any structures set back from bank crest.	
8	Netham	Sheet pile wall with concrete capping beam. Unknown lengths or pile size.	Do not use*
8	Netham Lock	Masonry walls – assumed to be gravity retaining walls but no construction details available	Can be relied upon to support raised defences

In all locations where natural river banks exist in front of the riparian walls it was agreed that it could be assumed that the profile would remain unaltered into the future and erosion or accretion would not be considered at this stage.

*The initial decision was reached not to rely on the existing sheet piling at Netham but during the design phase this had to be reconsidered as described in section 4.1 below.

2.5 Services

Services and utility information was made available for consideration during the strategy. As expected in a city centre a large number of cables, pipes and ducts are to be found close to the proposed alignment. It has been assumed that in the majority of cases services will be temporarily or permanently diverted away from the working area and an allowance has been included in the costs for this (5% of construction costs). Further work will be required in the next stage of the project to investigate services in more detail through service provider enquiries and surveys / site investigations.

Where services were shown to cross the proposed defence alignment further desk top investigations were undertaken. Specifically this related to Wessex Water sewers which were siphoned across the river

corridor. Meetings with Wessex Water culminating on 15 September 2016 and consideration of as built drawings provided by them confirmed that the locations and levels of the siphons did not impact on our proposed works. The Wessex Water information reviewed is listed in References section of this report (Section 7).

2.6 Defence Levels

2.6.1 Water Levels

Water levels were provided by the modelling team to which a freeboard allowance was added to derive the design levels to be working to. Further details of the modelling outputs can be found in the Final Preferred Option Modelling Report, October 2016 and the Additional Modelling Report December 2016.

2.6.2 Freeboard

Derivation of the freeboard allowance was based on the Quick Method within the Environment Agency's Fluvial Freeboard Guidance Note. This is not intended for direct application to a tidal flood alleviation scheme; however the enclosed nature of the estuary and channels makes this guidance relevant and it provides a methodology which can be applied to the varying uncertainties inherent in estimating the design water levels. The approach is described in detail in Appendix B.

Based on this approach a freeboard allowance of 200mm was applied to water levels to obtain design crest levels for low and high defences.

It should be noted that inclusion of freeboard in the defences has led to increased cost and visual impacts but is required under Environment Agency guidelines.

It should also be noted that subsequent to this work, revised guidance has been published on freeboard ('*Accounting for residual uncertainty: an update to the fluvial freeboard guide*' (Environment Agency, February 2017)); this was not available at the time of writing this report and is not reflected in the note in Appendix B. The updated guidance gives designers more flexibility in determining freeboard and follows a broader approach to managing residual risk rather than just the application of a vertical freeboard. It is recommended that the revised guidance is reviewed in the next phase of work on the project as part of design development.

2.6.3 Defence Levels

The design levels used in the strategy are presented in Table 2 below.

Table 2. Estimated water level of failure and standard of protection for Cumberland Road

Reach	Description	Modelled Water Level (2015)	Modelled Water Level (2115)	Low Defence level	High Defence Level
1	Entrance Lock	9.45m	10.1m	9.65m	10.3m
1	Brunel Dam	9.45m	10.1m	9.65m	10.3m
2	Cumberland Road	9.45m	10.1m	9.65m	10.3m
3	Cumberland Road East	9.45m	10.1m	9.65m	10.3m
4	Bathurst Dam	9.45m	10.1m	9.65m	10.3m
4	Commercial Road	9.45m	10.1m	9.65m	10.3m
5	Clarence Road	9.45m	10.1m	9.65m	10.3m
6	Cattle Market Road	9.6m	10.2m	9.8m	10.4m
7	Totterdown / St Phillips	9.6m	10.2m	9.8m	10.4m
8	Netham	9.6m	10.2m	9.8m	10.4m
8	Netham Lock	9.6m	10.2m	9.8m	10.4m

2.7 Alignments

The proposed alignments and associated cross sections are shown on the plans in Appendix C. The alignment identified in the Preferred Option Report was generally a frontline sheet piled defence, encroaching into the river channel by approximately 2m. This was considered as a worst case scenario both in terms of cost and physical impact. Since then refinements to the alignments and construction type have been sought to improve upon the proposals.

Alignments have been chosen to defend as much amenity, property and transport infrastructure as possible whilst maximising flood storage and flow capacity in the channel. When considering the alignments the following aspects have been taken into account:

- defence heights above ground levels
- defence type,
- construction access and buildability
- encroachment into the channel
- existing and future land use

Passive defences have been identified wherever possible. These include ramps or ground raising to maintain access across defence alignments rather than installing floodgates which inherently provide a greater source of residual risk and require maintenance. In some locations, floodgates have been necessarily identified as the only feasible way of maintaining access. This increases the residual risk of defence failure as there is a chance that the gates could be left open during flood events.

A site visit with the key project team was attended by representatives from the City Council, Environment Agency, Harbour Authority, Network Rail and other key stakeholders. The preferred alignment was chosen based on the discussions and the evidence that was collected on that day and subsequently verified through survey and analyses.

A more detailed description of the decision making process to arrive at the proposed alignments is included in the Preferred Option Refinement Report.

3 METHODOLOGY AND DESIGN ASSUMPTIONS

3.1 Methodology

Proposals have been prepared for all lengths of the required defence works but to varying levels of detail depending on the likely impact on the cost estimate.

Three reaches were deemed to have a major impact on cost due to their length and the proposed solution:

- Cumberland Road (high defences),
- Clarence Road (low and high defences),
- Netham (high defences).

These reaches were chosen as they are all proposed to be structures to retain the land behind as well as act as a tidal defence. As the ground behind the defences is up to 10m above the river bed level the structures will need to be fully engineered structures with the worst design case being the retention of the land behind rather than the tidal load case.

Geotechnical and structural analyses were applied to these structures to identify the likely sizes of the key elements. The results of these analyses can be found in Appendix D.

All other defences were chosen using engineering judgement and ‘rules of thumb’. Reinforced concrete cantilever walls have been proposed where defence heights above ground level are less than 2m. Sheet piled walls have been proposed for defences over 2m or where topography meant that a cantilever wall may not be able to be constructed.

Passive defences such as ramps have been proposed wherever possible to minimise operational requirements and residual risk. It is acknowledged that this will create some potentially unwieldy structures within the public realm and landscaping considerations will need to be fully incorporated into the next design phases to ensure that the impacts are minimised.

Ramps and road raising will be fully DDA (Disability Discrimination Act 1995) compliant and are assumed to have a maximum gradient of 1 in 20 or a steeper gradient with appropriate landings.

3.2 Assumptions Applicable To All Reaches

The following design assumptions have been applied to all reaches

- Design life to be 100 years (assume where raising existing structures that residual life exceeds 100 years).
- The recommended FCERM Climate change and sea level rise change factors (EA, 2014) were adopted and accounted for in the designs.
- Maximum water level to be at the top of the wall, no overtopping allowed for (but deemed to be covered by factors of safety incorporated into the design)
- Defences to be provided where the ground level is below the modelled water level. Freeboard only to be applied to the crest level of required defences not when considering the extent of the defences.
- Where defence types are the same for the low and high levels the low defences will be constructed with foundations suitably designed to be raised in the future to the high defence level.
- Brick or stone cladding will be applied where deemed appropriate or a fair faced concrete finish elsewhere. The costing assumptions around cladding can be viewed in the Unit Rates sheet of the costing table (Appendix E).
- Services and utilities are assumed to be able to be temporarily or permanently diverted
- Glass walls and demountable defences have not been explicitly considered in any of the reaches but remain as options particularly when raising from low to high defence levels. Foundations for either would be the same as for a standard wall raising but other issues such as maintenance (cleaning the windows), acceptability and operation (in the case of demountables) would need to be considered on a site by site basis.

3.3 Assumptions relating to analysed reaches

In addition to the assumptions in 3.2 the following design assumptions have been applied to the reaches specified in section 3.1.

- Assume river channel shape does not alter significantly during the design life (no active erosion or deposition of soft material).
- Ground water level on landside to be appropriate to land use and ground conditions behind. Assume that back of wall drainage will be installed if required.
- Design to Eurocodes as far as practicable (GI is not appropriate for a fully Eurocode compliant design).
- Where appropriate (e.g. Clarence Road) landscaping features (e.g. raised ground levels) may be used to assist with optimising the design.
- Services and utilities do not need to be considered.
- Below ground details (extent and condition) of existing structures are unknown and any assumptions relating to them are clearly stated in the calculation reports.
- Construction methods to be considered taking adjacent land use into account (e.g. minimal access at Netham).

4 PROPOSED WORKS

The proposed alignments and wall types are shown on the plans in Appendix C and are listed in the costing tables in Appendix E. Proposed works to Bathurst Dam were subsequently reviewed as a consequence of the MetroBus works on Commercial Road; a Technical Note and supporting plans are provided in Appendix F to report the findings of the review.

4.1 Designed Sections

The results for the three designed sections can be found in Appendix D. The solution for all three locations use contiguous piled walls below the ground with reinforced concrete upstands above ground level. The piles vary in size up to 1.5m diameter and in depth down to 25m below ground level. Worst case design scenarios have been analysed which have been deemed to be the locations where the tidal defence is tying into high ground and so the wall is retaining the most soil behind. The contiguous piled walls will not prevent below ground seepage but this is not understood to be an issue during tidal events. This will need to be confirmed during the detailed design.

It is believed that the designs proposed offer the worst case based on the limited ground investigation that has been undertaken to date. Bespoke ground investigation and optimisation of the design are

expected to reduce the pile diameters and lengths and therefore associated costs. There will also be scope to change the dimensions along the length of the wall to deal with the changing topography. Specific outcomes of each reach are:

- Cumberland Road: The analysis has been carried out at the riverside edge of the cross section even though the proposal is to pile beneath the heritage railway. This approach has been taken to be the most conservative and does not rely on any structural support from the existing Cholate Path retaining structure. The piles will be 1.5m diameter at 1.65m spacings (centre to centre) and 25m long
- Clarence Road: Due to the relatively high bedrock found in boreholes closest to this location piles will be 0.6m diameter and 0.75m spacings (centre to centre) and 18m long
- Netham: The proposed piles are 1.5m diameter at 1.65m spacings (centre to centre) and 19m long. The diameter of the piles required would be difficult to install with the building in their current location (less than a metre from the back of the defences in some locations) without encroaching into the channel. River levels in this area are particularly influenced by channel cross section as the fluvial flows are more influential than tidal, so a reduction in flow area was not acceptable. However, due to the 100 year design life required on all new structures raising the existing sheet piles was not considered to be a viable option for anything other than a relatively short term solution. With this in mind it is proposed that the existing sheet piles are raised to provide the low defence level and the contiguous piled wall is installed when redevelopment allows.

The outline design of the defence structures have been taken forward as far as possible within the limitations of the available ground investigation and geotechnical data and information. We consider the designs provided are robust solutions which take into consideration our current knowledge regarding site ground conditions, geotechnical parameters and the requirement of the scheme. This design can be refined and/or adapted once more detailed and site specific ground investigation data is obtained for the site.

4.2 Bridges

A check has been undertaken to compare the soffit levels of bridges which cross the River Avon with the defence level. All bridges within the city centre study area apart from those listed below have soffit levels above the design food level. The bridges listed below will need to be structurally checked to ensure that they are adequately protected against uplift and works may be required to tie down bridge decks. No costs have been included in the base cost to account for this and it is expected that an allowance will be incorporated into the risk budget.

Reach	Description	Soffit Level	Deck Level	High Defence Level	Comment
1	Ashton Avenue (MetroBus Bridge)	8.7m	9.4m	10.3m	Details based on 2010 survey and may have been modified by works associated with MetroBus. Defences include for ramp and floodgate to ensure defences not outflanked.
4-5	Bedminster Road Bridge	10.2m	11.7m	10.3m	
5	Langton Street Footbridge	9.9m*	10.4m	10.3m	*springing level at abutment. highest point of soffit approx. 10.9m
5	Bath Road Bridge	10.06m*	11.5m	10.3m	*springing level at abutment. highest point of soffit approx. 10.39m
8	Railway Bridge	6.09m*	Unknown.	10.4m	Masonry Arch Bridge *springing level at abutment. Apex of arch at approx. 13.12m. Parapet at 15.8

Where bridges have abutments or piers within the floodable river channel no checks have been undertaken to assess the increased scour risk. This will also need to be considered further during detailed design to ensure that the increased flood flows within the channel do not undermine the structures.

4.3 Defence Extents

This strategy has only considered works where tidal defences are required. There a number of reaches, such as Commercial Road and Clarence Road where the tidal defences are replacing riparian retaining walls and are shown to tie in to high ground only a short distance from a more appropriate end point such as a bridge.

When these works are carried out consideration should be given to extending these walls beyond what is needed for tidal defence purposes to provide benefits to other BCC departments.

How defences tie in to high ground or structures have not been considered explicitly. Where a defence ties in to high ground the use of stub walls or kerbs may be appropriate as above ground levels reduce. Tie-ins to existing structures will need to be carefully detailed to ensure a watertight connection while not transferring loads where is not appropriate to do so.

4.4 Detriment Mitigation

As a result of the implementation of the strategy and without additional measures some locations will experience greater flood risk; additional properties will flood or flooding will be deeper or longer lasting, particularly in the future as sea levels are predicted to rise. To mitigate against these impacts some additional localised measures are proposed and are described in the main preferred option development report.

These measures have not been designed and no modelling has been carried out to confirm the extents and heights of proposed defences nor volumes of flood storage needed to cancel out the effects of the strategy. They are believed to provide an effective solution to the mitigation issue but will need to be investigated further during design development.

5 COST ESTIMATION

Costs have been applied to all of the engineering elements to generate costs for the varying epochs and reaches. The costs are summarised in the Preferred Option Development Report and detailed in the tables in Appendix E.

Total costs for elements have been built up using unit rates per linear metre of structure type. Structure types have been linked to the Environment Agency unit cost database types i.e. flood walls up to 1.2m, and so are limited in number. Detailed cost build ups have not been created for every type of defence due to the stage of the project, the lack of design information and the number of different defence elements. This approach is recommended in the Environment Agency Cost Estimation Guidance[1] for strategy level costings.

Unit rates have been generated for linear and surface features such as walls and cladding based on Environment Agency Cost Estimation Guidance supplemented as appropriate with build ups using the Spon's 2016 Price Books[2].

The costs in the EA guidance include all associated works, temporary works and any contractor variations, compensation events/delay costs. The guidance was published in 2015 and it has been assumed that all costs within it were to a 2015 cost base so no additional inflationary uplift was applied.

Spon's rates include all method related costs to a May/ June 2015 cost base and so no additional inflationary uplift has been included.

A full list of the unit rates used and how they have been derived is included in Appendix E.

Where unit rates are not appropriate lump sums have been estimated for discrete elements of work (such as the lock gate replacements) based on previous similar works either planned or constructed. Further details are included in the cost table in appendix E.

The cost base for all works is 2015 and where appropriate rates have been elevated using the Construction Output (New Works) price index. The total cost provided in Appendix E includes a 60% allowance for Optimism Bias. The costs take into account the review of Bathurst Dam, noted in Section 4 above and in Appendix F.

Allowances have been included for non-construction items including environmental mitigation; pre construction investigations, design and justification (preparation of individual scheme business cases); compensation and compulsory purchase; and risk. These are based on a percentage of the construction cost estimated from other Environment Agency PAR's.

[1] http://evidence.environment-agency.gov.uk/FCERM/en/Default/FCRM/Project.aspx?ProjectID=7A5A59F4-7197-4DD4-8F31-60E4F5B38D4C&PageId=a0fe6dfc-506a-452c-9bff-a7ec06b4e6b0

[2] Spon's Civil Engineering and Highway Works Price Book 2016 and Spon's External Works and Landscape Price Book 2016

6 HEALTH, SAFETY AND ENVIRONMENT CONSIDERATIONS

6.1 Construction Design and Management Regulations

In accordance with the Construction Design and Management Regulations (CDM) 2015, hazards during construction, operation, maintenance and demolition have been considered while developing the designs. Due to the early stage of the design process only high level assessments have been carried out to date and mitigation measures will need continued review throughout the design phase. All of the designs shown on the various drawings contained within this report must be regarded as 'Preliminary - Not for construction'. The evidence of hazard consideration is recorded in the cost tables provided in Appendix E.

AECOM are the Principal Designer and have undertaken an independent internal review to confirm that the approach is acceptable.

6.2 Construction

Constructability of the proposals has been a key consideration when identifying the defence type. In addition to the general construction hazards associated with tidal and river engineering works. Specific hazards relating to the strategy are:

- Unknown condition and construction of existing riparian walls
- Constrained working particularly in Totterdown / St Philips and Netham. Considered that working from the river may partially overcome this problem but brings additional hazards associated with tidal working
- Proximity of buildings and infrastructure
- Unknown ground conditions.
- UXO
- Utilities and buried services

6.3 Operation

While every effort has been made to incorporate passive defences wherever possible in some locations this has not been possible. Hazards associated with the operation of the strategy are:

- Flood and lock gates will require operation in advance of high tides. Most are located within or close to Entrance Lock and are assumed to be able to be operated by the Harbour Master. Elsewhere it may be necessary to identify local flood wardens to close gates in the event that Council or EA staff cannot reach the sites in time. Alternatively the gates could be remotely operated. During the detailed design phase, consideration should be given to safe access and egress between operations room and the gates during flood events.
- The strategy aims primarily to protect people and property from tidal flooding and consequently there will continue to be flooding to roads, footpaths and other public areas. This hazard can be mitigated with the use of appropriate signage, public awareness and where necessary barriers or gates to prevent access
- The collection of overland flow behind the defences which cannot be discharged due to the high tide levels could still cause areas of floodwater behind the defences. Further work is required during the detailed design phase to mitigate this either through, storage, overpumping or educating the public to accept residual flooding and the associated hazards.

6.4 Maintenance

Regular maintenance activities associated with the strategy would be similar to tasks already undertaken by BCC and the Environment Agency and would include:

- Regular inspections and monitoring
- Small scale remedial works to defences including joint replacement, repointing, seal replacement etc.

Hazards associated with these tasks would need to be assessed on a case by case basis but would be exacerbated by tidal working. Further consideration should be given to these aspects during further outline and detailed design.

Larger scale capital maintenance such as replacement of elements of the lock gates or associated M&E infrastructure would have similar and comparable hazards to the construction phase described above.

6.5 Environment

The environmental impacts of the proposals are covered in detail in the Options Identification and Environmental Appraisal Addendum Report, December 2016. The items which have an effect on the proposals and have been included in the costs are:

- Cladding

Additional mitigation measures which have a percentage allowance included in the costs but should be considered in more detail during any further outline and detailed design stages are:

- Landscaping
- Incorporation of defences into public realm improvements
- Compensatory habitat for loss of intertidal habitat

7 REFERENCES

City & County of Bristol, 1970. Main Foul Water Drainage Scheme. Plan and Section of Siphon No.1. Cattle Market Road – Railway. Contract Number 51, Drawing Number 2, Plan 84/2A

City & County of Bristol, 1969. Main Foul Water Drainage Scheme. Intake to Siphon No.1 - Cattlemarket Road. General Arrangement. Contract Number 51, Drawing Number 6, Plan 84/8

City & County of Bristol, 1970. Main Foul Water Drainage Scheme. Outfall to Siphon No.1 - Cattlemarket Road. General Arrangement. Contract Number 51, Drawing Number 7, Plan 84/9

City & County of Bristol, 1973. Main Foul Water Drainage Scheme. Intake to Siphon No.1 - Cattlemarket Road. General Arrangement. Contract Number 51, Drawing Number 5, Plan 84/7C

APPENDICES

APPENDIX A: GROUND INVESTIGATION REVIEW

AECOM **Ground Engineering**

Submitted to
Bristol City Council

Submitted by
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November 2017

Avon Tidal Defence Strategy - Ground Investigation Review

November 2017

Revision schedule					
Rev	Date	Details	Prepared by	Reviewed by	Approved by
0	31 October 2016	For comment	A Holme Principal Engineering Geologist	Nancy Collins Principal Engineer	David Dales Technical Reviewer
1	7 November 2017	Updated following review of additional information & client comments.	A Holme Principal Engineering Geologist	Vasileios Stamatiou Associate Geotechnical Engineer	David Dales Technical Reviewer

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Limitations

AECOM Infrastructure & Environment UK Limited ("AECOM") has prepared this Report for the sole use of Bristol City Council ("Client") in accordance with the Agreement under which our services were performed **River Avon Tidal Flood Risk Management Strategy RESP1007626 (23/10/15) and Response to Tender Submission Clarifications (03/11/15) (the "Agreement")**. The report takes into account the particular instructions and requirements of the Client in accordance with the provisions of the Agreement. It is not intended for and cannot be relied upon by any third party. No liability is accepted by AECOM and no responsibility is undertaken to any third party.

Information obtained by AECOM has not been independently verified by AECOM, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report. The work described in this Report was undertaken between September 2016 and November 2017 and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

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1 Introduction

1.1 Background

AECOM are developing a strategy to protect the city of Bristol from tidal inundation from the river Avon. The preferred option is to build flood defence walls to a height of up to 2m above existing ground level. In some locations these walls will also be required to retain the ground on the landward side of the wall which may be up to 10m above the existing river bed level.

The location where defence walls are required are shown on the 'High Defences – Floating Harbour' drawing in Appendix A. The exact alignment of the defences is yet to be agreed, but will be generally in a zone from 5m into the river to any buildings behind the defence.

AECOM are required to provide designs for all the proposed works including more detailed ground engineering design sections in three locations. The locations, which have been chosen so far, are within the Cumberland Road, Clarence Road and Netham sections of the scheme; however, there are some limitations in the geological and geotechnical information in the latter two locations, which may require a review of the location of these 'type' cross sections.

1.2 Methodology behind the study

In order to provide information on ground conditions and also characteristic values/parameters to facilitate concept and, more detailed, outline design for the scheme, AECOM have reviewed previous ground investigation information and reports (both factual and interpretive) produced by others, that have been made available to them by Bristol City Council (the Client).

Comprehensive GI and geotechnical information is not available for all parts of the scheme and there has been a requirement to supplement the information provided with historical borehole information obtained from the British Geological Survey's (BGS) 'on line' database.

The various sources of information have then been used to provide a summary of the generalised geology and ground conditions within each section of the scheme. Where the length of these sections is extensive, they have been sub-divided into subsections to provide better information concerning the detail and variation of the generalised (or characteristic) geology and ground conditions along their length.

The study then considers the ground conditions, and provides parameters/characteristic values for three specific areas of the site chosen for ground engineering design, based on the geology and geotechnical parameters determined from the background information consulted by AECOM. Finally, conclusions and recommendations are made to facilitate refinement of the proposed concept, or outline, design for the scheme.

1.3 Sources of Information

1.3.1 Reports

The Client supplied reports, which have been reviewed and utilised to determine the geology, ground conditions and design parameters, for each particular tidal defence section of the proposed scheme, are detailed below.

Cumberland Road (west and central):

- Report on Ground Investigation at Bristol Rapid Transit Ashton Vale to Temple Meads, Structural Soils Ltd, October 2013.
- Report on Ground Investigation at Bristol Heritage Railway, Structural Soils Ltd, November 2013.
- Cumberland Road Slip, Situation Report for County Engineer and Surveyor, City Engineer's Office, City of Bristol August 1981.

Cumberland Road (east):

- Ground Investigation Report for Camden Road Bridge, CH2MHILL, September 2015.

Cumberland Road (general):

- Introductory Note to the AVTM Ground Investigation and Geotechnical Data, CH2MHILL, November 2013.

Bathurst Basin:

- Factual Report on Ground Investigation at AVTM Bathurst Basin Bridges, Structural Soils Ltd July 2015.

Clarence Road:

- River Wall Movement at Clarence Road Redcliff, Bristol, Craddy Pitchers Davidson, March 2014.
- Clarence Road Wall Stabilisation – 'Conceptual Repair Proposals' Sketch, produced by Craddy Pitchers Davidson, August 2014.
- Method Statement for Emergency Strengthening of New Cut River Wall, produced by Craddy Pitchers Davidson, October 2014.

Cattlemarket Road:

- Ground Investigation Report Temple Quarter Enterprise Zone RIF Cattle Market Project by CH2MHILL, July 2015.

Totterdown:

- Draft Ground Investigation Report for Bristol Harbour Walkway & Avon River Path produced by CH2MHILL, February 2015.
- Ground Investigation Report Temple Quarter Enterprise Zone RIF St. Philip's Footbridge, produced by CH2MHILL, May 2016.

1.3.2 British Geological Survey (BGS)

Where previous GI reports are unavailable, or in order to supplement the information already provided by reports detailed above, AECOM have obtained historical exploratory hole information from the BGS website.

2 Geology and Geological Units Encountered Within the Scheme

According to the relevant BGS mapping and literature for the area, the site is indicated to be extensively underlain by Made Ground, defined as “man-made deposits such as embankments (or raised ground), and spoil heaps on the natural ground surface”.

Worked Ground, defined as “areas where the ground has been cut away such as quarries and road cuttings”, is also noted to be present to the west and east, associated with the excavation of the River Avon New Cut channel and Feeder Canal, respectively.

The Made Ground is generally underlain by Superficial Deposits comprising recent (Holocene) Tidal Flat Deposits (TFDs) comprising clay and silt of variable thickness. These deposits are restricted to the present and past course of the River Avon flood plain. The Tidal Flat Deposits are underlain locally by River Terrace Deposits (RTDs) comprising sand and gravel.

Superficial Deposits which have been categorised as ‘Alluvium’ in some of the documents reviewed as part of this study, have generally been grouped into the Tidal Flat Deposit category, on the basis that they are not easily distinguished from, and also likely to exhibit the same engineering behaviour as, the TFD’s. There is one location (Clarence Road), however, were more recent deposits, comprising silt on the mud flats adjacent to the present day river, are more recent and are categorised as Superficial Deposits.

Similarly, although it is noted that layers of sand and gravel are sometimes characteristic of the Tidal Flat Deposits, superficial deposits comprising predominantly sand and gravel material have been classified as River Terrace Deposits for the purposes of this study.

The solid geology underlying the site, and its surrounding area, is identified on the relevant British Geological Survey (BGS) mapping geological maps as Triassic age Mercia Mudstone Group (MMG) of mainly undivided Mercia Mudstone, or a local sandstone formation within the MMG called the Redcliffe Sandstone Formation.

The BGS describe the MMG as mudstone, subordinate siltstone and also sandstone, with widespread thin beds of gypsum/anhydrite and thick halite-bearing units in some basinal areas.

The Redcliffe Sandstone Formation is a basal calcareous sandstone unit that underlies and interdigitates with the MMG mudstones/siltstones and forms distinctive red sandstone cliffs to the west in the New Cut and Redcliffe areas of Bristol. The basal part of the MMG (including the Redcliffe Sandstone Formation) is also characterised by Breccia or Conglomerate. These MMG beds rest unconformably on beds of the Coal Measure (CM) Group comprising mudstone, siltstone and sandstone. These are generally not encountered until depths in excess of 35m below the majority of the site. The boundary does; however, appear to decrease in depth to circa 26m towards the extreme eastern end of the site.

3 Generalised Geology & Ground Conditions along the Route of the Tidal Defence Scheme

3.1 Introduction

In order to provide an overview of ground conditions along the route of the proposed tidal defence scheme, the site has been separated into different sections, from the ‘Entrance Lock’ section (located towards the western end of the scheme) to the ‘Netham’ section, at the extreme eastern end (please refer to the High Defences/Floating Harbour drawing in Appendix A).

Where appropriate, longer sections of the route, or sections of the route which straddle existing infrastructure or surface water features (i.e. locks, bridges etc.), have been sub-divided to highlight variations in ground conditions which may affect the design of the proposed flood protection measures.

Details of the ground conditions for each section have been generalised using a 'type' exploratory hole chosen to provide a good representation of the ground conditions. Where available, these generalised ground conditions are supported by cross-sections produced by others, and reviewed by AECOM as part of this study (please refer to Appendix B).

3.2 Tidal Defence Sections

3.2.1 Entrance Lock

The Entrance Lock section of the scheme is located towards the extreme western end of the site. Previous GI information is limited to BGS records only. The geology and ground conditions that have been determined to the north-west (and slightly down-river) of the entrance to the lock, as well as those adjacent to the entrance to Cumberland Basin, are provided in the following tables.

Table 3.1: Ground Conditions - Entrance Lock - western 'lock entrance' section.

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer cu (kPa)
Made Ground	'Made Ground'	0	2.1	2.1	-	-
Tidal Flat Deposit - CLAY	'Clay'	2.1	5.7	3.6	-	-
Tidal Flat Deposit - SILT	'Soft Silt'	5.7	11.7	6	-	-
Completely Weathered Bedrock - CLAY (MMG)	'Stiff brown clay'	11.7	14.4	2.7	-	-
Completely Weathered Bedrock - SAND & GRAVEL (MMG)	'Sand & fine to rough gravel'	14.4	15.9	1.5	-	-
Bedrock - SANDSTONE (MMG)	'Red Rock'	15.9	>15.9	-	-	-

Standing Groundwater (m BGL) – Not recorded

Table 3.2: Ground Conditions – Entrance Lock - eastern 'basin entrance' section

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer cu (kPa)
Made Ground	Loose 'silty brick fill', below 4.9m becoming, firm grey silt with traces of peat and fragments of wood.	0	9.9	9.9	5 to 14	-
Tidal Flat/Superficial Deposit - SILT	Soft to firm grey SILT.	9.9	15.6	5.7	5 to 8	-
Completely Weathered Bedrock - SAND & GRAVEL (MMG)	Dense SAND & GRAVEL.	15.6	16.5	0.9	58	-
Bedrock - SANDSTONE (MMG)	Red SANDSTONE	16.5	>16.8	>0.3	>60	-

Standing Groundwater (m BGL) = 3 & 10m

The Made Ground is variable between granular and cohesive materials that contain some organics, and is significantly thicker towards the basin entrance (i.e. almost 10m in thickness). The base of the completely weathered bedrock material, comprising sand and gravel, is similar between the eastern and western sections (circa 16m) and underlain by sandstone bedrock.

3.2.2 Cumberland Road

The Cumberland Road section of the site is relatively extensive and, therefore, for the purposes of demonstrating ground conditions along this route, is split into three separate areas (denoted by Exploratory Hole/Report reference drawings in Appendix A). The ground conditions determined in these areas is provided in the following tables.

Table 3.3: Ground Conditions - Cumberland Road – western section

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer cu (kPa)
Made Ground	Very dense, below circa 4.5m becoming loose and clayey, blue grey, medium to coarse gravel of limestone with medium cobble content.	0	6.1	6.1	>70 & 7	-
Tidal Flat Deposits - CLAY	Soft grey brown silty CLAY with occasional pockets of peat. Below 8.0m locally very soft and below 11.45m becoming firm.	6.1	11.85	5.75	2	0, 7, 16,25,32, 38, 55
River Terrace Deposits – SAND & GRAVEL	Medium dense dark grey brown clayey gravelly SAND with rare pockets of peat, low cobble content and rare unit (700mm thick) of dark brown grey organic CLAY. Below 13.8m becoming very dense green grey GRAVEL with high cobble content.	11.85	15.1	3.25	20 & 181	
Completely Weathered Bedrock - CLAY (MMG)	Red brown sandy CLAY with occasional mudstone lithorelicts.	15.1	16.05	0.95	57	
Bedrock - SANDSTONE (MMG)	Extremely weak partially weathered red brown SANDSTONE. Below 16.6m becoming strong to very strong and thinly to medium bedded.	16.05	18.6	2.55	-	
Bedrock – CONGLOMERATE (MMG)	Medium strong medium bedded pink red and grey CONGLOMERATE	18.6	>20.9	>2.3	-	

Standing Groundwater (m BGL) = 3.8 & 6.3m during drilling. 1.4m depth during monitoring.

It has been noted that a section of river bank within the western section of Cumberland Road (south of Underfall Yard) experienced a significant slippage during July 1981. This was stabilised at the time by the addition of a significant amount of coarse rock aggregate. Although, not highlighted within the above table, the affected area of the site may be locally characterised by coarse (cobble sized) aggregate of rock within the first 10m below Cumberland Road and any residual impact of the slippage in terms of ground conditions will need to be considered in future design work.

Table 3.4: Ground Conditions - Cumberland Road – central section

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer cu (kPa)
Made Ground	Asphalt over grey brown very sandy gravel of concrete brick and limestone. Cobbles of concrete. Below 0.8m becoming firm grey brown silty sandy clay with some gravel.	0	1.8	1.8	6	
Tidal Flat Deposit - CLAY	Stiff brown mottled grey slightly sandy CLAY with occasional organic matter	1.8	4.1	2.3	10	80-95
Completely Weathered Bedrock - CLAY (MMG)	Stiff, below 6.1m becoming very stiff, red brown slightly sandy CLAY	4.1	6.4	2.3	42, 57	95-100
Bedrock – MUDSTONE/ SILTSTONE (MMG)	Extremely weak red brown thinly to medium bedded SILTSTONE	6.4	8.8	2.4		
Bedrock - SANDSTONE (MMG)	Very weak to weak thinly to medium bedded fine to coarse SANDSTONE, interbedded with medium beds of siltstone.	8.8	>10.4	>1.6	-	

Standing Groundwater (m BGL) = 3.7 during drilling. Between 2.2 and 7.8m depth, during monitoring.

Table 3.5: Ground Conditions - Cumberland Road – eastern section

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer cu (kPa)
Made Ground	Concrete over very soft red brown sandy slightly gravelly clay with occasional rootlets. Gravel of concrete. Below 1.35m brown mottled orange brown clayey slightly gravelly sand. Gravel of sandstone and siltstone.	0	1.6	1.6	9	
Completely Weathered Bedrock - SAND/GRAVEL (MMG)	Loose to medium dense orange and red brown silty clayey very sandy GRAVEL with medium cobble content.	1.6	2	0.4		
Bedrock - SANDSTONE (MMG)	Very weak to weak orange and red brown SANDSTONE recovered as fine to coarse gravel. Below 3.2m becoming weak to medium strong and thinly to medium bedded.	2	5.1	3.1	N=68	
Bedrock – MUDSTONE (MMG)	Weak dark red brown closely to medium fractured MUDSTONE. Above 8.6m with widely spaced medium beds of weak to medium strong thinly bedded fine to coarse SANDSTONE.	5.1	26.85	21.75	-	-
Bedrock – BRECCIA/CONGLOMERATE (MMG)	Very weak to weak dark red brown and pink grey BRECCIA. Clast are medium strong to strong, below 31m locally strong to extremely strong	26.85	36	9.15	-	-
Bedrock – MUDSTONE (CM)	Weak thinly laminated, very closely to closely fractured dark red brown, mottled red brown and yellow brown MUDSTONE	36	>37.8	1.8		-

Standing Groundwater (m BGL) = 0.8 & 5.5m. Between 4.2 and 8.1m depth during monitoring.

Within the Cumberland Road section of the site, the depth at which the solid geology, comprising predominantly extremely weak to weak sandstone, siltstone and mudstone of the MMG, is encountered decreases in an easterly direction, from approximately 16m at the western end, to 2m towards the eastern end. Towards the western end, medium strong conglomerate is encountered at approximately 18.5m depth (i.e. circa 2.5m below the level at which bedrock is first encountered).

As a consequence, the thickness of the overlying RTDs and TFDs also decreases in an easterly direction, from 9m in the western section to circa 2m in the central section, then eventually petering out in the eastern section.

MG, comprising predominantly very sandy gravel, with medium cobble content, is encountered to a depth of 6m toward the western end of this section. Its thickness decreases in an easterly direction to circa 2m and characterised by sandy, slightly gravelly clay. This directly overlies completely weathered MMMG bedrock comprising slightly clayey, very sandy gravel.

Section drawings 203742-CH-SBR-ST-DR-GE-0102 & 203742-CH-SBR-ST-DR-GE-0106 presented in CH2MHILL's GIR report for Camden Road Bridge (September 2015) provide a good representation details of the geology and ground conditions along the north bank of the river, parallel, and perpendicular, to the eastern end of the Cumberland Road section. These are presented in Appendix B.

3.2.3 Bathurst Basin

Previous ground investigation work undertaken in the vicinity of the entrance to Bathurst Basin has revealed the following general ground conditions: - Circa 5m of variable Made Ground, underlain by approximately 2.5m of TFD's and medium dense RTDs which are, in turn, underlain by beds of the MMG comprising very weak to weak mudstone.

The following table provides a summary of the geology and ground conditions encountered in the vicinity of this part of the site.

Table 3.6: Ground Conditions - Bathurst Basin

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer cu (kPa)
Made Ground	Medium to thick units (200/1000/1850mm) of sandy GRAVEL, very gravelly SAND, and slightly sandy, slightly gravelly CLAY. Medium to high cobble content above 3.05m. Gravel and cobbles of sandstone, mudstone, limestone, concrete and brick	0	5.2	5.2	6 to 17	40 -100
Tidal Flat Deposit - CLAY	Firm red brown sandy, slightly gravelly CLAY with sand parting. Becoming soft, grey brown with occasional black organic matter.	5.2	6.5	1.3	-	13 -22
River Terrace Deposit – SAND & GRAVEL	Medium dense red brown very sandy GRAVEL with medium cobble content, becoming very clayey gravelly SAND. Gravel and cobbles of sandstone.	6.5	7.5	1	19	-
Bedrock – MUDSTONE (MMG)	Very weak to weak MUDSTONE with very closely to medium spaced thin beds of fine to coarse sandstone. Below 8.7m extremely weak to very weak, below 24m locally very weak to weak, thinly to medium bedded red brown MUDSTONE with widely spaced very thin beds of fine to medium sandstone above 13m. Below 31m with medium to widely spaced, thick beds of extremely weak to weak, fine to coarse sandstone.	7.5	39	31.5	176, 211	-
Bedrock - CONGLOMERATE (MMG)	Very weak to weak thinly bedded, fine to coarse quartzitic SANDSTONE.	39	40	1	-	-
Bedrock – SILTSTONE (CM)	Extremely weak to weak grey and brown slightly to moderately weathered MUDSTONE. Below 42.35m becoming weak to medium strong slightly weathered grey MUDSTONE and SILTSTONE.	40	>46.7	>6.7	-	-

Standing Groundwater (m BGL) = 5.15 during drilling. Between 3.6 & 4.9m during monitoring.

3.2.4 Commercial Road

Previous GI information for this part of the site is severely restricted, with the only information being provided by a single BGS borehole. A summary of the findings are presented in the table below:

Table 3.7: Ground Conditions - Commercial Road

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer Cu (kPa)
Made Ground	-	0	2.2	2.2	-	-
Tidal Flat Deposit - CLAY	'Blue Clay'	2.2	13.2	11	-	-
River Terrace Deposit – SAND & GRAVEL	'Clay and gravel'	13.2	15	1.8	-	-
Bedrock – MUDSTONE (MMG)	'Marl rock'	15	21.7	6.7	-	-
Bedrock – SANDSTONE (MMG)	'Sandstone'	21.7	38.6	16.9	-	-

Bedrock - CONGLOMERATE (MMG)	'Conglomerate'	38.6	41.5	2.9	-	-
Bedrock – SILTSTONE (CM)	'Shale, red sandstone'	41.5	>50	>8.5	-	-

Standing Groundwater (m BGL) = Not recorded

At this location, a significant thickness of TFDs has been determined (circa 11m) over approximately 2m of RTDs, resulting in bedrock being encountered at a depth of 15m below existing ground level.

3.2.5 Clarence Road

Similar to the Commercial Road Section of the site, previous GI information related to the Clarence Road section is limited to three trial pits that have been hand dug through the river bank sediment material encountered at the base of the existing river wall. This work was undertaken in response to a total horizontal movement in excess of 100mm of the river wall at this location over the course of two isolated incidents in January and August 2014; this was believed to be associated with a horizontal sliding translation of the wall towards the river.

Therefore, the table below provides details of the ground conditions encountered with depths recorded from below the top of the river wall.

Table 3.8: Ground Conditions - Clarence Road

Unit	Description	Top (m BGL)*	Base (m BGL)*	Thickness (m)	SPT N Values	Hand Penetrometer Cu (kPa)
River Wall (with unknown retained material)	-	0	3.5	3.5	-	-
Superficial Deposit - SILT	Very soft grey SILT.	3.5	3.9	0.4	-	-
Completely Weathered Bedrock - CLAY (MMG)	Stiff silty CLAY	3.9	4.4	0.5	-	-
Bedrock - MUDSTONE (MMG)	Mudstone	4.4	>4.4	-	-	-

Standing Groundwater (m BGL) = Not recorded. *Depths taken from top of river wall.

As these holes have been completed on the riverbank, it is difficult to determine what ground conditions exist behind the existing river wall. However, in front of the river wall, completely weathered MMG bedrock, comprising stiff clay, is encountered within 0.5m of the top of superficial deposits, and it is likely that competent MMG bedrock (comprising mudstone) will be encountered at relatively shallow depth (i.e. within one metre of the top of these deposits). The residual conditions resulting from the potential ground movements causing the wall to move towards the river will also need to be considered as part of any ongoing design.

3.2.6 Cattlemarket Road

A summary of the geology and ground conditions encountered are presented in the following tables.

Table 3.9: Ground Conditions - Cattlemarket Road (West of Temple Meads Bridge)

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer/hand vane Cu (kPa)
Made Ground	Medium to thickly interbedded units (250/600/1050mm) of soft brown sandy very gravelly clay and very clayey, gravelly to very gravelly sand with roots and rootlets present. Gravel of brick, concrete, ceramics, coal and limestone.	0	3.5	3.5	4	-
Tidal Flat Deposit – CLAY/SILT	Firm to stiff grey mottled, slightly sandy silty CLAY. Below 4.7m becoming soft to firm and, below 6.3m, very soft CLAY and very sandy clayey SILT.	3.5	7.6	4.1	4 to 7	66 decreasing to 22 & 12
River Terrace Deposit – SAND &	Loose blue grey mottled dark grey very clayey, very silty SAND.	7.6	>8.45	>0.85	6	-

GRAVEL						

Standing Groundwater (m BGL) = 4m. Between 1 and 5m during monitoring.

Table 3.10: Ground Conditions - Cattlemarket Road (East of Temple Meads Bridge)

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer Cu (kPa)
Made Ground	Medium to thickly interbedded units (250/800/1050mm) of very soft to soft grey brown slightly sandy, slightly gravelly clay and clayey, sandy gravel and cobbles of brick concrete, limestone ceramic, clinker and coals. Occasional rootlets, organic material and fragments of metal.	0	2.8	2.8	8	35
Tidal Flat Deposit - CLAY	Soft to firm grey brown, thinly laminated and fissured silty CLAY. Becoming slightly sandy below 8m	2.8	11.4	8.6	2, 7 & 8	45, 41, 13, 20, 19,21,24
River Terrace Deposit – SAND & GRAVEL	Light brown grey clayey very sandy GRAVEL of sandstone and chert.	11.4	12.9	1.5	4	-
Bedrock – SANDSTONE (MMG)	Weak to medium strong thinly to thickly laminated, extremely closely to medium fractured light red brown fine to medium partially weathered SANDSTONE	12.9	17	4.1	>200	-
Bedrock – MUDSTONE (MMG)	Very weak to weak thinly laminated closely to medium fractured red brown mottled green grey partially weathered MUDSTONE.	17	>20.4	>3.4	-	-

Standing Groundwater (m BGL) = 4.8m during drilling. Between 1.1 and 5.1m during monitoring.

More comprehensive ground information exists for the eastern side of Temple Meads Bridge, however, the ground conditions encountered either side of the bridge are broadly similar. The Tidal Flat Deposits, however, extend to a greater depth on the eastern side of the bridge (circa 11.5m, as opposed to circa 7.5m on the western side). Weak to medium strong sandstone is then encountered, below a circa 1.5m thickness of RTD material, at a depth of circa 13m on the eastern side of the bridge and >8.5m on the western side.

The generalised ground conditions are represented in cross sections, either side of the bridge, in CH2MHILL's July 2015 report, provided in Appendix B of this report.

3.2.7 Totterdown

The Totterdown section of the site represents another extensive section of the scheme. Ground investigation information for the western and southern sections of the site is limited to BGS records, for which a summary table is provided below.

Table 3.11: Ground Conditions - Totterdown – South & East

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer Cu (kPa)
Made Ground	'Dark grey sandy ash and brick fill with occasional cobbles and boulders'.	0	3.5	3.5	-	-
Tidal Flat Deposit - SILT	Soft grey very clayey SILT with organic fragments and occasional rootlets.	3.5	10	5.5	-	-
Bedrock – SANDSTONE (MMG)	'Weak' highly weathered red brown silty fine grained SANDSTONE	10	>10.4	>0.4	-	-

Standing Groundwater (m BGL) = 3.35 & 9.9m

For the Totterdown (West) section, ample GI information is provided within the River Avon Path & St Philips Footbridge GIRs. The latter includes cross sections, which are provided for reference in Appendix B of this report, orientated perpendicular and parallel to the river bank at this location. These indicate the general downward sequence comprises between 4-6m of Made Ground, 5-8m of TFDs, then circa 2m of RTDs overlying MMG bedrock at circa -4m OD, which comprises mudstone and occasionally sandstone and siltstone. Post site monitoring of standpipe installations suggest groundwater levels between 0.6 and 4.7m below existing ground level.

3.2.8 Netham

Previous information regarding ground conditions for this section of the site is limited to historical BGS data. A summary of these provided is provided in the table below.

Table 3.12: Ground Conditions - Netham

Unit	Description	Top (m BGL)	Base (m BGL)	Thickness (m)	SPT N Values	Hand Penetrometer Cu (kPa)
Made Ground	'Topsoil & made up ground'	0	1.5	1.5	-	-
Tidal Flat Deposit - CLAY	Pale grey brown silty CLAY	1.5	10.35	8.85	-	-
River Terrace Deposit – SAND & GRAVEL	'Flint Pebbles'	10.35	11.7	1.35	-	
Bedrock – SANDSTONE (MMG)	Red calcareous SANDSTONE.	11.7	26.4	14.7	-	-
Bedrock – MUDSTONE (CM)	MUDSTONE with 'hard coal'.	26.4	>50	>23.6	-	-

Standing Groundwater (m BGL) = 1.8m

4 Characteristic Values/Design Parameters

4.1 Introduction

As part of this review, and to progress the preliminary design of retaining structures, three cross-sections have been selected at various locations along the scheme (refer to Appendix C for locations and annotated sketches). These locations have been chosen to reflect the various ground support requirements within the scheme and the variation in the alignment of the proposed retaining structures, relative to existing structures. Where possible, geotechnical parameters have then been determined from available GI information at these specific 'type' sections. Where specific geotechnical and design parameter information is not available, data has been obtained from the nearest area to the site where this information has been provided. The intention is that, for outline design purposes, characteristic values and design parameters are made available for various geological units encountered within the selected cross-section areas, using a combination of geotechnical information sourced from previous GI work along the route of the scheme presented below and also within Section 3 of this report.

4.2 Cumberland Road (Section: Avon 01_0919)

This cross-section is located within the western section of Cumberland Road and, therefore, the generalised ground conditions are considered to be consistent with those provided in Table 3.3 (Section 3.2.2). According to CH2MHILL's 'Introductory Note to the AVTM Ground Investigation and Geotechnical Data', dated November 2013, a Ground Investigation Report (GIR) has not been completed for the Ashton Vale Temple Meads (AVTM) Metrobus scheme. Therefore, the geotechnical parameters provided below, are taken from CH2MHILL's Ground Investigation Report Camden Road Bridge, dated September 2015, which relates to the eastern section of Cumberland Road (Section 3.2.2 - Table 3.5). Although, not directly affecting the selected cross section location (01_0919), the residual impact of the localised ground slippage event (and subsequent remedial works) that occurred between July and August 1981 (see Section 3.2.2), will also need to be considered in future design work.

Unit	SPT N Values	N60 Value	Hand Penetrometer cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ') °	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Youngs Modulus (GPa)
Made Ground	0, >70 & 7	0, 79 & 8	-	-	-	30	0	-	1.9	-
Tidal Flat Deposits - CLAY	2	2	0, 7, 16,25,32, 38, 55	10	TBC	TBC	TBC	-	-	-
River Terrace Deposits – SAND & GRAVEL	20 & 181	23 & 204	-	-	-	33	0	-	2.0	-
Completely Weathered Bedrock - CLAY (MMG)	57	64	-	>300	TBC	TBC	TBC	-	-	-
Bedrock - SANDSTONE (MMG)	-	-	-	-	-	-	-	0.5 increasing to 26	2.31	-
Bedrock – CONGLOMERATE (MMG)	-	-	-	-	-	-	-	TBC	TBC	-

4.3 Clarence Road (Section: Avon 01_3157)

As the only geotechnical information available regarding this part of the site relates to previous ground investigation work comprising 3 hand excavated trial pits within recent river bank material (refer to section 3.2.5), ground conditions and parameters provided within CH2MHILL's report entitled *Ground Investigation Report Temple Quarter Enterprise Zone RIF Cattle Market Project*, (July 2015) for the Cattlemarket Road section of the site, have been the primary source of the data used. As highlighted in Section 3.2.5 the residual ground conditions resulting from any potential ground movement which may have resulted in the movement of the river wall in the vicinity of the Section 01_3157, will need to be considered in any ongoing design work.

Unit	SPT N Values	N60 Value	HP Cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ')°	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Young's Modulus (GPa)
River Wall/Retained material (unknown composition)	-	-	-	-	-	-	-	-	-	-
Superficial Deposit – SILT.	-	-	-	-	-	-	-	-	-	-
Completely Weathered Bedrock - CLAY (MMG)	-	-	-	-	-	-	-	-		-
Bedrock - MUDSTONE (MMG)	-	-	-	-	-	-	-	1-3	2.37	0.1

4.4 Netham (Section: Avon 01_6270)

Previous information regarding ground conditions for this section of the site is limited to historical BGS data (Section 3.2.8). The geotechnical parameters used below have, therefore, been determined from CH2MHILL's reports entitled *Draft Ground Investigation Report for Bristol Harbour Walkway & Avon River Path* (February 2015) and *Ground Investigation Report Temple Quarter Enterprise Zone RIF St. Philip's Footbridge* (May 2016). These relate more to the Totterdown section of the site, which is situated a significant distance further west of the Netham section of the site, but should hopefully provide representative parameters for potentially similar geological units found at these two locations .

Unit	SPT N Values	N60 Value	HP Cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ')°	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Young's Modulus (GPa)	Plasticity Index (%)
Made Ground	1-42	-	25	11	22	26	0	-	2	-	26
Tidal Flat Deposit - CLAY	1-5	-	-	10	28	26	0	-	1.9	-	27
River Terrace Deposit – SAND & GRAVEL	22	-	-	-	-	32	0	-	2	-	-
Bedrock – SANDSTONE (MMG)	-	-	-	-	-	-	-	16-52	2.4	-	-
Bedrock – MUDSTONE	-		-	-	-	-	-	3.5	2.3	0.19	23

Unit	SPT N Values	N60 Value	HP Cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ')°	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Young's Modulus (GPa)	Plasticity Index (%)
(CM)											

5 Conclusions & Recommendations

The quantity and quality of available ground investigation (GI) data and information for the River Avon Tidal Defences varies along the route of the proposed scheme. Certain sections of the scheme have detailed GI information which is supplemented by fairly comprehensive Ground Investigation Reports (GIRs) produced by CH2MHILL. GIRs are available for Cumberland Road (eastern section), Cattlemarket Road and Totterdown (western section).

For those sections of the site where detailed ground investigation and a GIR are available, the determination of geotechnical parameters and characteristic values is relatively straightforward. Unfortunately, this available information does not always coincide with the sections that have been identified as requiring a more detailed ground engineering design, namely Cumberland Road (western section), Clarence Road and Netham. Available GI data for the latter two sites is severely limited, and the outline design for the cross-section on Cumberland Road would benefit from a review of any additional information (such as the geotechnical laboratory test data) associated with this part of the site, which has not be supplied as part of the background material provided to AECOM.

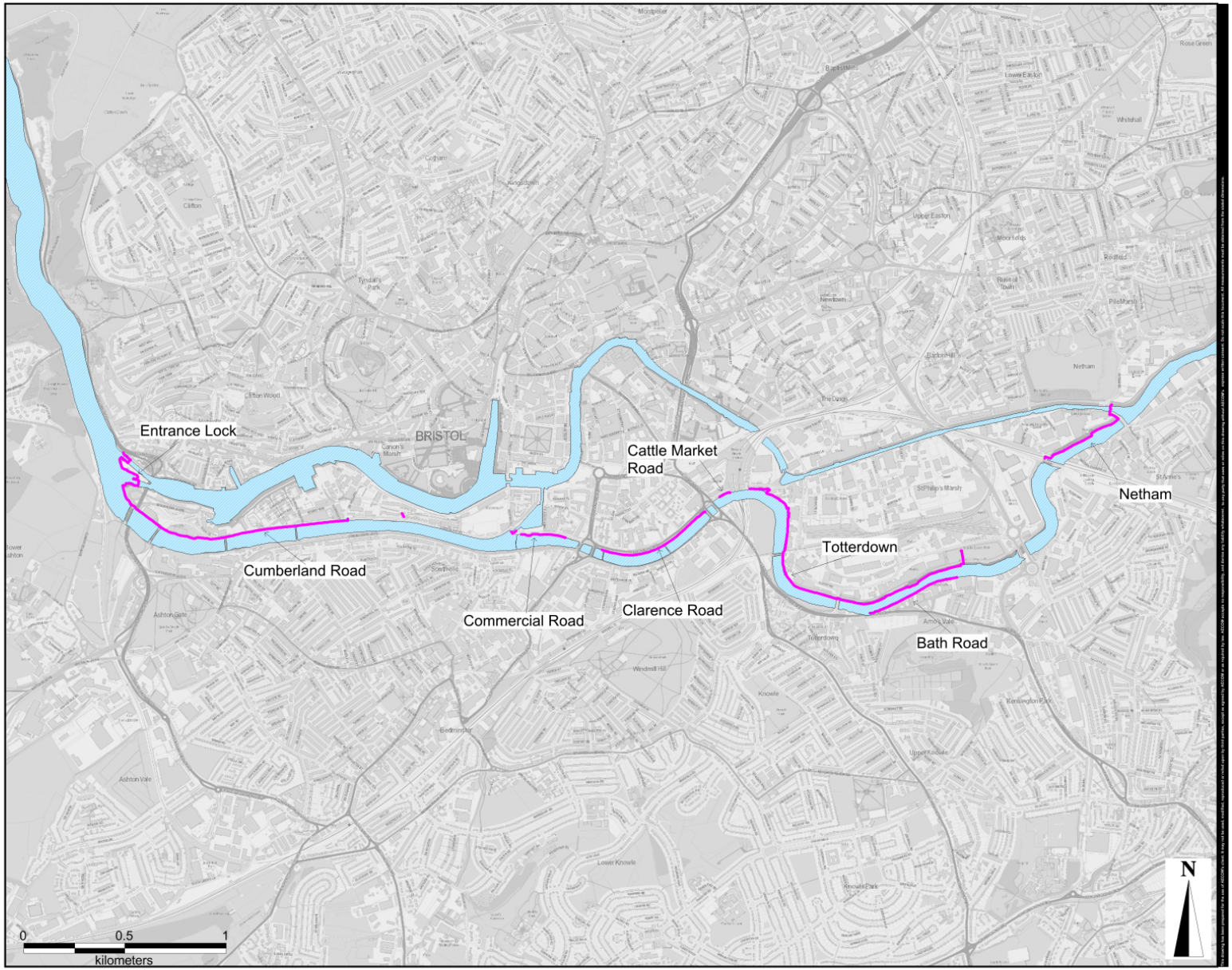
In terms of concept ground engineering design, the available information could be used for the entire length of the scheme. For the Clarence Road section, assumptions could be made as to the nature of the material behind the river wall and weathered MMG beds have already been identified at relatively shallow depth (compared with the remainder of the site) on the river side of the wall. With regards to the rest of the sections along the route of the scheme, Section 3 of this report provides ample geological and ground condition information, which can be combined with information regarding the proposed position of the new walls (relative to the existing river walls) and the support requirements for nearby structures/features, in order to facilitate a concept design.

It is anticipated that the proposed scheme could potentially make use of a variety of engineering solutions, depending on consideration of the previously mentioned factors and the prevailing ground conditions, including the construction of sheet pile, secant/contiguous pile or king post walls.

Potential engineering solutions are due to be progressed further during refinement of the Strategy, subsequent to this review of GI data and ground conditions, and it is recommended that any supplementary data which hasn't yet been provided to AECOM, including the geotechnical lab data associated with the factual GI report entitled Report on Ground Investigation at Bristol Rapid Transit Ashton Vale to Temple Meads, produced by Structural Soils Ltd in October 2013, is made available. This would help with the selection of appropriate geotechnical parameters and characteristic values to facilitate the outline geotechnical design required for the western and central parts of the Cumberland Road section of the site.

.

Appendix A. Figures



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Project Title:

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

BRISTOL CITY COUNCIL

LEGEND

- River Avon / Floating Harbour
- High Defences

AECOM Internal Project No:

60478613

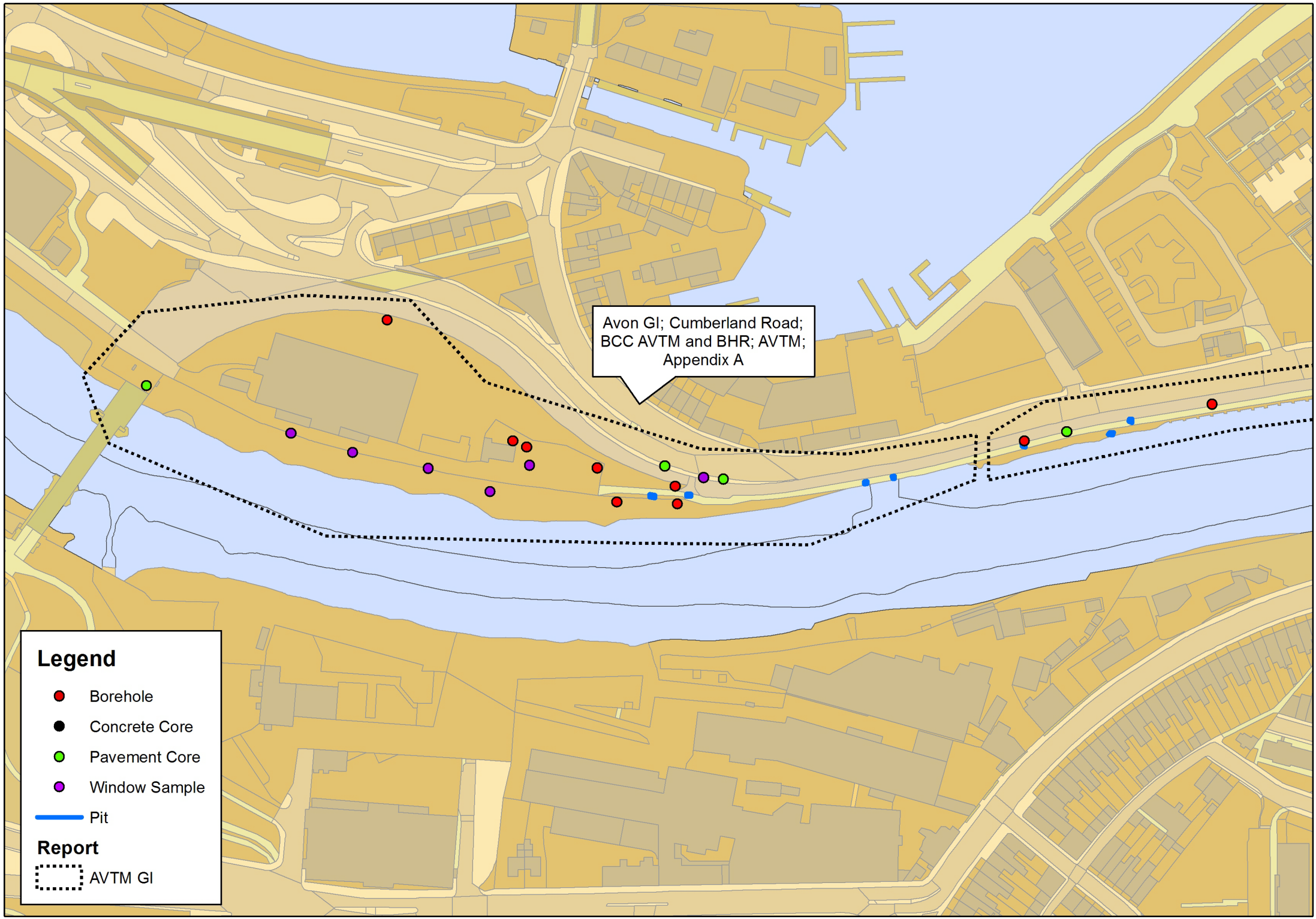
Drawing Title:

HIGH DEFENCES
FLOATING HARBOUR

Scale at A3: 17,500

Drawing No: **Rev:** 1

Drawn:	Chk'd:	App'd:	Date:
RM	MD	JS	July 2016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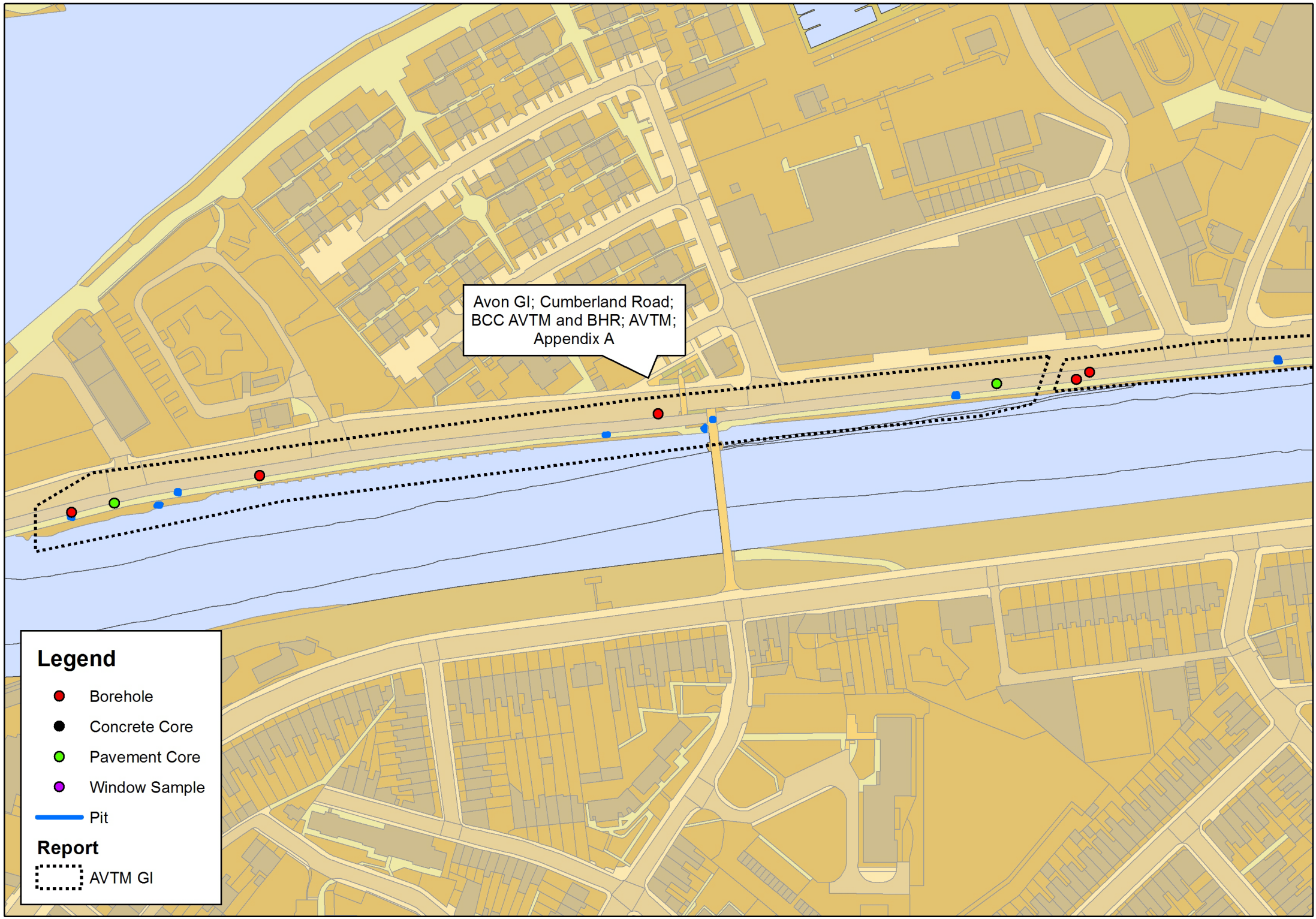
Legend
Borehole
Concrete Core
Pavement Core
Window Sample
Pit
Report
AVTM GI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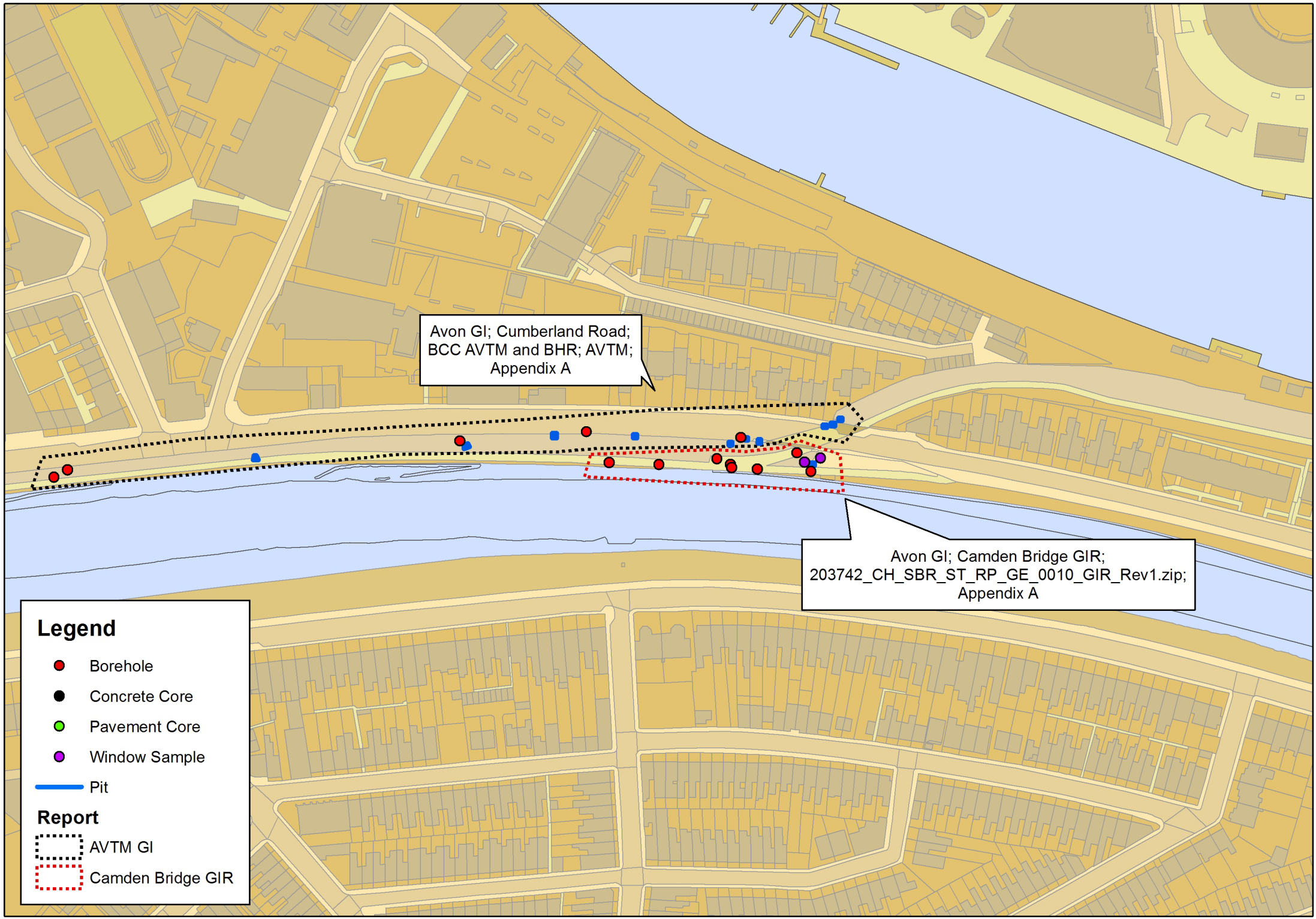
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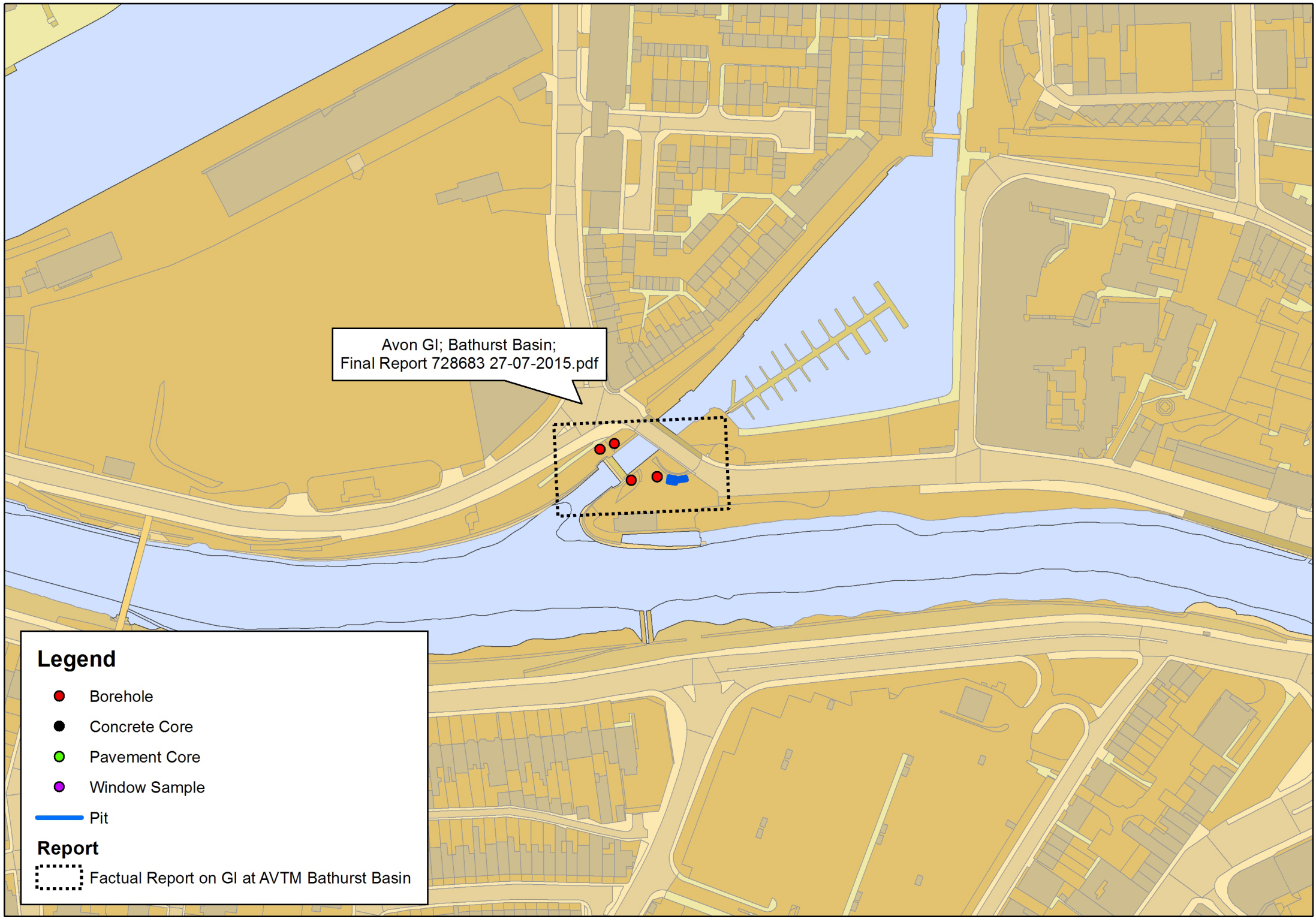
Legend
Borehole
Concrete Core
Pavement Core
Window Sample
Pit
Report
AVTM GI
Camden Bridge GIR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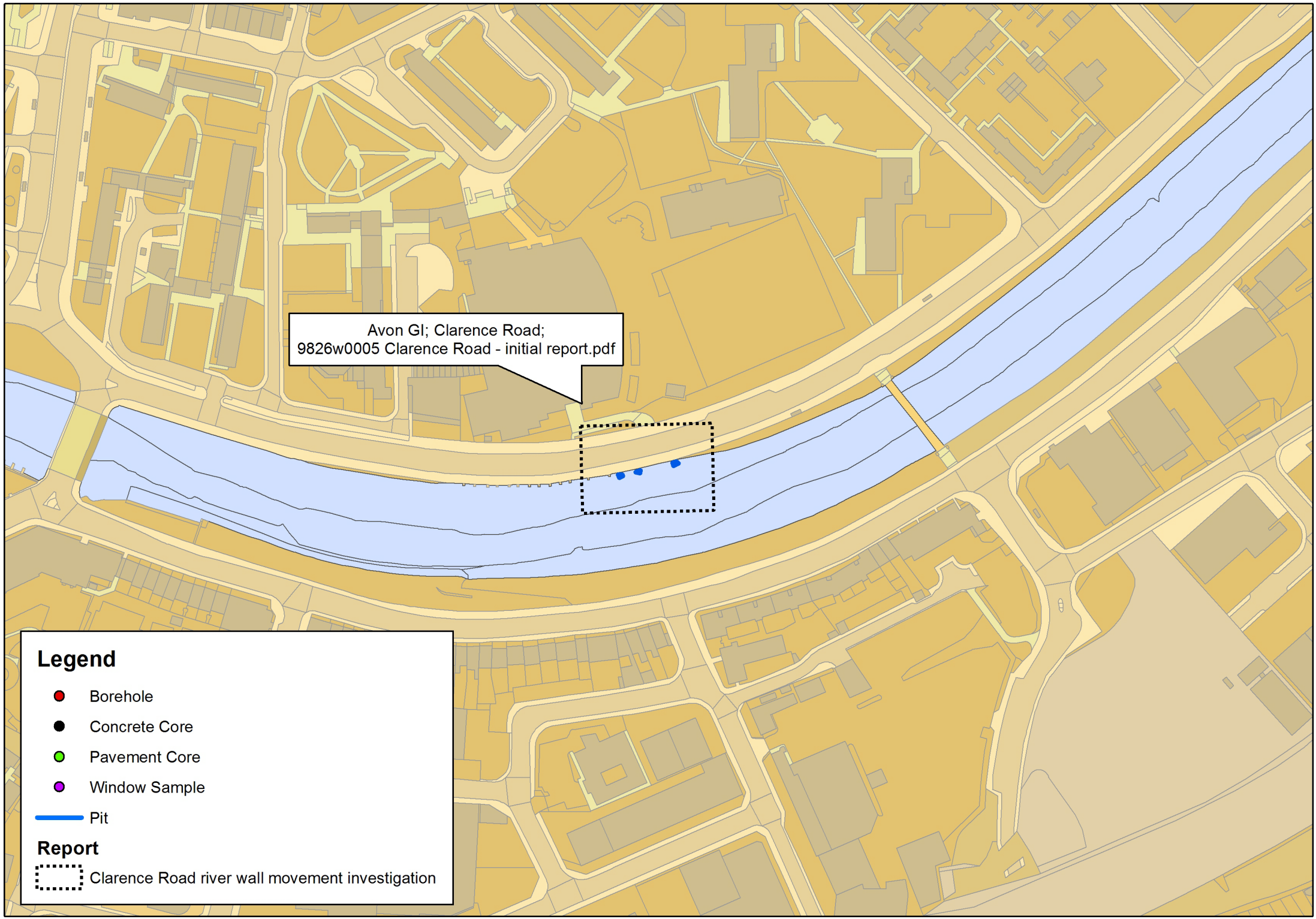
Legend
Borehole
Concrete Core
Pavement Core
Window Sample
Pit
Report
Factual Report on GI at AVTM Bathurst Basin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Borehole
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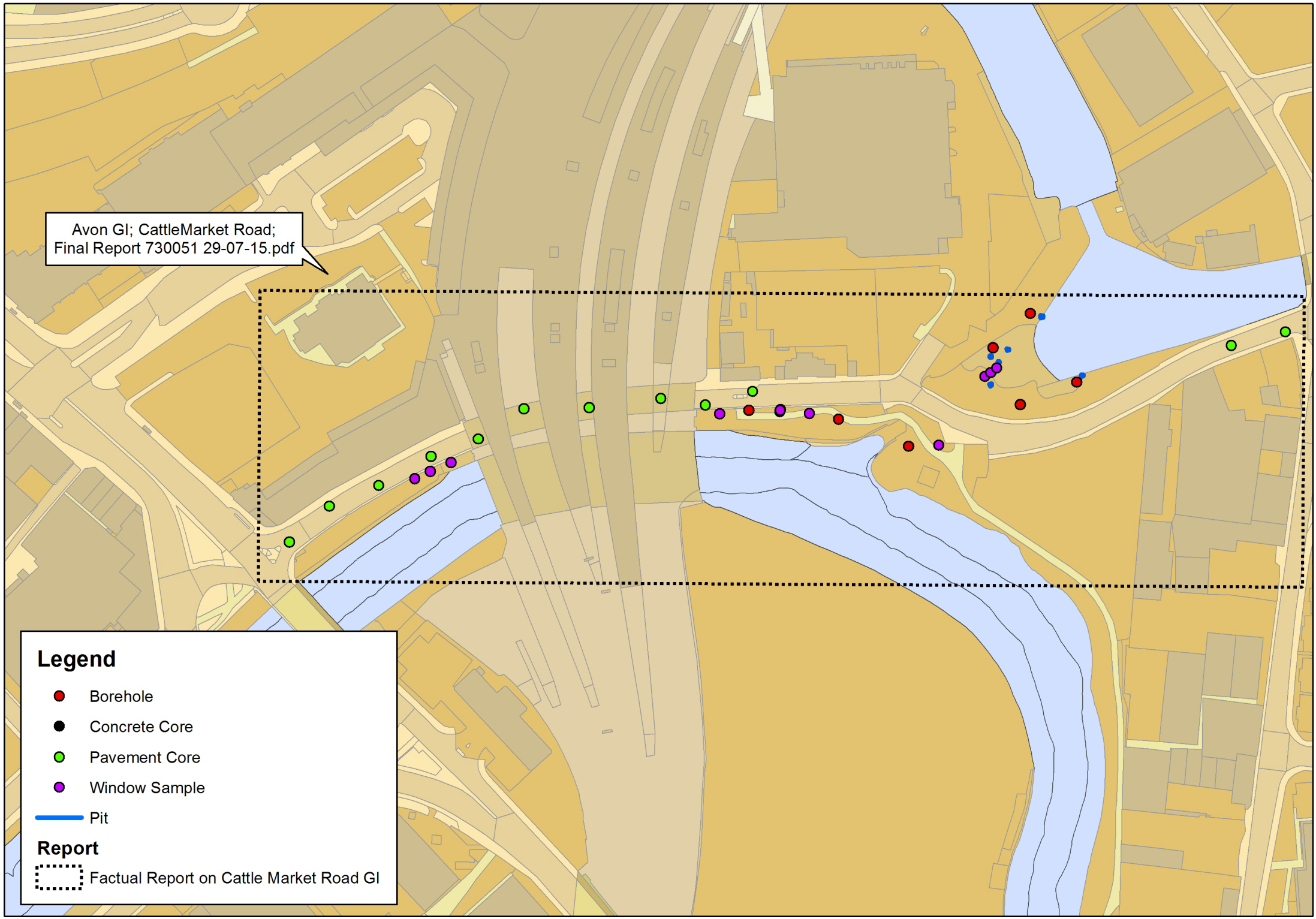
Pavement Core
Window Sample
Pit
Report
Clarence Road river wall movement investigation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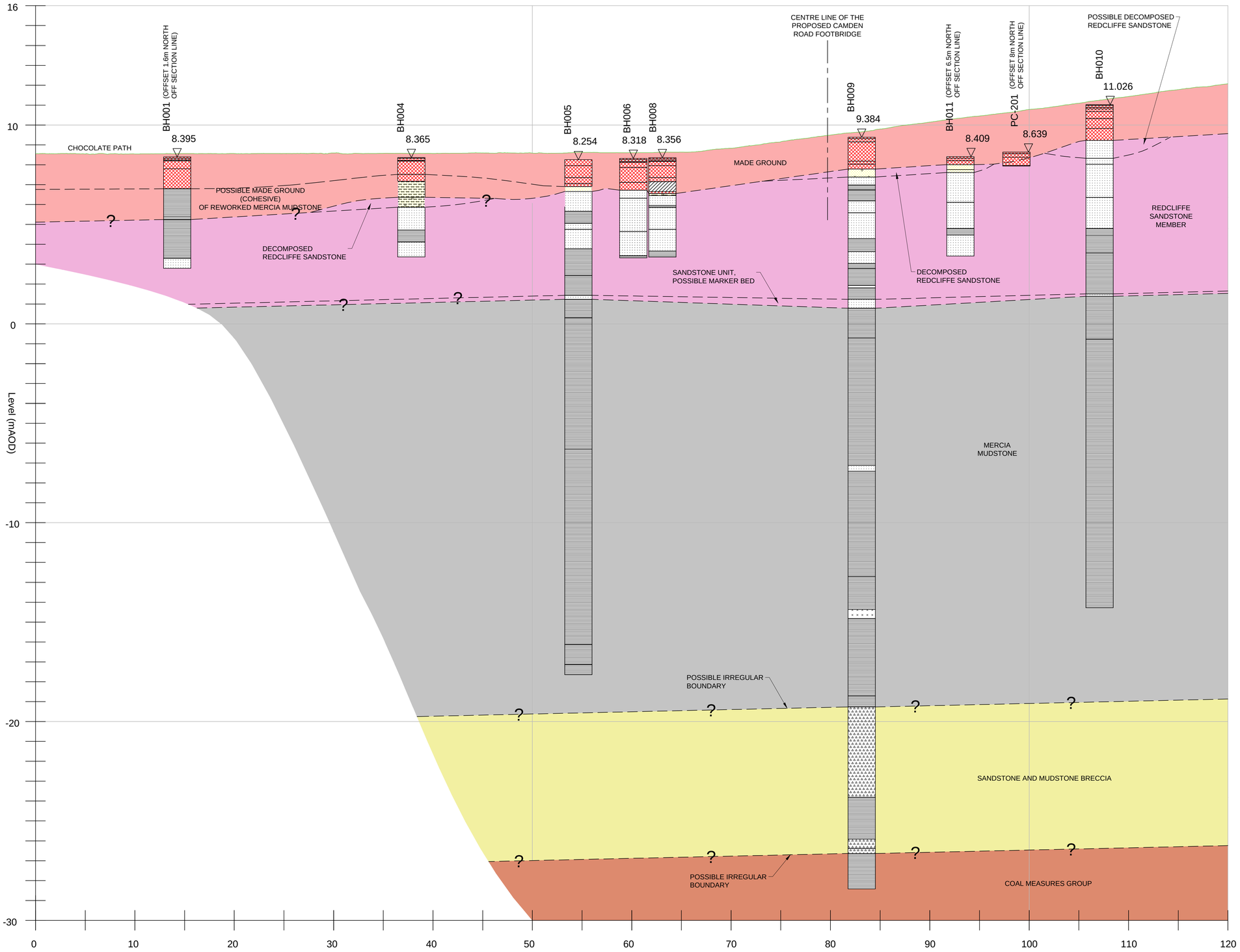
Legend
Borehole
Concrete Core
Pavement Core
Window Sample
Pit
Report
Factual Report on Cattle Market Road GI

Appendix B.
Geological Sections

.

1 WEST EAST 1'



SECTION 1-1'
GEOLOGICAL SECTION ALONG THE CHOCOLATE PATH ON THE NORTH BANK OF THE RIVER AVON NEW CUT

HORIZONTAL SCALE 1:200 (A1)
VERTICAL SCALE 1:100 (A1)

0 5 10 METRES
SCALE 1:100 (A1)
SCALE 1:200 (A3)

0 5 10 20 METRES
SCALE 1:200 (A1)
SCALE 1:400 (A3)

NOTES

1. ALL LEVELS ARE IN METRES AOD UNLESS STATED OTHERWISE.
2. TO BE READ IN CONJUNCTION WITH THE CAMDEN ROAD BRIDGE GROUND INVESTIGATION REPORT.

KEY

- Existing Ground Level
- Made Ground
- Concrete
- Sandy Clay
- Sandy Gravelly Clay
- Gravelly Sand
- Clayey Gravelly Sand
- Mudstone
- Siltstone
- Sandstone
- Breccia
- Zone of Core Loss
- Made Ground
- Redcliffe Sandstone
- Mercia Mudstone
- Sandstone and Mudstone Breccia
- Coal Measures Group

Rev	By	Chkd	Apprvd	Date	Description
01	JRV	PH	MF	25/06/15	Initial Revision.

Client

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Project
BRISTOL CITY COUNCIL CYCLING AMBITION FUND

Drawing
CAMDEN ROAD BRIDGE GROUND INVESTIGATION SECTIONS SHEET 1 OF 5

Drawn by: JRV	Date: 25/06/15
Checked by: PH	Date: 25/06/15
Approved by: MF	Date: 25/06/15
Drawing No. 203742-CH-SBR-ST-DR-GE-0102	Revision 01
Drawing Scale: As shown at A1	

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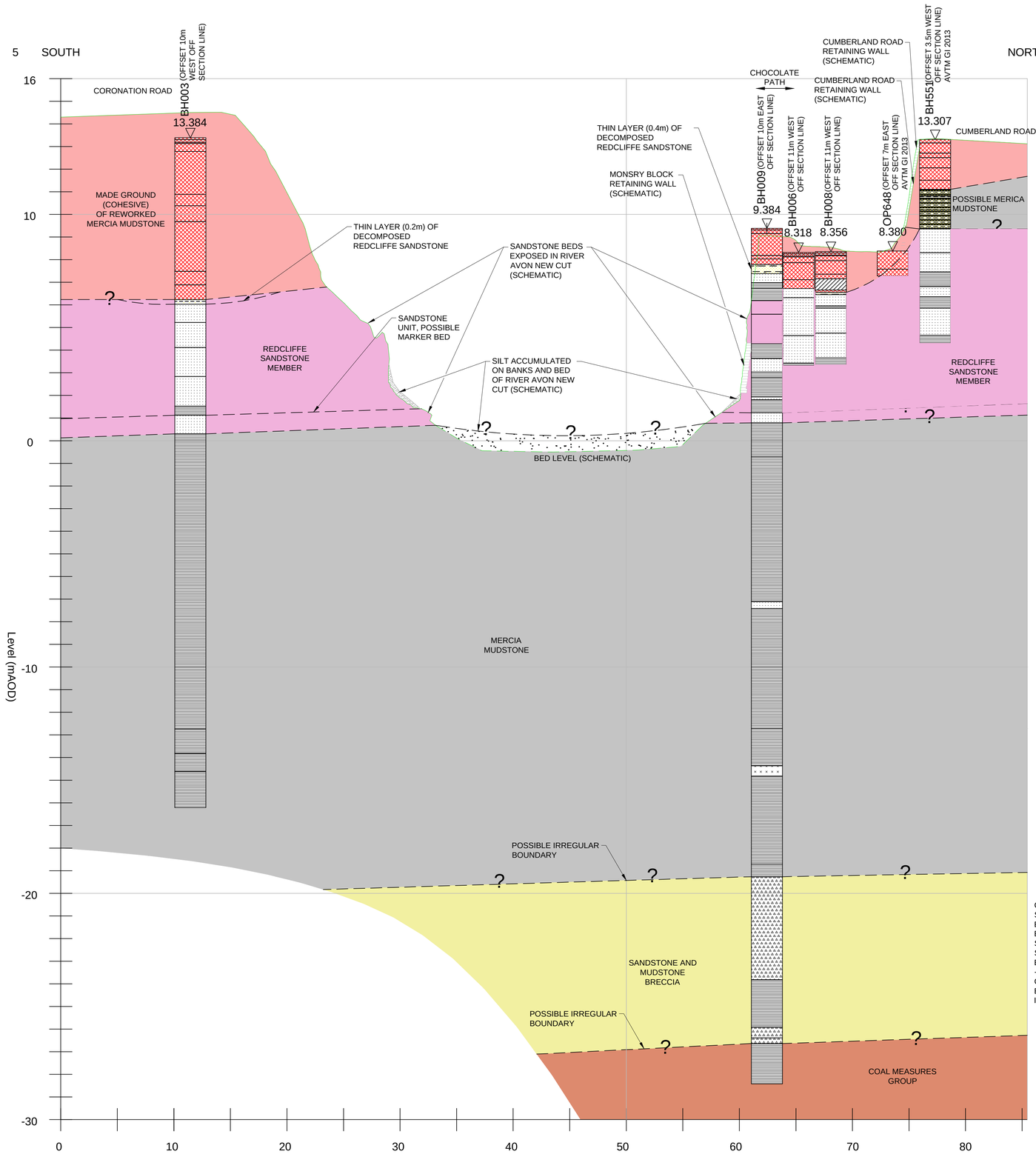
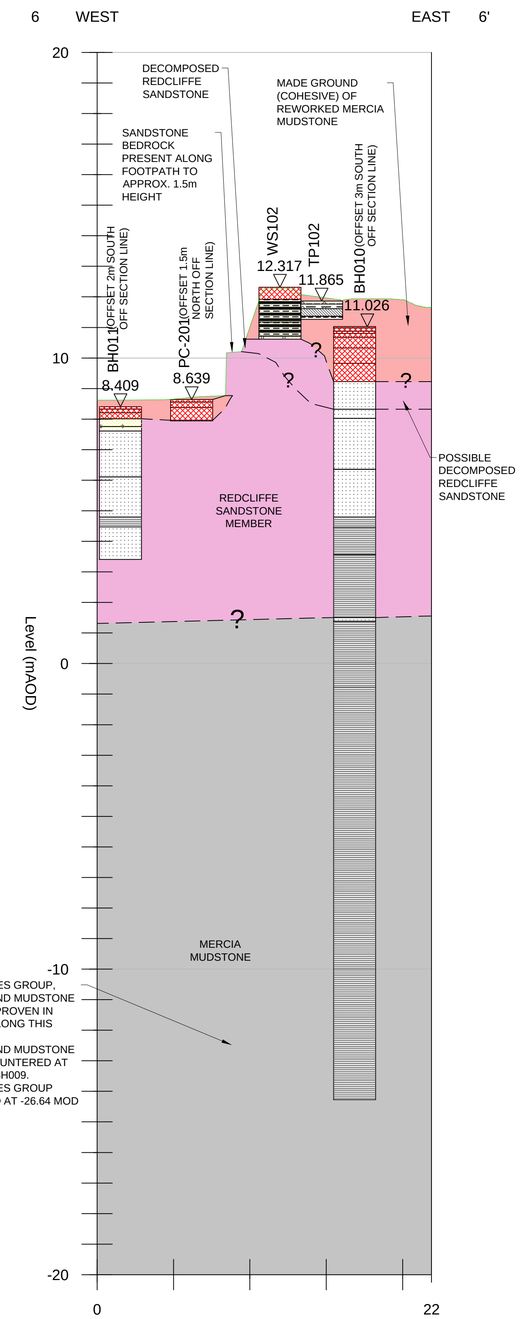


SECTION 5-5'
GEOLOGICAL SECTION FROM THE SOUTH TO THE NORTH BANK OF THE RIVER AVON NEW CUT
HORIZONTAL SCALE 1:200 (A1)
VERTICAL SCALE 1:100 (A1)



SECTION 6-6'
HORIZONTAL SCALE 1:200 (A1)
VERTICAL SCALE 1:100 (A1)

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SCALE 1:100 (A1)
SCALE 1:200 (A3)

0 5 10 20 METRES
SCALE 1:200 (A1)
SCALE 1:400 (A3)

NOTES

1. ALL LEVELS ARE IN METRES AOD UNLESS STATED OTHERWISE.
2. TO BE READ IN CONJUNCTION WITH THE CAMDEN ROAD BRIDGE GROUND INVESTIGATION REPORT.

KEY

- Existing Ground Level
- Made Ground
- Sandy Clay
- Sandy Gravelly Clay
- Clayey Sand
- Gravelly Sand
- Clayey Gravelly Sand
- Mudstone
- Siltstone
- Sandstone
- Breccia
- Zone of Core Loss
- CSG and COB
- Made Ground
- Redcliffe Sandstone
- Mercia Mudstone
- Sandstone and Mudstone Breccia
- Coal Measures Group

Rev	By	Chkd	Apprvd	Date	Description
01	JRV	PH	MF	25/06/15	Initial Revision.

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Project

BRISTOL CITY COUNCIL
CYCLING AMBITION FUND

Drawing

CAMDEN ROAD BRIDGE
GROUND INVESTIGATION
SECTIONS
SHEET 5 OF 5

Drawn by: JRV	Date: 25/06/15	
Checked by: PH	Date: 25/06/15	
Approved by: MF	Date: 25/06/15	
Drawing No. 203742-CH-SBR-ST-DR-GE-0106		Revision 01

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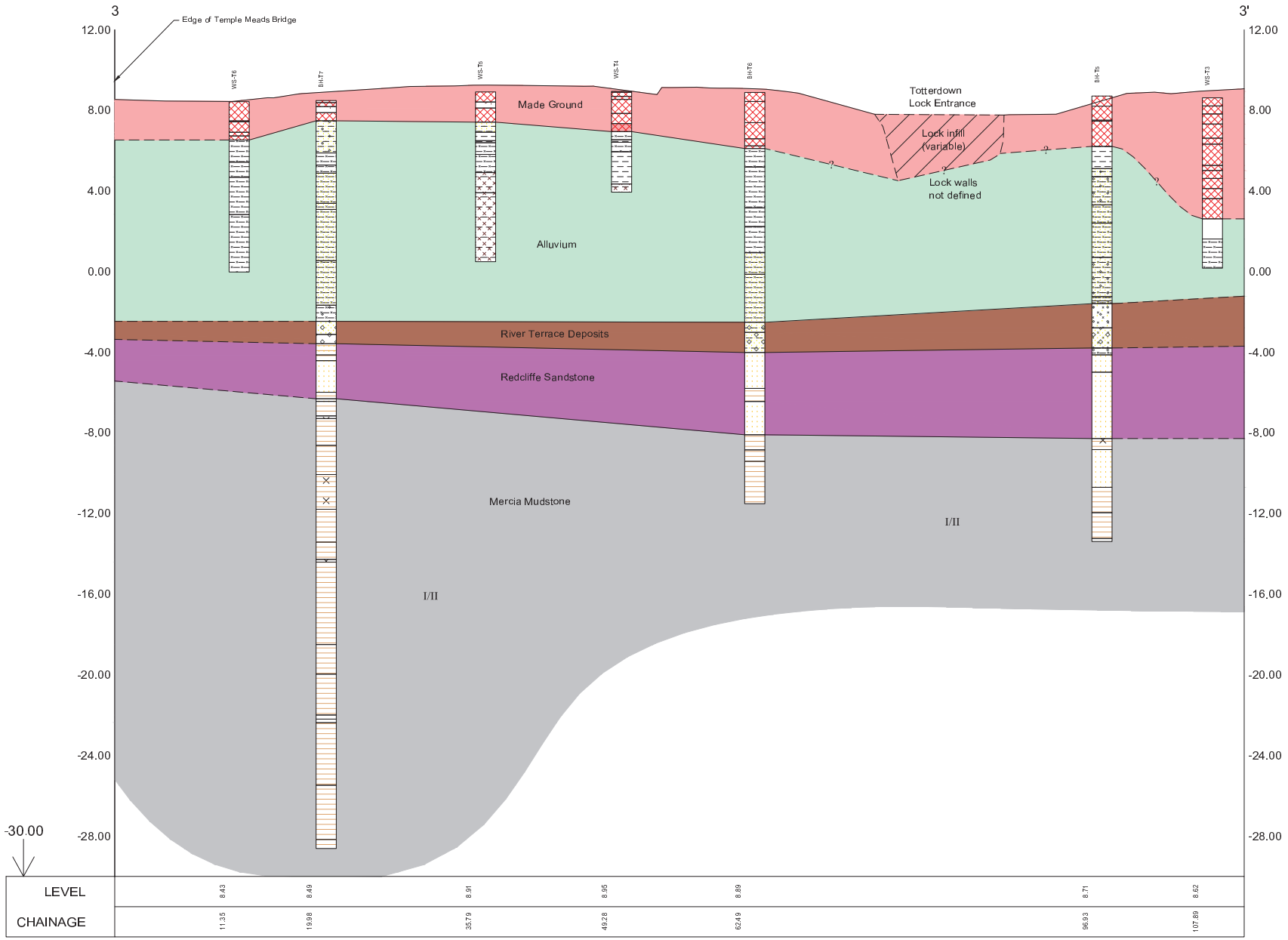

Section 3–3'
Totterdam Lock Viewing Platform
and Cattle Market Road East Wall
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Vertical Scale 1:200

SCALE 1:100 (A1)
SCALE 1:200 (A3)
METRES

SCALE 1:200 (A1)
SCALE 1:400 (A3)
METRES

NO.	DATE	DSGN	REVISION	BY	APVD
0	27/05/2015	DR	ISSUE WITH GIR	JRV	MF
		RN	CHK	JRV	MF

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CH2MHILL

Totterdown Basin/Cattle Market Road

GROUND INVESTIGATION
SECTIONS

SCALE AS SHOWN @ A1	
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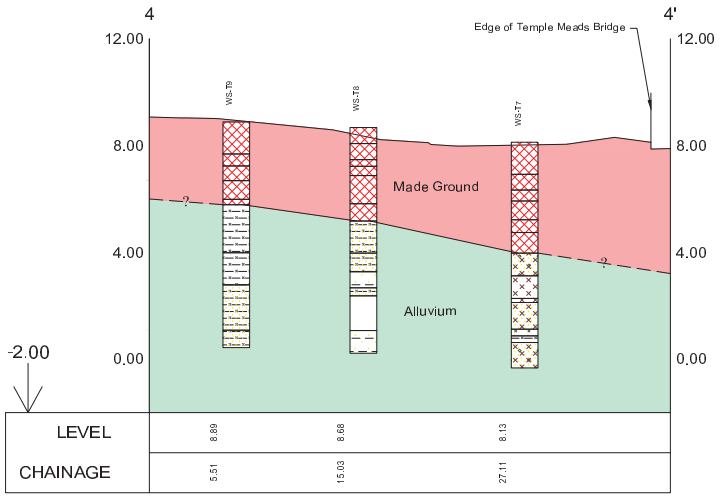

Section 4–4'
Cattle Market Road West Wall
Horizontal Scale 1:200
Vertical Scale 1:100

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0	27/05/2015	REVISION	RN	JRV	MF

DSGN	BY	APVD
JRV	JRV	MF

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CH2MHILL

Tollerdown Basin/Cattle Market Road

GROUND INVESTIGATION SECTIONS

SCALE 1:100 (A1)
SCALE 1:200 (A3)
0 5 10 METRES

SCALE 1:200 (A1)
SCALE 1:400 (A3)
0 5 10 20 METRES

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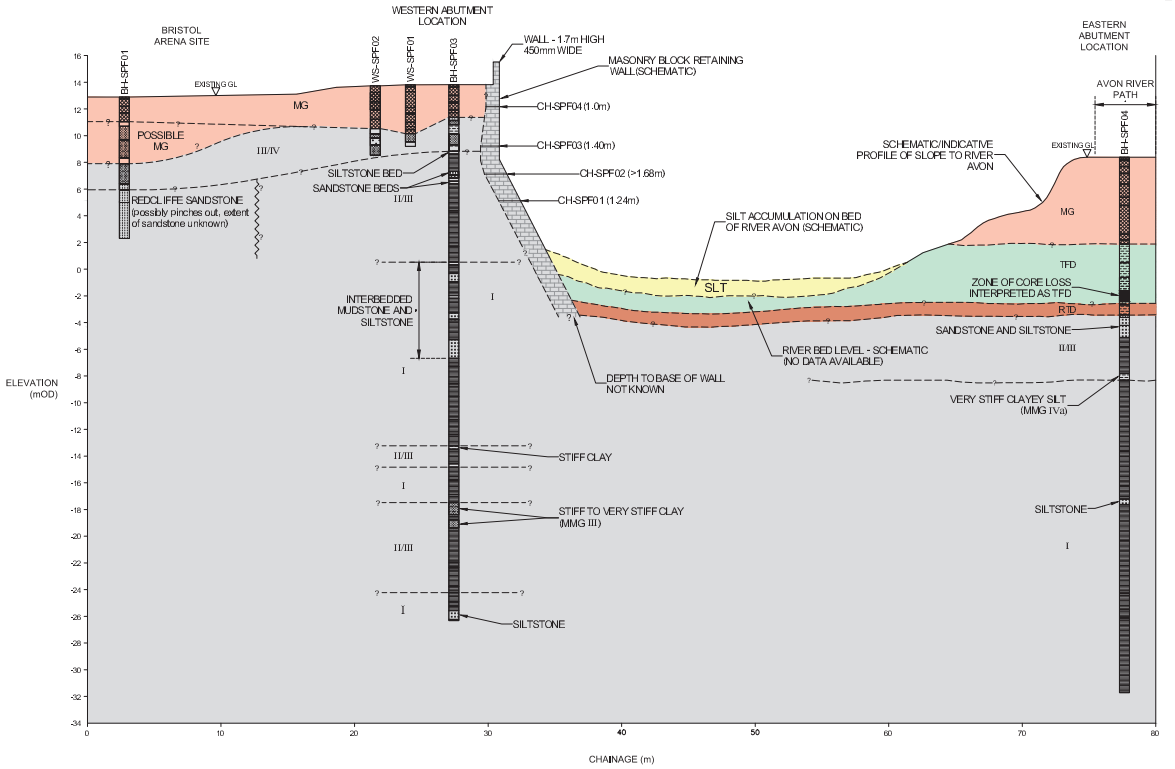

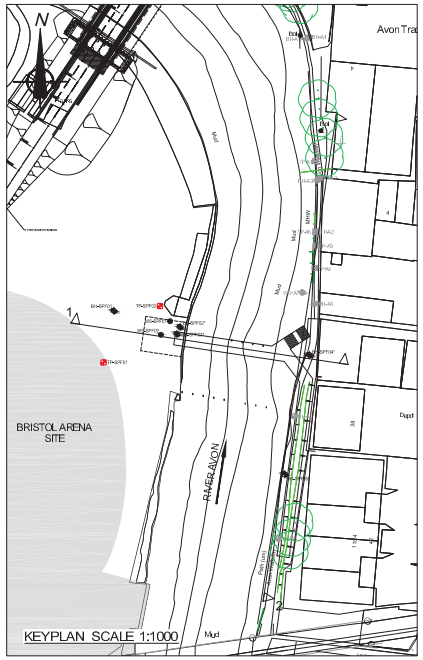

KEY

	MADE GROUND	MG	MADE GROUND
	GRAVEL	SLT	SILT
	SILT	TFD	TIDAL FLAT DEPOSITS
	SAND	RTD	RIVER TERRACE DEPOSITS
	CLAY		MERCIA MUDSTONE GROUP
	SANDSTONE		ZONE OF CORE LOSS
	SILTSTONE	II/III	MERCIA MUDSTONE WEATHERING GRADE (CIRIA 570)
	MUDSTONE	CH-SPF04(1.0m)	HORIZONTAL MASONRY COREHOLE WITH WALL THICKNESS PROVEN

Notes:

1. ALL LEVELS ARE IN METRES AOD UNLESS STATED OTHERWISE
2. TO BE READ IN CONJUNCTION WITH THE ST PHILLIPS FOOTBRIDGE GROUND INVESTIGATION REPORT (CH2M HILL 2016).
3. FOR GROUND INVESTIGATION DETAILS REFER TO FACTUAL REPORTS ON ST PHILLIPS FOOTBRIDGE (2016) AND AVON RIVER PATH (2014) BY STRUCTURAL SOILS LIMITED (SSL).
4. GEOLOGICAL BOUNDARIES ARE INDICATIVE ONLY
5. TOPOGRAPHY SCHEMATIC ONLY
6. WEATHERING GRADES IN MERCIA MUDSTONE GROUP INDICATIVE ONLY - REFER TO BOREHOLE LOGS FOR FULL DETAILS.

INFORMATION

Rev	By	Chkd	App	Date	Description
0	NG	PH	-	06/04/16	INFORMATION

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ch2m.

Project:
ST PHILIP'S FOOTBRIDGE
GROUND INVESTIGATION

Drawing:
GEOLOGICAL CROSS SECTIONS
SHEET 1

Suitability:
INFORMATION

Drawn by:	NG	Date:	06.04.2016
Checked by:	PH	Date:	06.04.2016
Approved by:		Date:	
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Revision: 0

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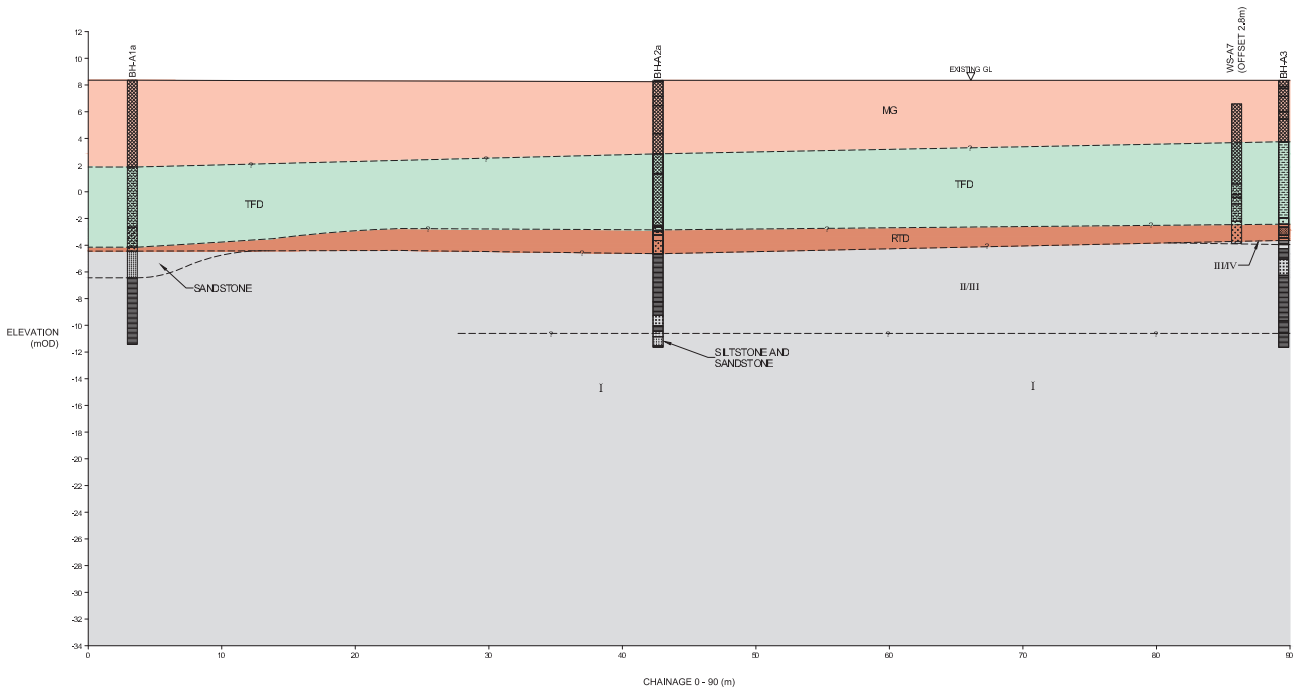

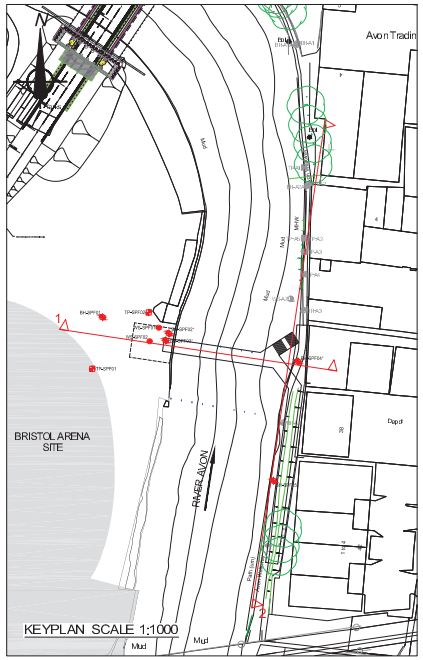

Notes:

1. ALL LEVELS ARE IN METRES AOD UNLESS STATED OTHERWISE
2. TO BE READ IN CONJUNCTION WITH THE ST PHILLIPS FOOTBRIDGE GROUND INVESTIGATION REPORT (CH2M HILL 2016).
3. FOR GROUND INVESTIGATION DETAILS REFER TO FACTUAL REPORTS ON ST PHILLIPS FOOTBRIDGE (2016) AND AVON RIVER PATH (2014) BY STRUCTURAL SOILS LIMITED (SSL).
4. GEOLOGICAL BOUNDARIES ARE INDICATIVE ONLY
5. TOPOGRAPHY SCHEMATIC ONLY
6. WEATHERING GRADES IN MERCIA MUDSTONE GROUP INDICATIVE ONLY - REFER TO BOREHOLE LOGS FOR FULL DETAILS.

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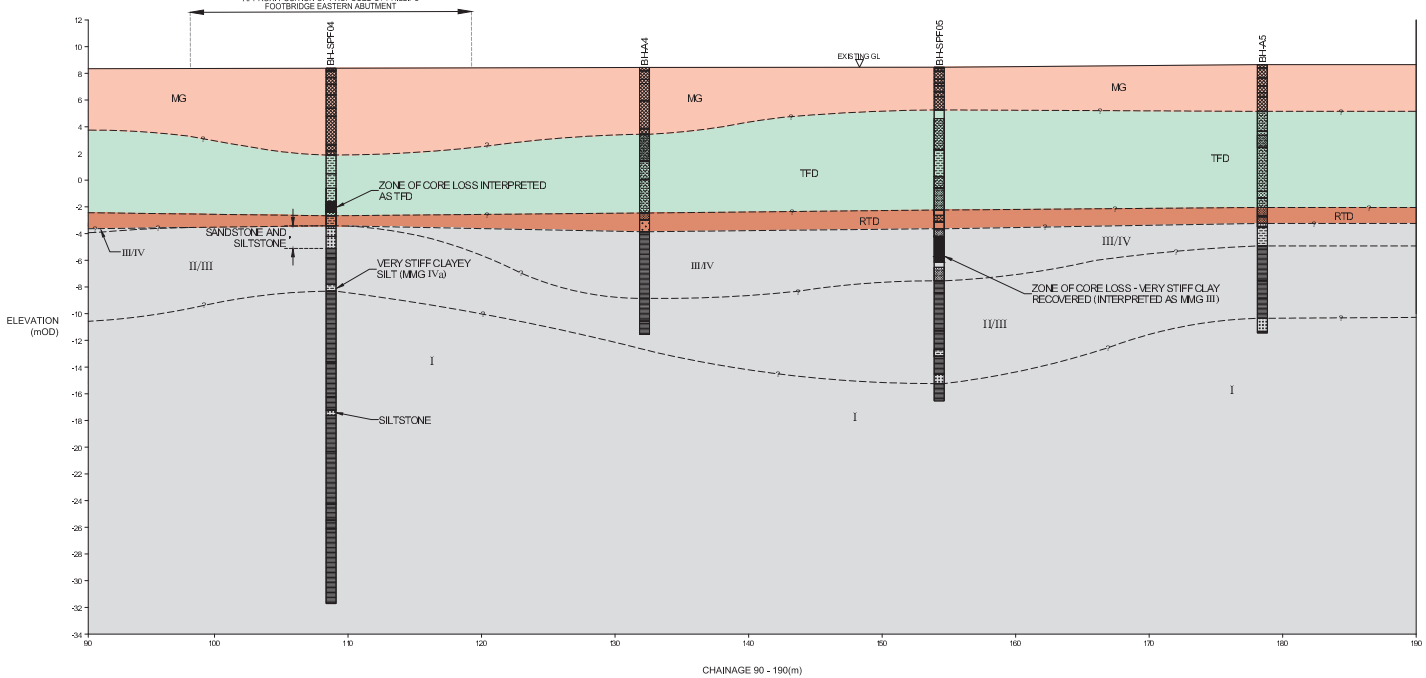


KEY

MADE GROUND	MG	MADE GROUND	
GRAVEL	SLT	SILT	
SILT	TFD	TIDAL FLAT DEPOSITS	
SAND	RTD	RIVER TERRACE DEPOSITS	
CLAY		MERCIA MUDSTONE GROUP	
SANDSTONE		ZONE OF CORE LOSS	
SILTSTONE	II/III	MERCIA MUDSTONE WEATHERING GRADE (CIRIA 570)	
MUDSTONE			

INFORMATION

Rev	By	Chkd	App	Date	Description
0	NG	PH	-	06/04/16	INFORMATION

Client: BRISTOL CITY COUNCIL

CH2M, BURDEROP PARK
SWINDON, WILTSHIRE, SN4 0QD
Tel +44 (0)1793 812478 Fax +44 (0)1793 812089

ch2m.

Project:
ST PHILIP'S FOOTBRIDGE
GROUND INVESTIGATION

Drawing:
GEOLOGICAL CROSS SECTIONS SHEET 2

Suitability:
INFORMATION

Drawn by:	NG	Date:	06/04/16
Checked by:	PH	Date:	06/04/16
Approved by:	-	Date:	
Drawing Scale:	As shown @ A1		

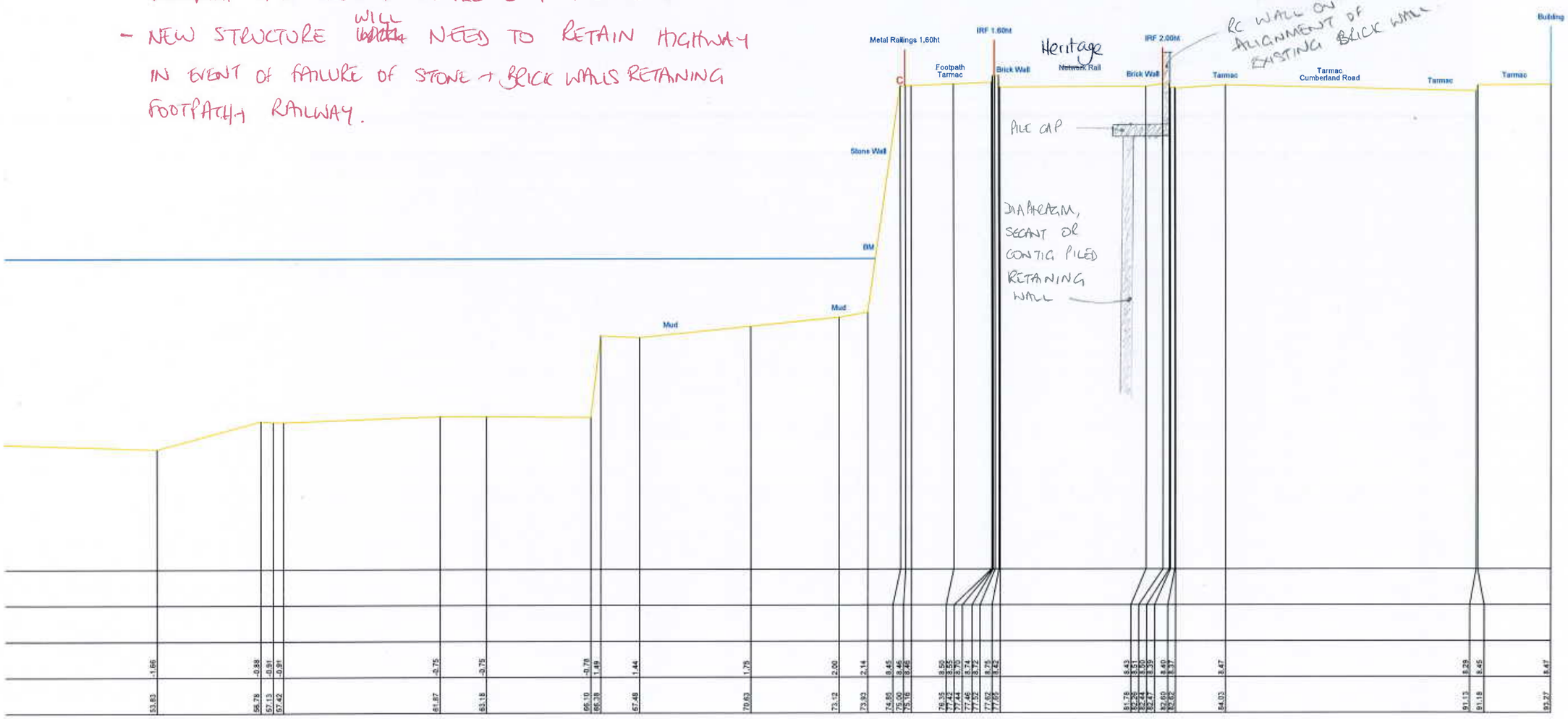
Drawing No.: FIGURE A3
Revision: 0

Appendix C.
Proposed Design Cross-Sections & Locations

CUMBERLAND ROAD.

- TOP OF DEFENCE 10.15M.
- BRICK WALLS BELIEVED TO BE RETAINING STRUCTURES (HISTORIC) FOR HIGHWAY + RAILWAY. CONSTRUCTION DETAILS UNKNOWN.
- DEFENCE ALIGNMENT TO BE ADJACENT TO HIGHWAY (ABOVE GROUND).
- FOOTPATH HAD RECENT 'SETTLEMENT' PROBLEMS
- NEW STRUCTURE WILL NEED TO RETAIN HIGHWAY IN EVENT OF FAILURE OF STONE + BRICK WALLS RETAINING FOOTPATH + RAILWAY.

SUGGESTED SOLUTION



CROSS SECTION A1ON01-0919.

Ori

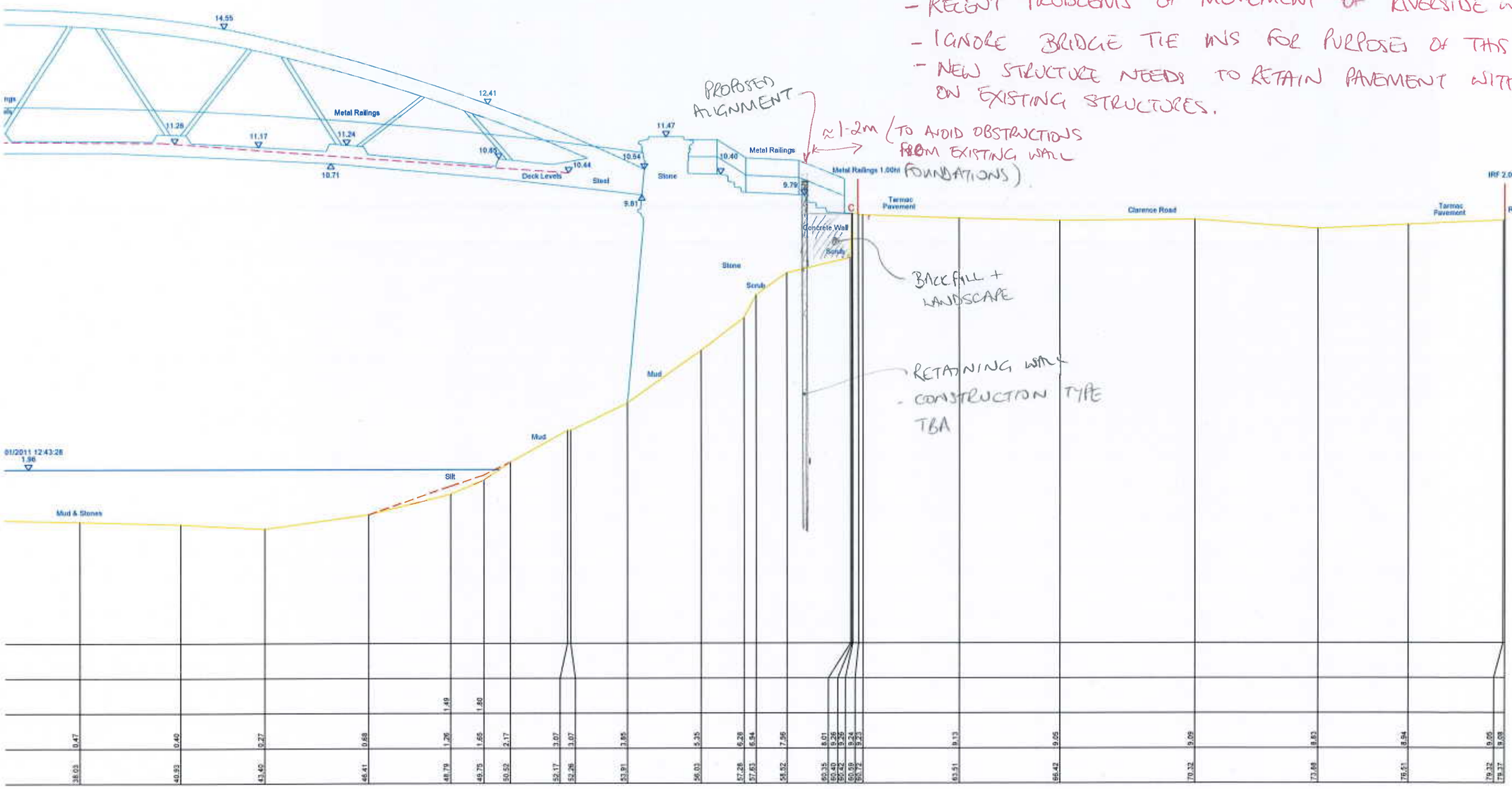
KEY TO SECTIONS:

C

KEY TO LONGITUDINAL

CLARENCE ROAD.

- TOP OF DEFENCE 10·15M.
- RECENT PROBLEMS OF MOVEMENT OF RIVERSIDE WALL.
- IGNORE BRIDGE TIE INS FOR PURPOSES OF THIS ASSESSMENT.
- NEW STRUCTURE NEEDS TO RETAIN PAVEMENT WITHOUT RELYING ON EXISTING STRUCTURES.



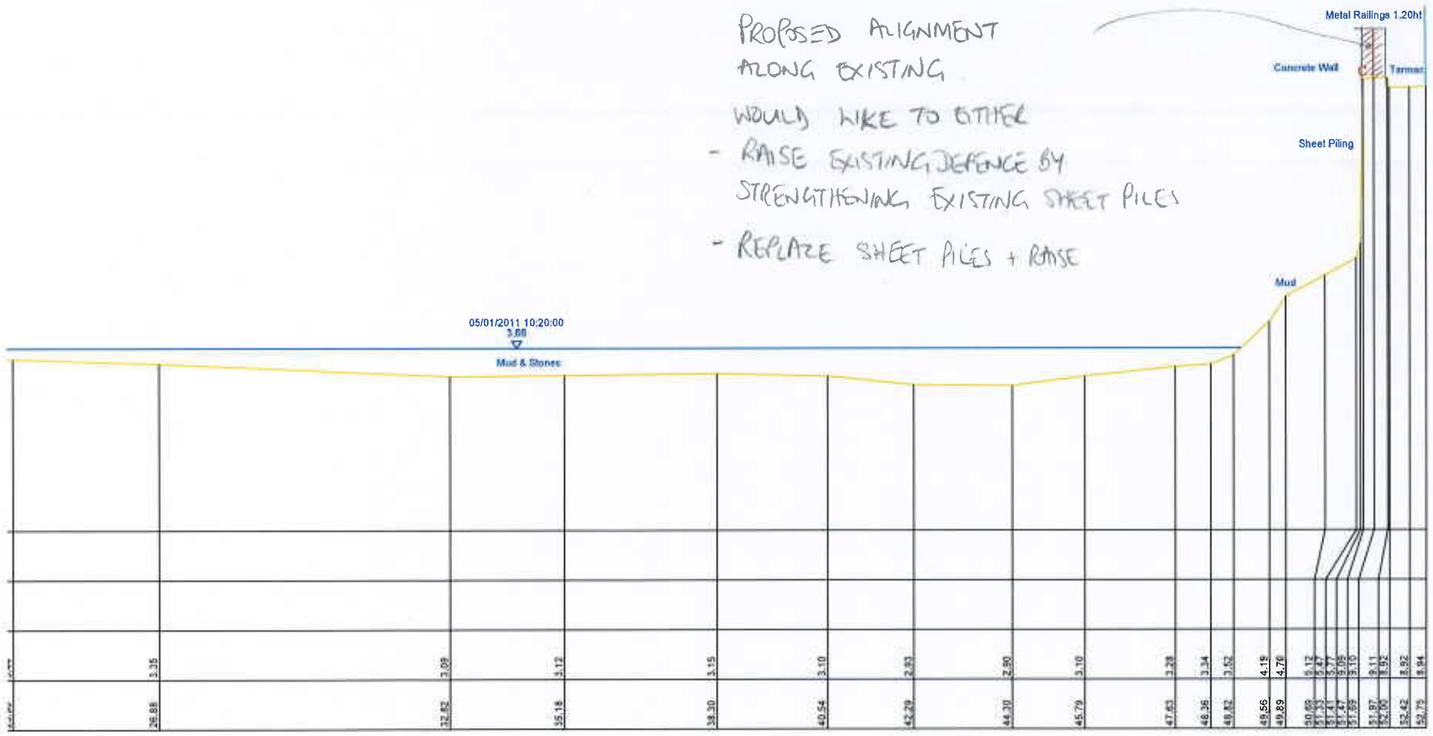
NETHAM

- TOP of DEFENCE 10.25m.

PROPOSED ALIGNMENT ALONG EXISTING

WOULD LIKE TO EITHER

- RAISE EXISTING DEFENCE BY STRENGTHENING EXISTING SHEET PILES
- REPLACE SHEET PILES + RAISE



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PROJECT
Br

SITE/LIM

SURVI
SURVI
SCALE
DATUM
GRID:
CAD FIL

Original Drawing Size: A0

KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

} VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

GRID

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SURVEY LEGEND

REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:

TYPE	DESCRIPTION	LEVEL
OSNET		

CONTROL USED:

TYPE	DESCRIPTION	LEVEL

CITY DEVELOPMENT – FLOOD RISK
Brunel House, 3rd Floor, St Georges Road, Bristol, BS1 5UY

PROJECT/WATERCOURSE
Bristol Central Area Flood Risk Assessment

SITE/LIMITS
RIVER AVON (THE CUT)
LOCATION PLAN

SURVEYED BY: MALTBY LAND SURVEYS LTD	Ref: KS_012	
SURVEY DATE: JANUARY 2011		
SCALE: 1:2500	DRN: MN	CHKD: RAM
DATUM: GPS NETWORK	DATE: JAN 11	DATE: JAN 11
GRID: OSNET	DRAWING NO. MLS_10912_29	REV. –
CAD FILENAME: AVONW_17.dwg		

Original Drawing Size: A0

KEY TO SECTIONS:

- WATER LEVEL
- VISIBLE BED (TOP OF SILT) AND GROUND
- HARD BED (DETERMINED BY PROBING)
- C BANK CREST

KEY TO LONGITUDINAL SECTION ONLY:

- LEFT BANK CREST
- RIGHT BANK CREST

} VIEWED LOOKING DOWNSTREAM. POINTS INDICATED BY 'C' ON CROSS SECTIONS AND ADDITIONAL POINTS BETWEEN SECTIONS

GRID

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REV.	AMENDMENT	DRN	CHKD	DATE

CONTROL USED:
TYPE | DESCRIPTION | LEVEL
OSNET

CONTROL USED:
TYPE | DESCRIPTION | LEVEL

CITY DEVELOPMENT – FLOOD RISK
Brunel House, 3rd Floor, St Georges Road, Bristol, BS1 5UY

PROJECT/WATERCOURSE
Bristol Central Area Flood Risk Assessment

SITE/LIMITS
RIVER AVON (THE CUT)
LOCATION PLAN

SURVEYED BY: MALTBY LAND SURVEYS LTD		And XS_R12
SURVEY DATE: JANUARY 2011		
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DATUM: GPS NETWORK	DATE: JAN 11	DATE: JAN 11
GRID: OSNET	DRAWING NO. MLS_10912_30	REV. –
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APPENDIX B: FREEBOARD TECHNICAL NOTE

Technical Note

Project:	**R Avon TFRMS**	Job No: **60478613**	
Subject: **Freeboard calculations**			
Prepared by:	**Ben Taylor**	Date:	**Dec 16**
Checked by:	**Jason Drummond**	Date:	**Dec 16**
Approved by:	**David Dales**	Date:	**Dec 16**

BACKGROUND

This technical note provides details of the freeboard calculations that have been undertaken to derive the freeboard allowance of the raised defences (during the refinement of the preferred strategic option phase). No freeboard guidance is available from the Environment Agency for defences protecting primarily against tidal flood risk. It has therefore been necessary to adopt the existing guidance which is available for fluvial defences, and modify it accordingly for use with tidal defences.

During the shortlist and preferred options stage of the Strategy, a freeboard of 0.15m was applied to low defences. No freeboard was applied to high defences and instead the crest level of the high defences was rounded up to the nearest 0.1m of a meter.

The reason why no freeboard was applied to high defences was that the high defences are precautionary, protecting to a 1:200 year standard to 2115. Therefore, at the time of construction (at 2065), the SoP provided by the defences will be way in excess of the 2065 1:200 year standard. As sea levels rise, the SoP is expected to gradually fall, reaching the 1:200 year SoP in 2115.

The following sections provide details of the freeboard calculations used for the concept design phase. Two sets of calculations have been undertaken; for low defences and for high defences. The calculations are based on a similar methodology to the 'quick fluvial method' (EA, 2000).

Using this approach a freeboard calculation has been undertaken for low defences only. At this stage it is not beneficial to undertake a calculation for high defences as the defences will not be constructed until epoch 3 (2065 onwards) and due to the uncertainty in long term climate change projections a calculation undertaken with existing projections is unlikely to be valid at the time of construction.

In order to provide a more conservative approach than previously followed in the Strategy (when no freeboard was applied to high defences), then the low defence freeboard (as derived from the calculation below) has also been applied to high defences. This is considered to be appropriate for this stage of work when planning high defences is still at a conceptual stage and heights are used for costing purposes. However, from 2065 onwards when the high defences are constructed it will be necessary to revisit the freeboard calculation and adjust the recommendation as appropriate.

The 'Quick method'

The 'quick method' in the guidance is a qualitative method that uses a scoring and weighting system. Six uncertainty parameters are considered and given a score of 1 to 5 where 1 represents low uncertainty and 5 represents high uncertainty.

Once scored, the parameters are summed and then converted into a freeboard allowance using the formula given below:

*Freeboard (m) = k * (overall score of parameters (range 6-30) / 30) * (FL – MAMWL)*

Where k = a factor, initially proposed in the guidance as 0.5

FL = derived flood level (m)

MAMWL = mean annual maximum water level (m)

Parameter scoring

The parameters used to derive the freeboard allowance are not directly applicable to tidal conditions but judgement has been used to apply the scoring system to the Strategy. The parameters include; accuracy of hydrological data, accuracy of hydrological analysis, accuracy of hydraulic data, accuracy of the hydraulic model, significance of physical parameters and consequences of failure. The scoring for the Strategy is described below:

Parameter	**Score**
1. Accuracy of hydrological data	
Water levels based on measured data from the mouth of the Avon which is reliable	2
2. Accuracy of hydrological method	
Tidal projection is simplistic and relatively short term (2030 for low defences standard)	2
3. Accuracy of hydraulic data	
Water levels are dominated by tidal boundary rather than river channel shape	1
4. Accuracy of hydraulic model	
Although the model is complex, the important tidally dominated aspect is simple / accurate and the model has been peer reviewed	2
5. Significance of physical effects (waves etc.)	
Limited fetch for wave generation. Overflowing of defences by wave overtopping alone is unlikely to cause significant damage in the future	1
6. Consequences of failure	
Urban area at risk but inundation of defences will not lead to immediate deep flooding as water will mostly be contained in the floating harbour	4

Calculations and freeboard recommendation

Based on the parameter scores provided above, the total parameter score for the low defences along the Strategy frontage is **12** (out of a maximum of 30). The design water level for low defences varies along the New Cut, but the design water level for low defences at Cumberland Basin (typical of the city centre) is **9.45m AOD**. The 1:1 year water level has been used to represent the mean annual maximum water level in the calculations. The 1:1 year water level in 2030 (design standard year for low defences) is **8.24m AOD**. The calculation is shown below.

*Freeboard (m) = 0.5 * (12 / 30) * (9.45 – 8.24) = 0.24m*

The freeboard calculation has been rounded to the nearest 0.1m and based on this a freeboard of **0.2m** has been applied to low defences. As discussed above, for the purpose of this piece of work, this freeboard has also been applied to high defences. However, at the time of constructing high defences from 2065 onwards (when there is likely to be more clarity with regards to future water levels and uncertainty), the high defences freeboard recommendation will need to be revisited and revised if necessary.

RECOMMENDATIONS

Based on these calculations it is recommended that a 0.2m freeboard is applied to low and high defences in the Strategy.

In recommending this figure we have considered the following points:

- The previous advice (for preferred option reporting) was 0.15m and no allowance was used for high defences.
- Climate change predictions are the primary source of uncertainty to the allowance. Model uncertainty is the next most relevant contributor – this suggests an allowance of 0.17m would be appropriate.
- Industry has noted that there is significant potential for double counting contributions of uncertainty / allowances in deriving the freeboard allowance.
- The majority of works are at the front end of the Strategy (say 15 years, 2015-2030). Therefore, an allowance for the low defences is the priority.
- The allowance for latter intervention in 2065 should be based on revised climate change allowances and latest freeboard guidance available – see next bullet.
- The recommendation is made without sight of revised freeboard guidance, entitled residual uncertainty allowance, which was scheduled to be published by the EA / Defra Research and Development Programme in summer 2016 i.e. it is overdue. The recommended freeboard allowance should be reviewed when this information becomes available. Until that time, the low wall allowance of 0.2m should be applied to high walls too.

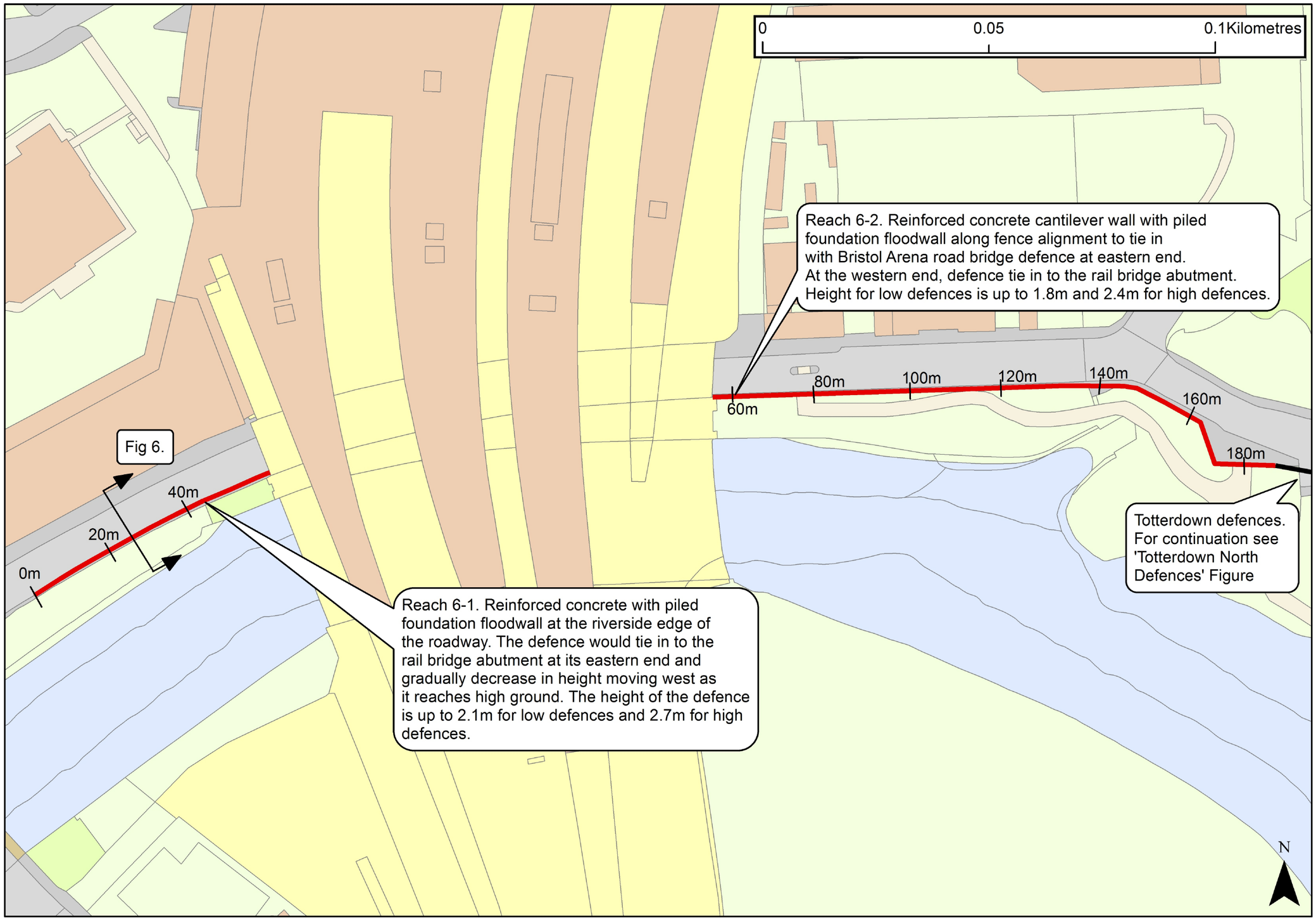
REFERENCES

Hyder (2015) Verification of CAFRA model against 2014 tides

Hyder (2012) Central Area Flood Risk Assessment, Modelling Report (Workstream 3)

Environment Agency (2000) Fluvial Freeboard Guidance Note

APPENDIX C: ALIGNMENT PLANS & CROSS SECTIONS



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Project Title:

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

- Alignments and defence heights are indicative only and will need to be confirmed during detailed design.

- Defence heights quoted are above existing adjacent ground level.

- Design level for low defences (including 200mm freeboard) = 9.80m

- Design level for high defences (including 200mm freeboard) = 10.40m

- Structure references relate to the contents of the associated table

- Under no circumstances must this drawing be used for construction

Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

CATTLE MARKET ROAD DEFENCES

Scale at A3: 1:10,000

Drawing No: **Rev:** V1

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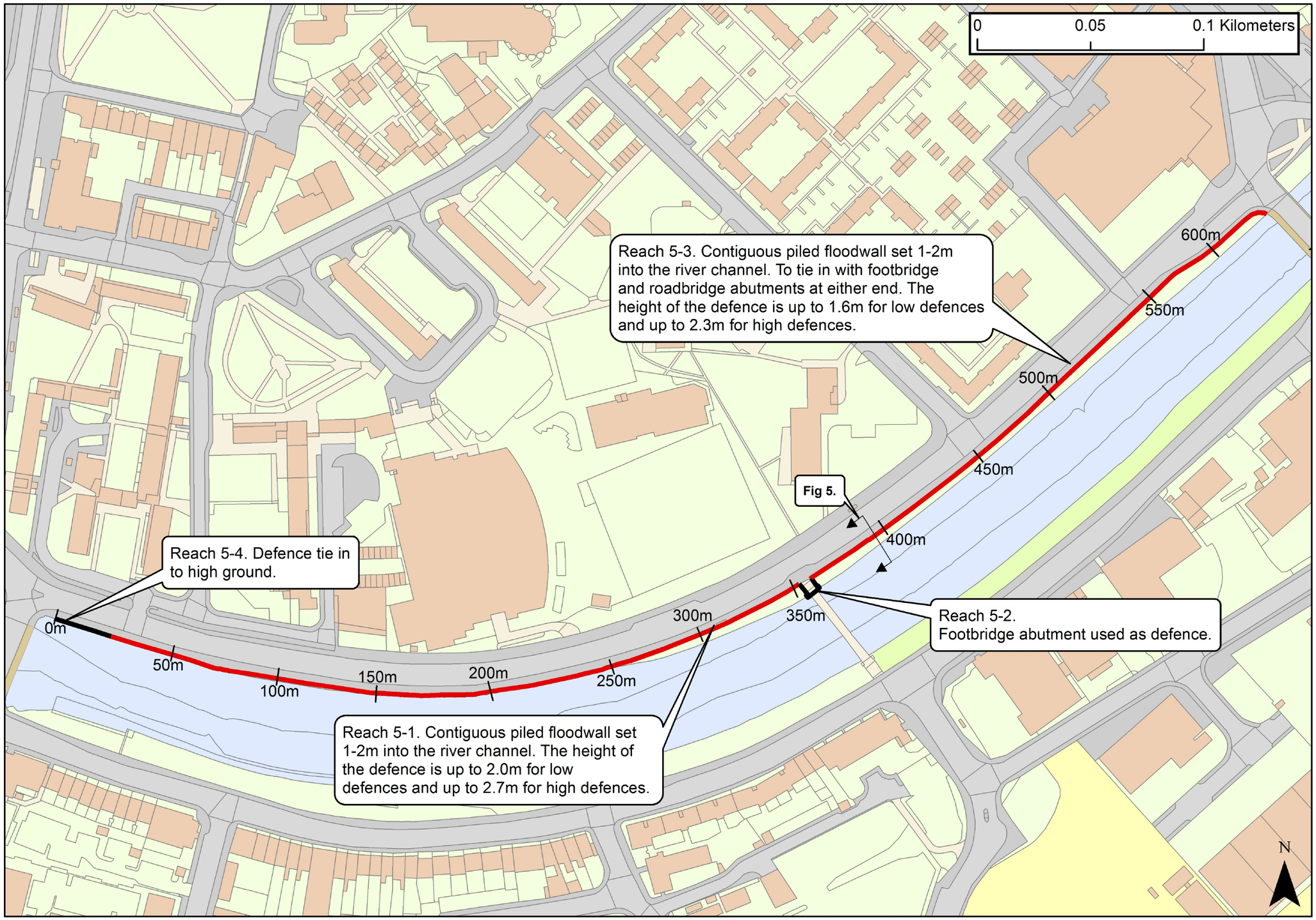

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www.aecom.com

Project Title:

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

BRISTOL CITY COUNCIL

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Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

CLARENCE ROAD DEFENCES

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Drawing No: **Rev:** V1

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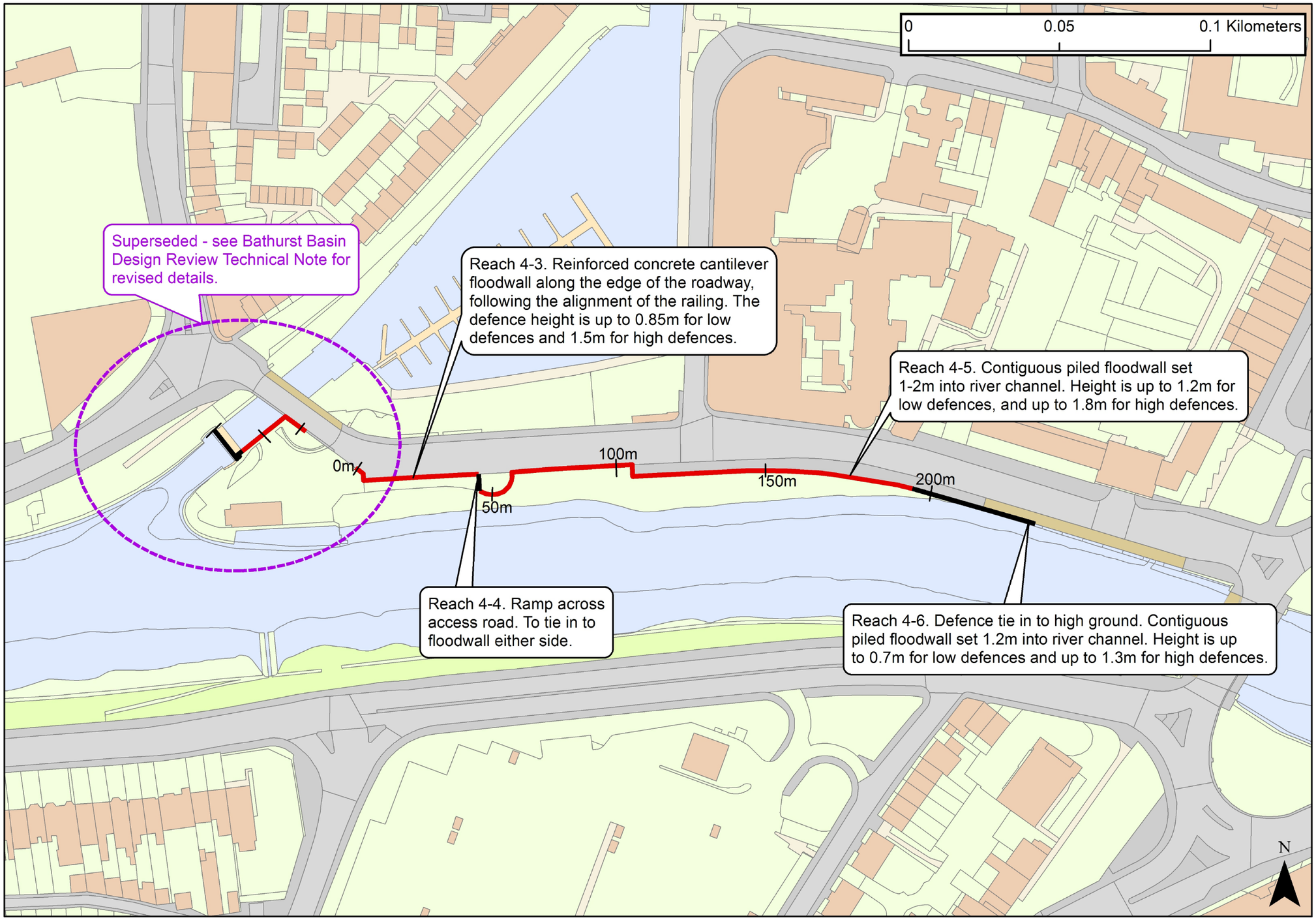

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RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:
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- Design level for high defences (including 200mm freeboard) = 10.30m

- Structure references relate to the contents of the associated table

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Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:
60478613

Drawing Title:
COMMERCIAL ROAD DEFENCES

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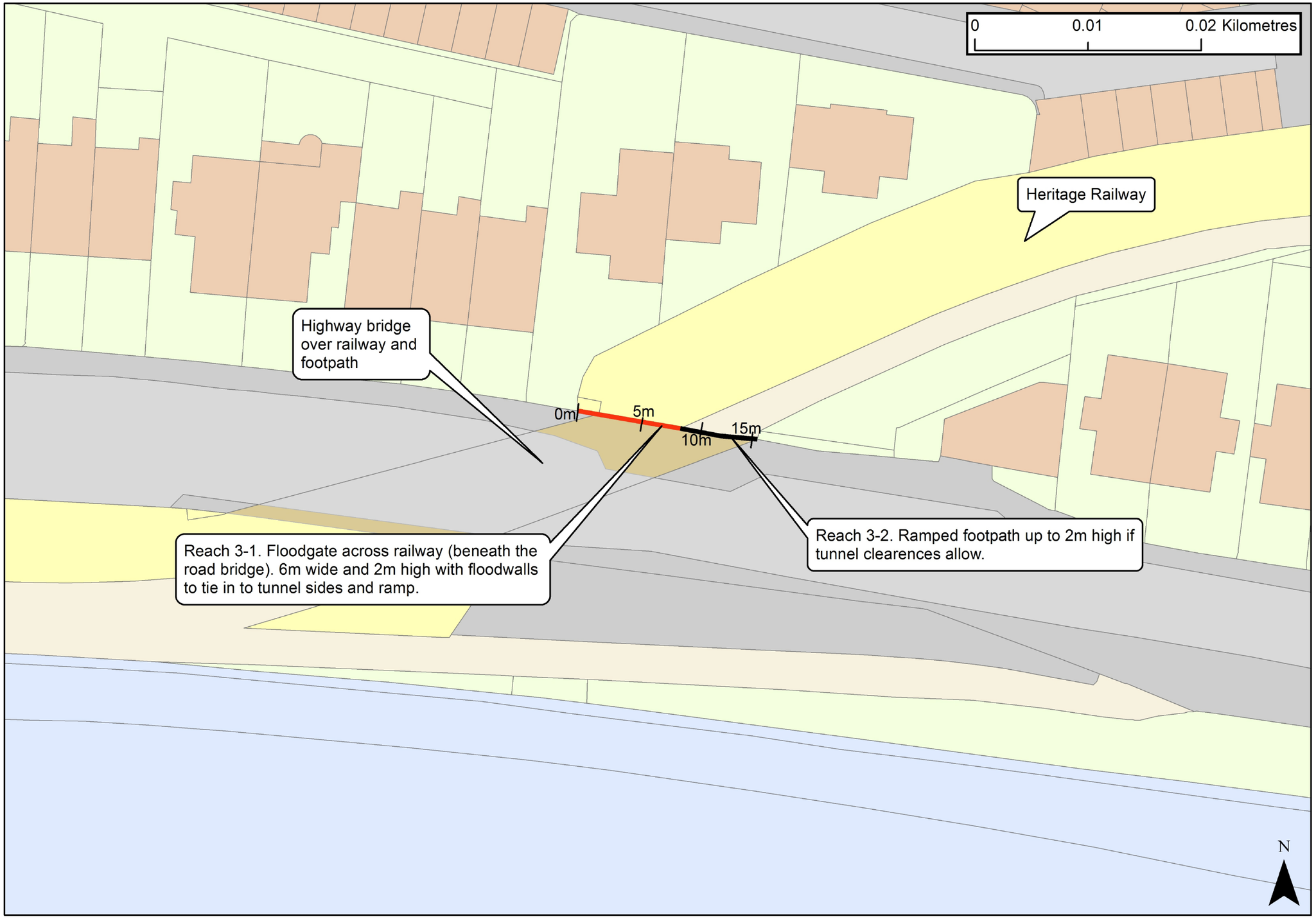

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RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

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- Design level for high defences (including 200mm freeboard) = 10.30m

- Structure references relate to the contents of the associated table

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Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

CUMBERLAND ROAD EAST DEFENCES

Scale at A3: 1:10,000

Drawing No: **Rev:** V1

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BT	JD	JD	31/10/17

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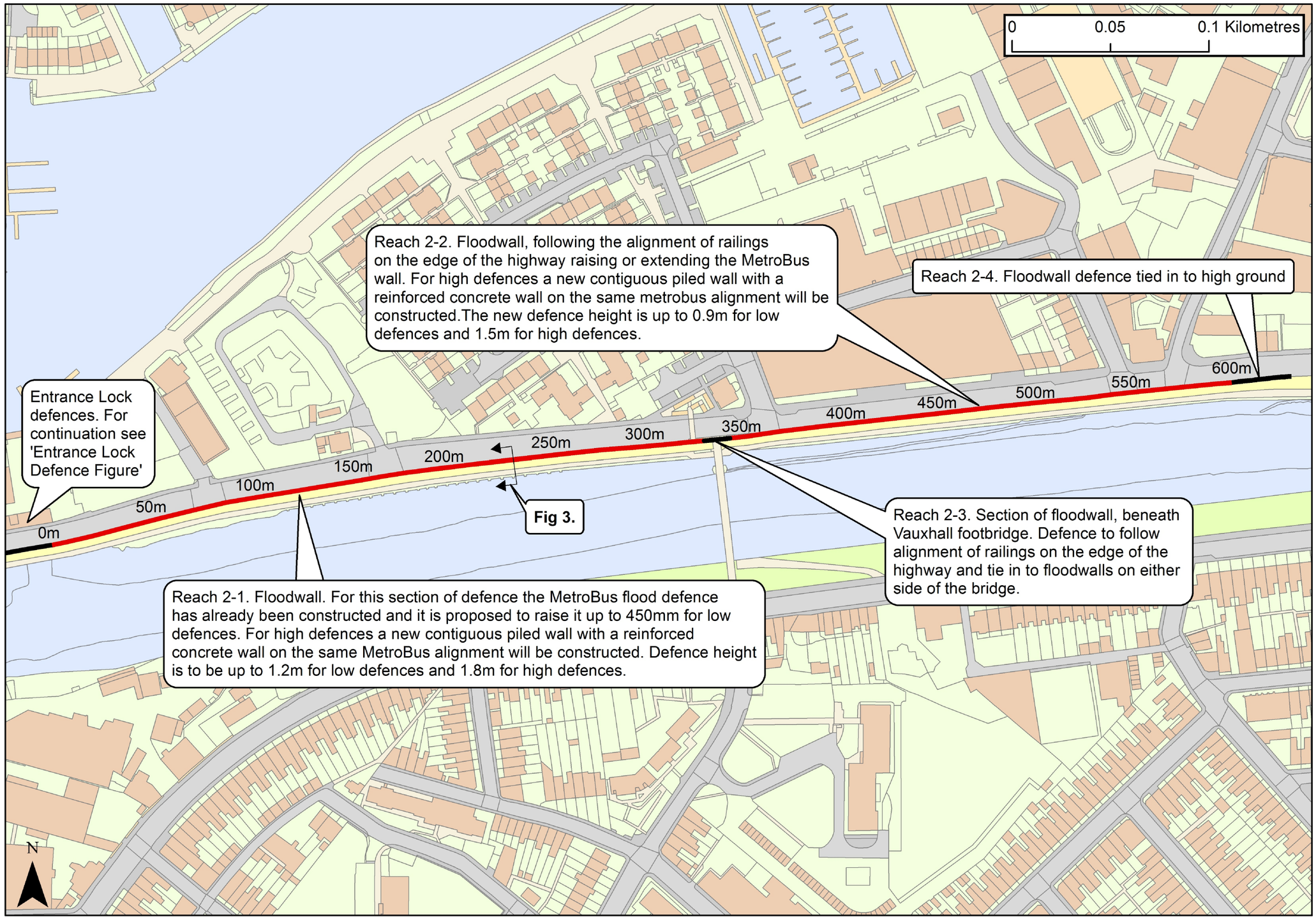

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Project Title:

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

BRISTOL CITY COUNCIL

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- Design level for high defences (including 200mm freeboard) = 10.30m

- Structure references relate to the contents of the associated table

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Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

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Drawing Title:

CUMBERLAND ROAD DEFENCES

Scale at A3: 1:17,000

Drawing No: **Rev:** V1

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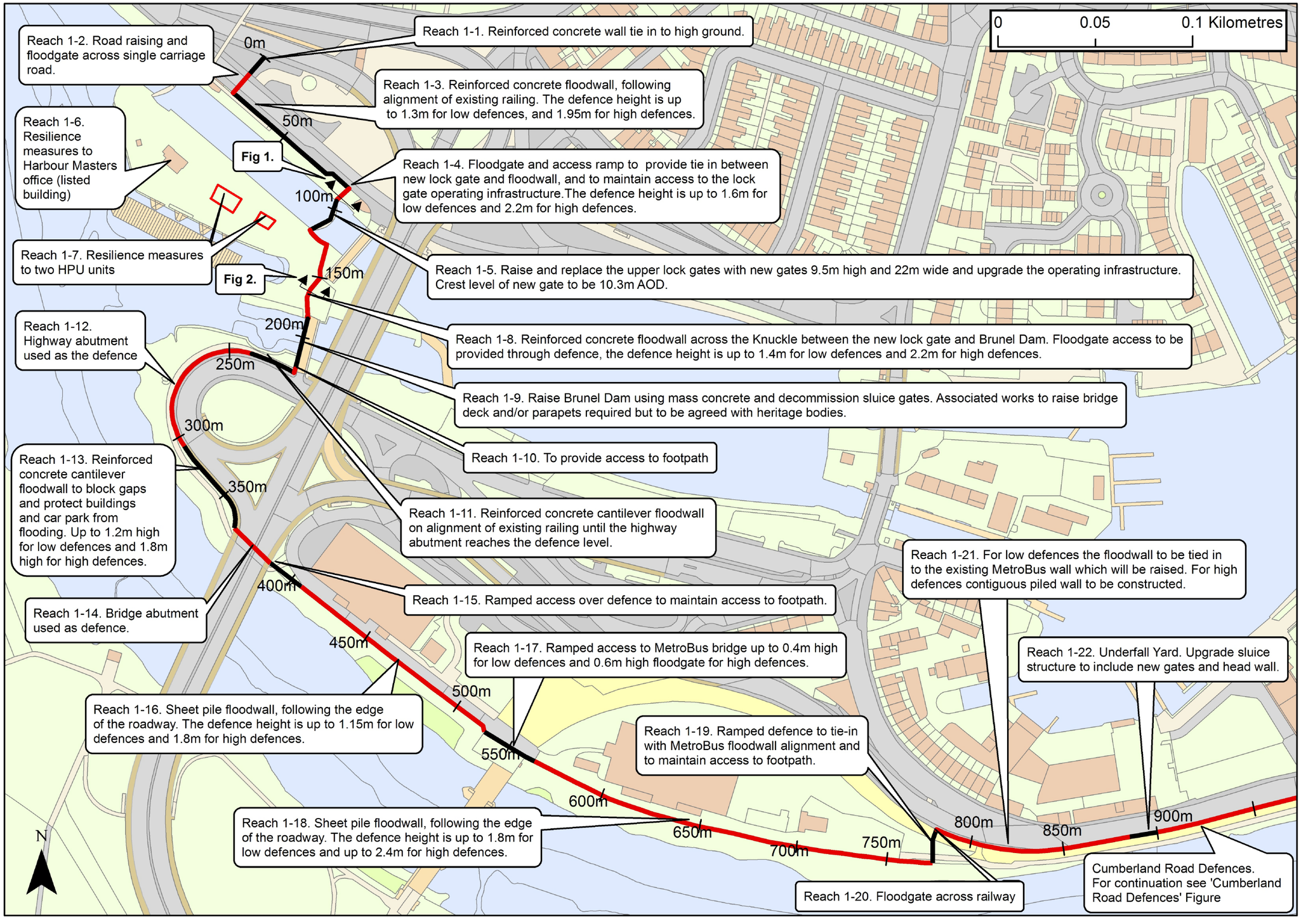

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- Design level for high defences (including 200mm freeboard) = 10.30m

- Structure references relate to the contents of the associated table

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Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

ENTRANCE LOCK DEFENCES

Scale at A3: 1:17,000

Drawing No: **Rev:** V1

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BT	JD	JD	31/10/17

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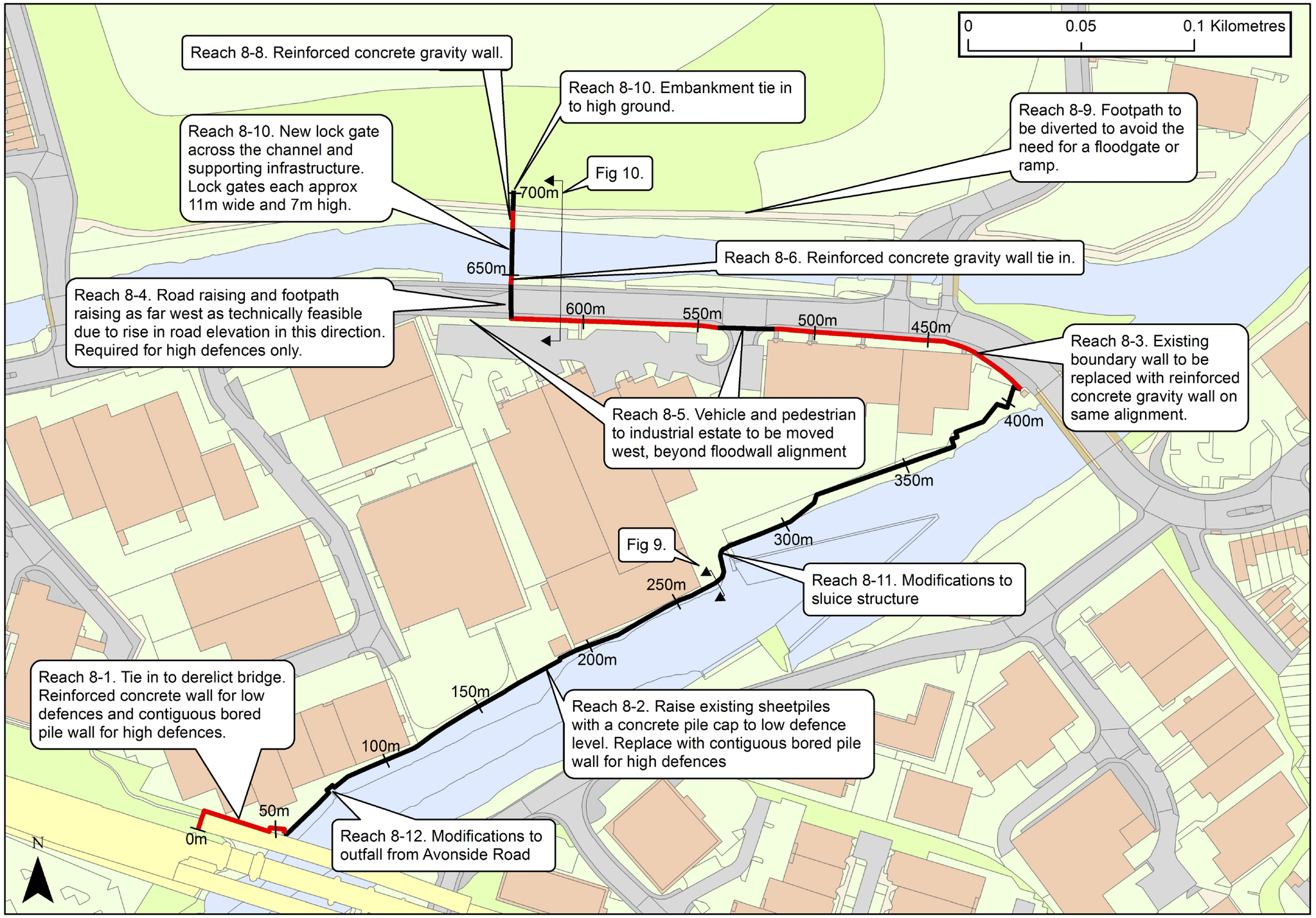

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RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

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- Design level for low defences (including 200mm freeboard) = 9.80m

- Design level for high defences (including 200mm freeboard) = 10.40m

- Structure references relate to the contents of the associated table

- Under no circumstances must this drawing be used for construction

Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

NETHAM DEFENCES

Scale at A3: 1:17,000

Drawing No: **Rev:** V1

Drawn:	Chk'd:	App'd:	Date:
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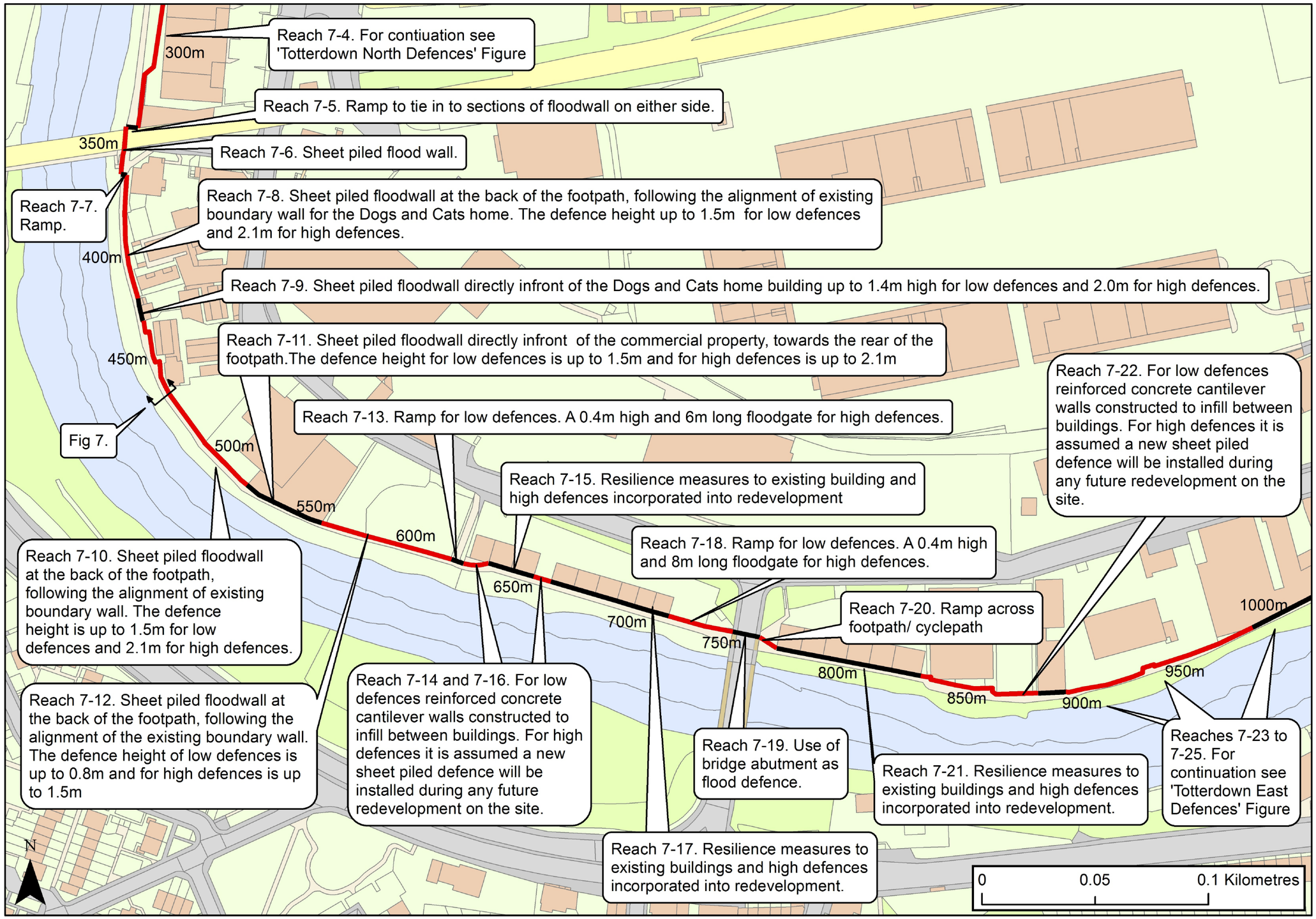

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Project Title:

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- Structure references relate to the contents of the associated table

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Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

TOTTERDOWN CENTRE DEFENCES

Scale at A3: 1:17,000

Drawing No: **Rev:** V1

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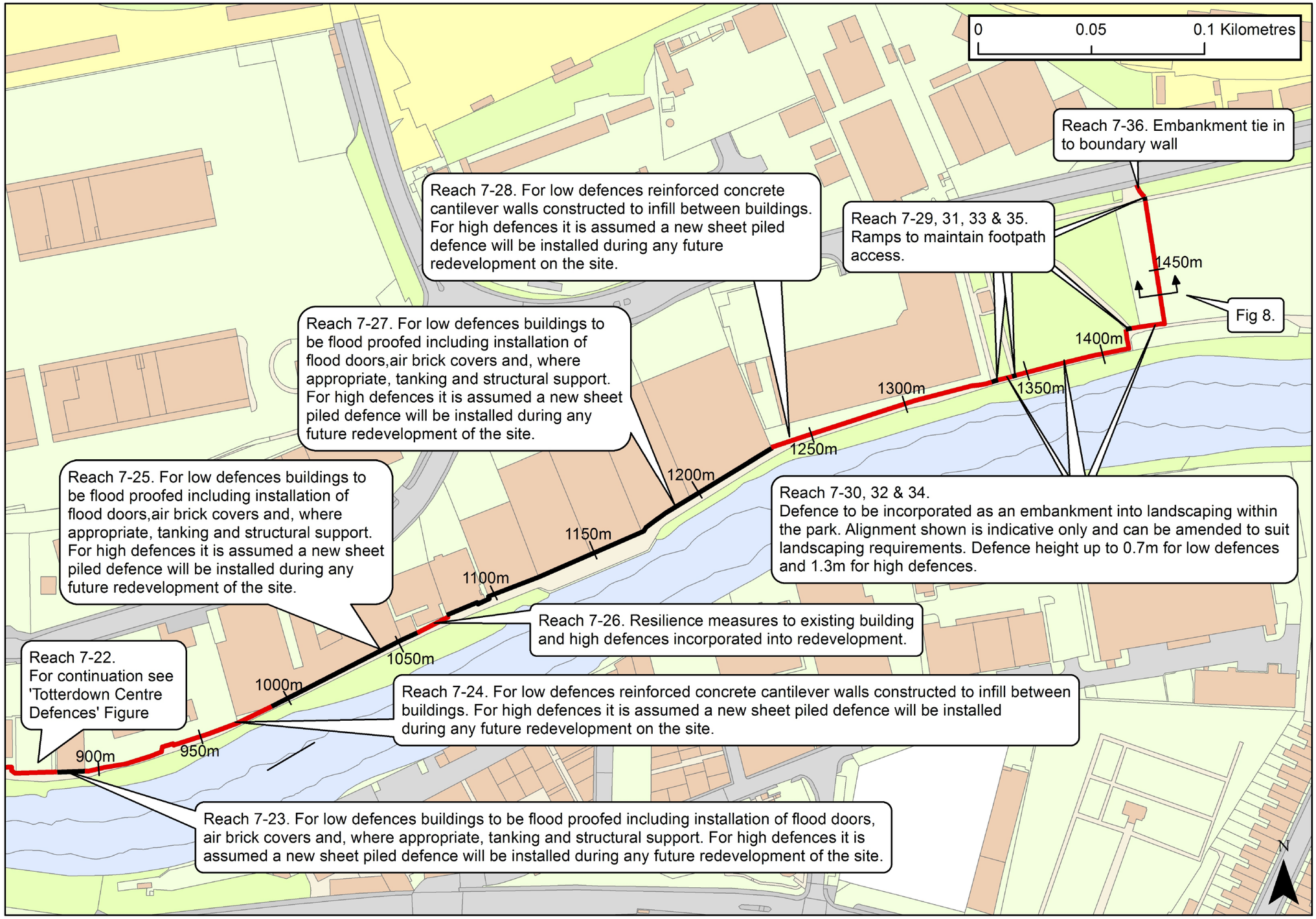

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Project Title:
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- Under no circumstances must this drawing be used for construction

Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:
60478613

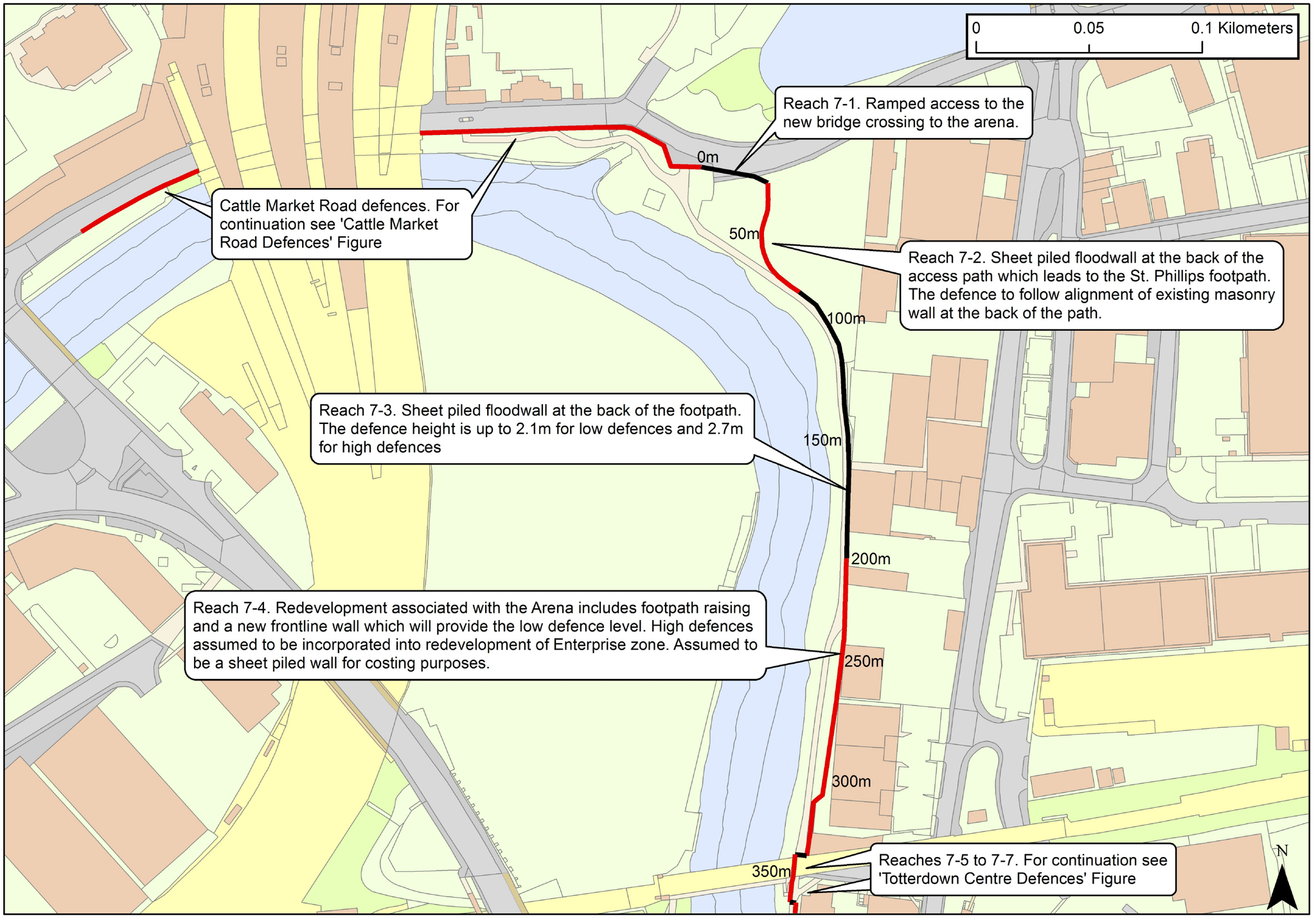
Drawing Title:
TOTTERDOWN EAST DEFENCES

Scale at A3: 1:17,000

Drawing No: **Rev:** V1

Drawn:	Chk'd:	App'd:	Date:
BT	JD	JD	31/10/17

Filename: L:\Water\Projects & Jobs\River Avon TFRMS\20 CAD_GIS\GIS Workspace\Outline design alignments - updated Oct17\Template versions\Totterdown E template.mxd



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Project Title:

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

BRISTOL CITY COUNCIL

- Alignments and defence heights are indicative only and will need to be confirmed during detailed design.

- Defence heights quoted are above existing adjacent ground level.

- Design level for low defences (including 200mm freeboard) = 9.80m

- Design level for high defences (including 200mm freeboard) = 10.40m

- Structure references relate to the contents of the associated table

- Under no circumstances must this drawing be used for construction

Issue/Revision:

	25/01/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

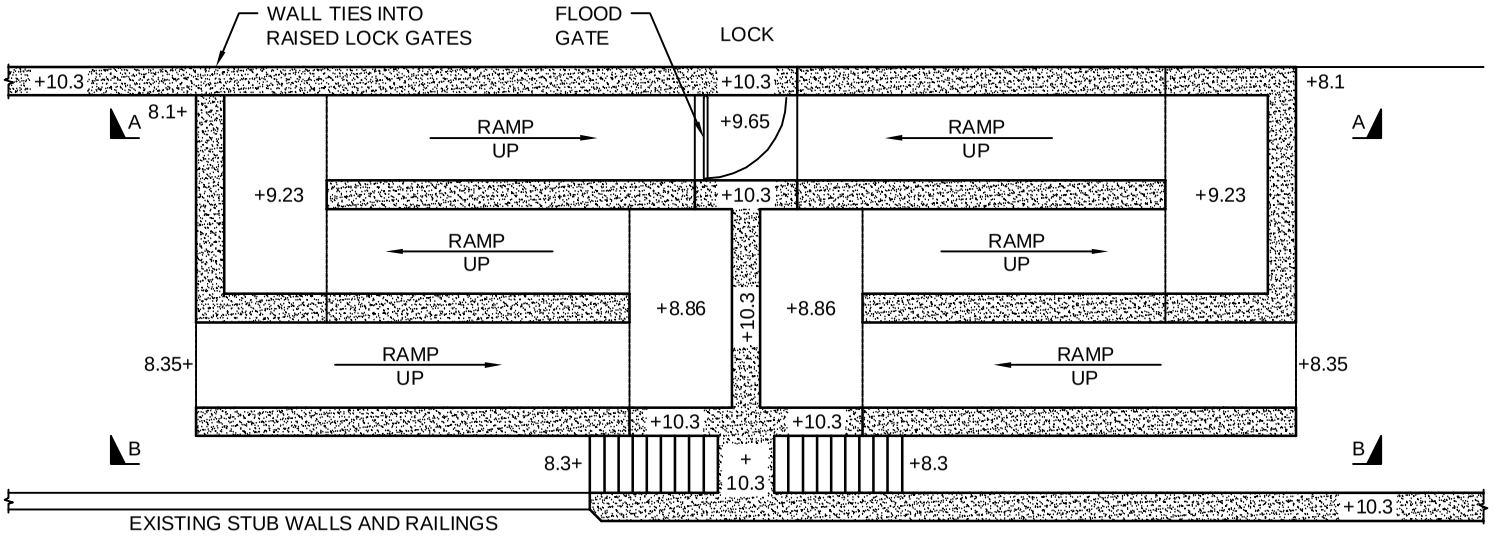
TOTTERDOWN NORTH DEFENCES

Scale at A3: 1:17,000

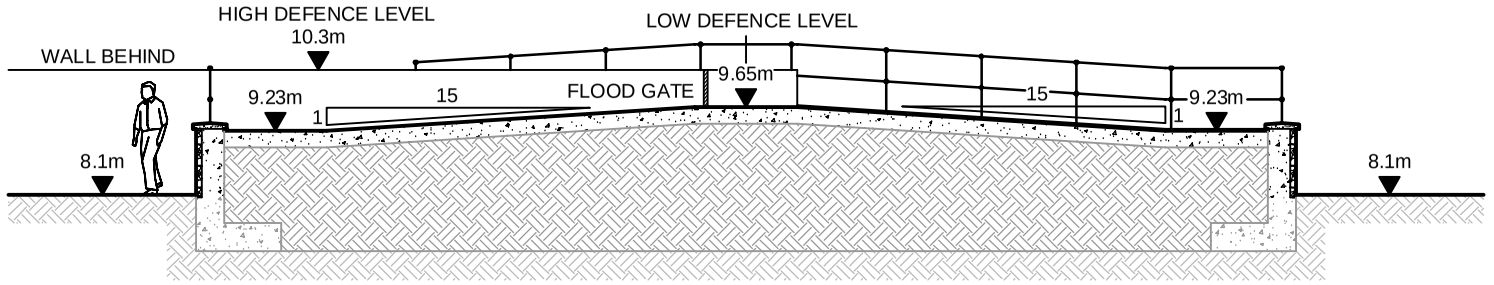
Drawing No: **Rev:** V1

Drawn:	Chk'd:	App'd:	Date:
BT	JD	JD	31/10/17

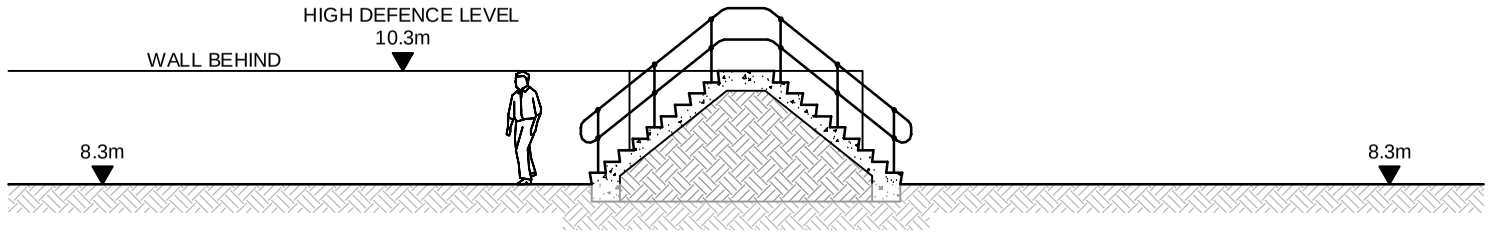
Filename: L:\Water\Projects & Jobs\River Avon TFRMS\20 CAD_GIS\GIS Workspace\Outline design alignments - updated Oct17\Template versions\Totterdown N template.mxd



PLAN



SECTION A-A



SECTION B-B

0 2.5 5.0 m

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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. Walls, ramp and steps to be constructed initially to low defence level. Flood gate installed when steps and walls raised to high defence level.
2. No calculations have been undertaken to confirm the viability of this solution which has been developed based on engineering judgement. All layouts and dimensions are indicative and will need to be determined at detailed design.
3. Levels are referred to Ordnance Datum Newlyn

+8.35 = SPOT LEVEL

AECOM Internal Project No:

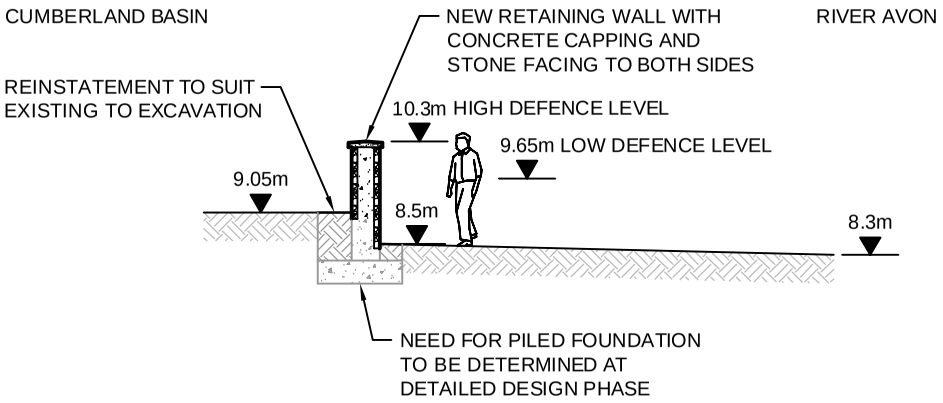
60478613

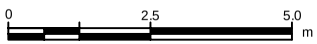
Drawing Title:

Entrance Lock Gate
Access Ramp and Steps

Scale at A4: 1:150

Drawing No:			Rev:
Figure 1			2
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BKW	NJC	JD	Nov. 2016





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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

Notes

1. Wall to be built initially to low defence level but with foundations capable of wall being raised to high defence level. When raising to high defence level glass walls or demountable defences could be used in place of wall as shown.

2. No calculations have been undertaken to confirm the viability of this solution which has been developed based on engineering judgement. All layouts and dimensions are indicative and will need to be determined at detailed design.

3. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

60478613

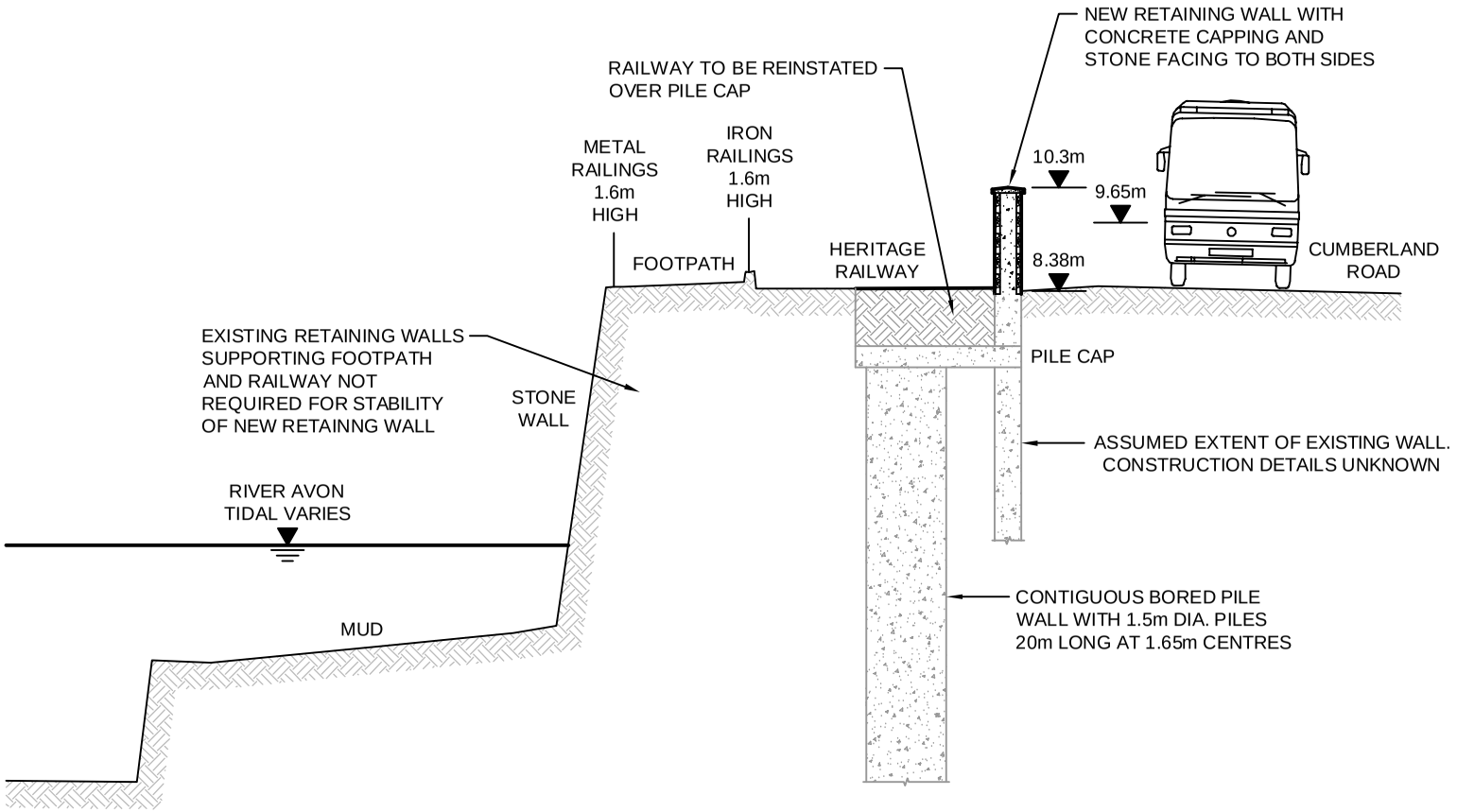
Drawing Title:

Entrance Lock
'The Knuckle'
Cross section

Scale at A4: 1:150

Drawing No:	Rev:
Figure 2	2

Drawn:	Chk'd:	App'd:	Date:
BKW	NJC	JD	Nov. 2016



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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. Existing Metrobus wall to be raised and extended for low defence level (not shown).
2. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

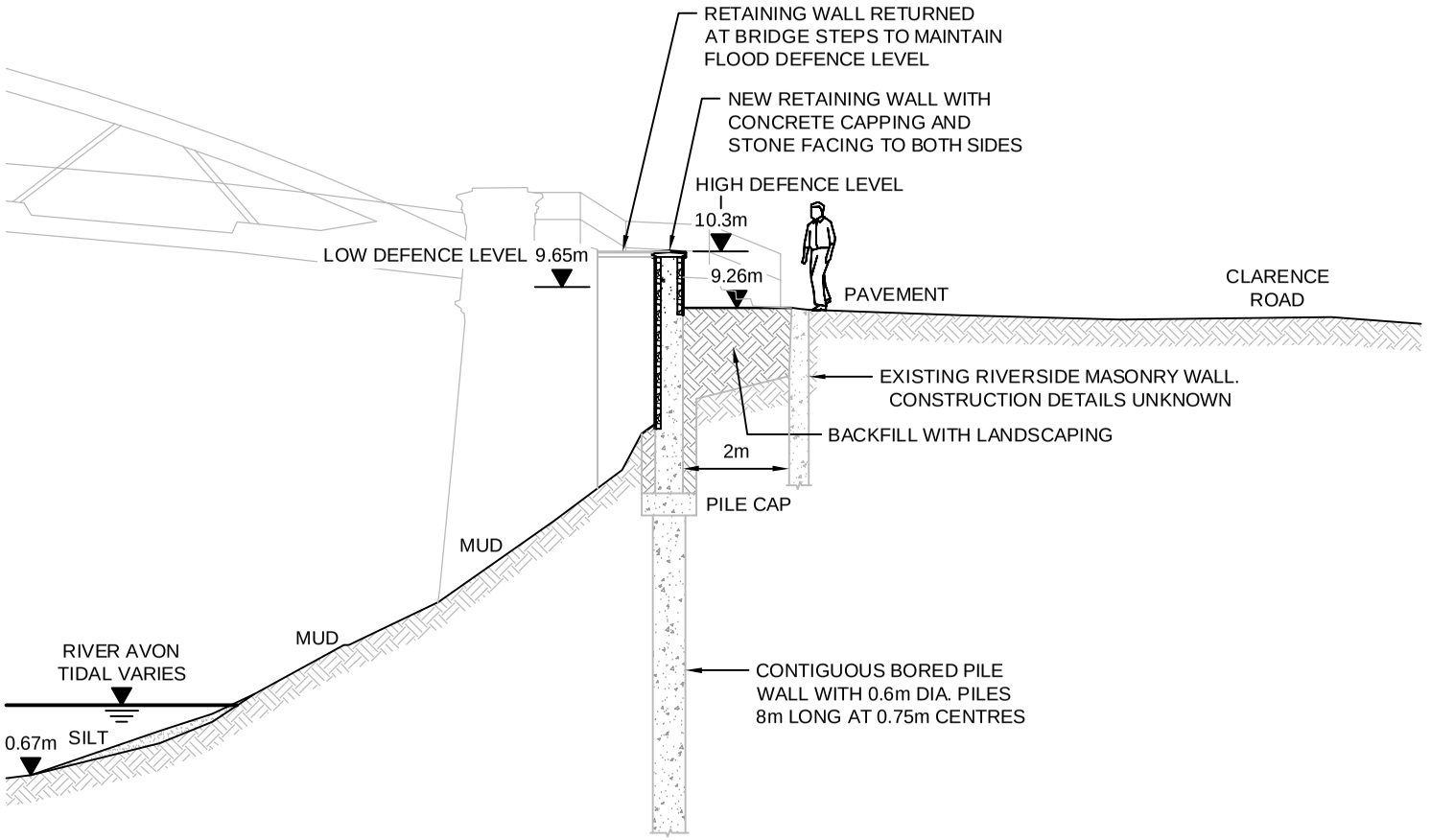
60478613

Drawing Title:

Cumberland Road Cross Section

Scale at A4: 1:150

Drawing No:			Rev:
Figure 3			2
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BKW	NJC	JD	Nov. 2016



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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. Wall to be built initially to low defence level but with foundations capable of wall being raised to high defence level. When raising to high defence level glass walls or demountable defences could be used in place of wall as shown.
2. Ground levels at Clarence Road vary from 10.1m to 7.6m.
3. The maximum wall height above ground level will be 2.05m for low defences and 2.70m for high defences.
4. The average wall height above ground level will be 1.0m for low defences and 1.65m for high defences.
5. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

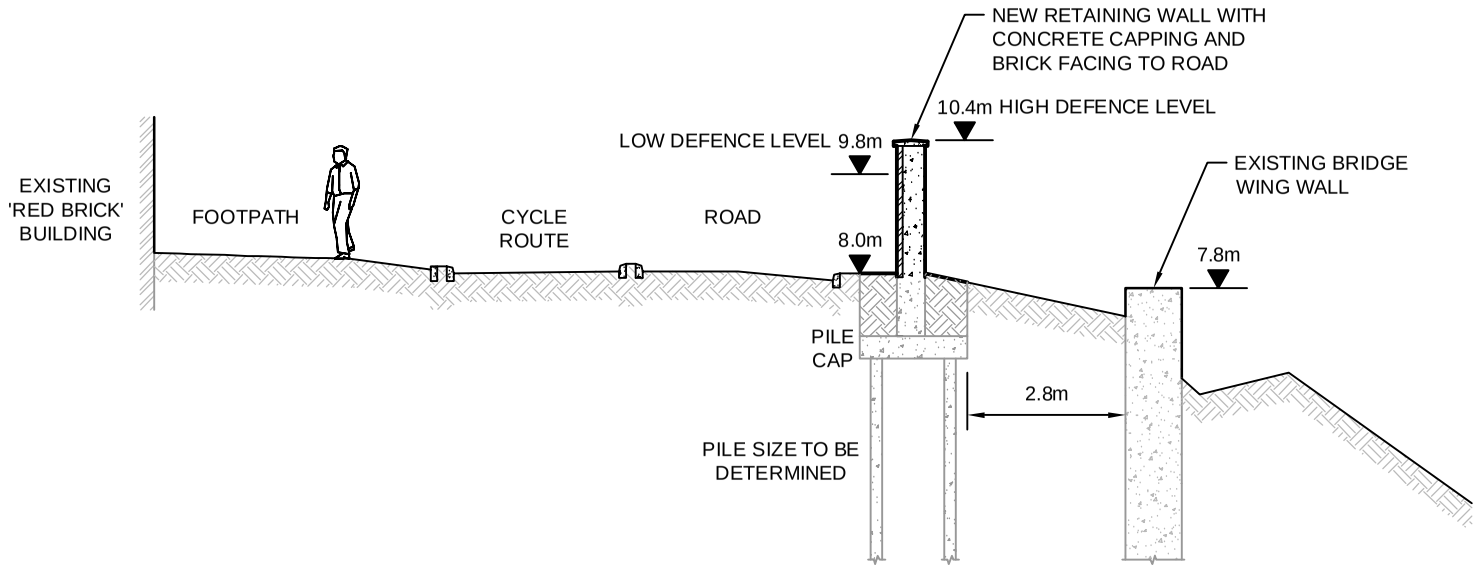
60478613

Drawing Title:

Clarence Road Cross Section

Scale at A4: 1:150

Drawing No:			Rev:
Figure 5			2
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BKW	NJC	JD	Nov. 2016



0 2.5 5.0 m

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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. Wall to be built initially to low defence level but with foundations capable of wall being raised to high defence level. When raising to high defence level glass walls or demountable defences could be used in place of wall as shown.

2. No calculations have been undertaken to confirm the viability of this solution which has been developed based on engineering judgement. All layouts and dimensions are indicative and will need to be determined at detailed design.

3. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

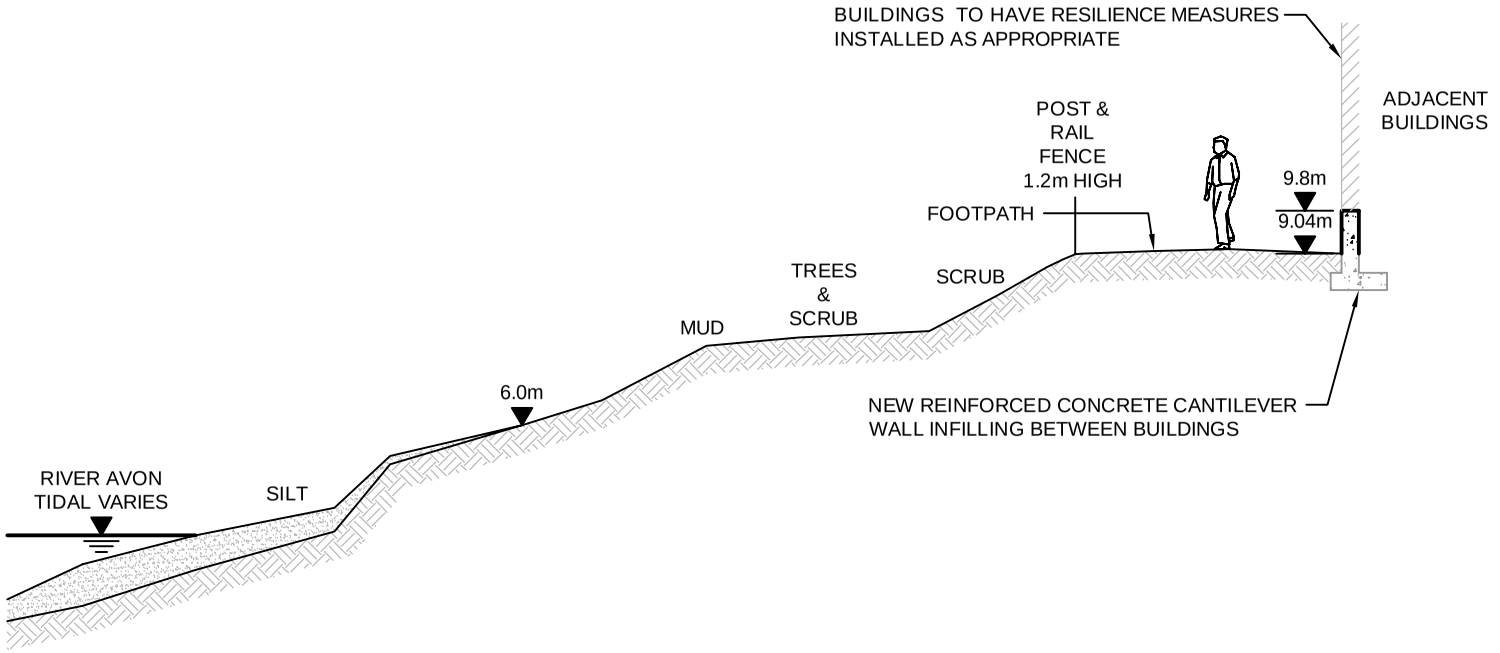
60478613

Drawing Title:

Cattle Market Road (West Side)
Cross Section

Scale at A4: 1:150

Drawing No:			Rev:
Figure 6			2
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BKW	NJC	JD	Nov. 2016



0 2.5 5.0 m

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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. Infill defences to be constructed to low defence level. High defence level to be incorporated into any new development.
2. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

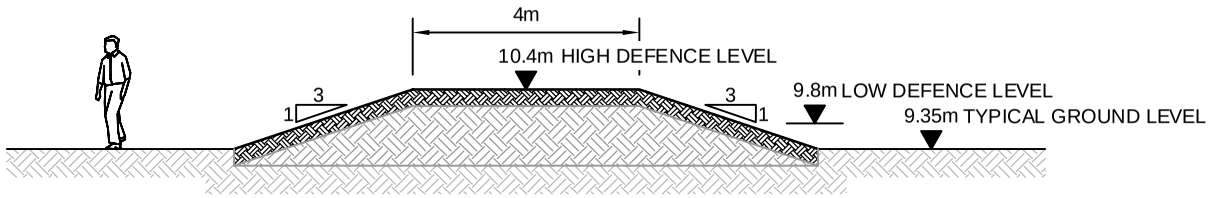
60478613

Drawing Title:

Totterdown Cross Section

Scale at A4: 1:150

Drawing No:			Rev:
Figure 7			2
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BKW	NJC	JD	Nov. 2016



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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

Notes

1. Slopes to be 1 (vertical) in 3 (horizontal) or slacker to suit landscaping within park.
2. Crest width 4m minimum.
3. Embankment to have clay core with topsoil and appropriate seeding on top.
4. Ground levels in the park vary from 10.2m to 9.1m.
5. The maximum height of the embankment will be 0.7m for low defences and 1.3m for high defences.
7. The average height of the embankment will be 0.6m for low defences and 1.2m for high defences.
8. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

60478613

Drawing Title:

Sparke Evans Park St. Philips Embankment Cross Section

Scale at A4: 1:150

Drawing No:	Rev:
Figure 8	2

Drawn:	Chk'd:	App'd:	Date:
BKW	NJC	JD	Nov. 2016

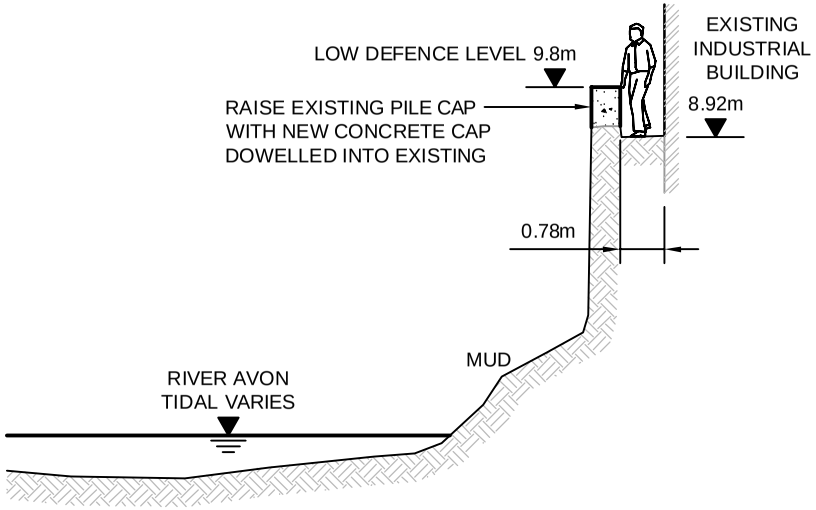


Fig. 9a - Low Defence Level

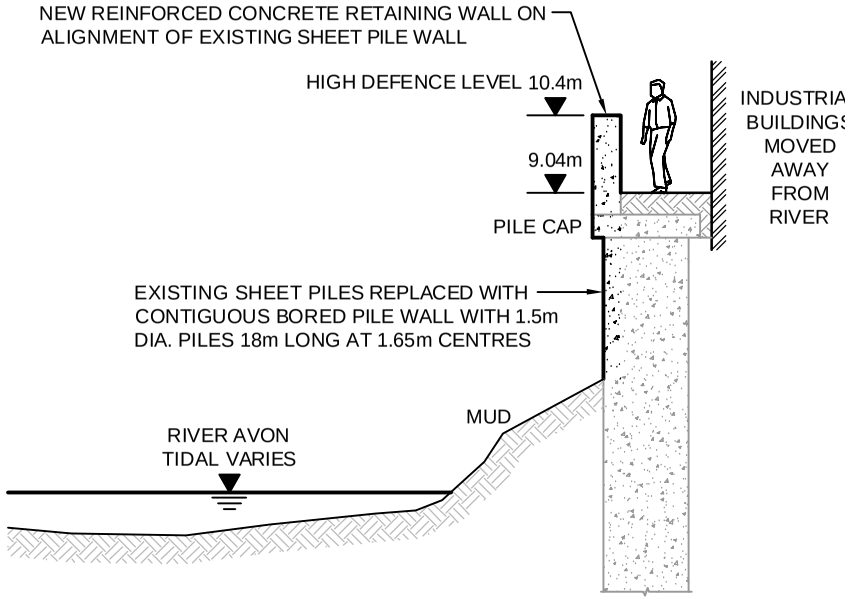
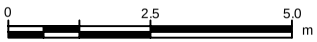


Fig. 9b - High Defence Level



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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

Notes

1. Calculations have been undertaken to confirm the viability of the high defence level solution 9b only. However, in both solutions layouts and dimensions are indicative and will need to be determined at detailed design.
2. It is assumed that the high defences shall be incorporated into any future redevelopment of the adjacent site to avoid conflicts with existing structures.
3. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

60478613

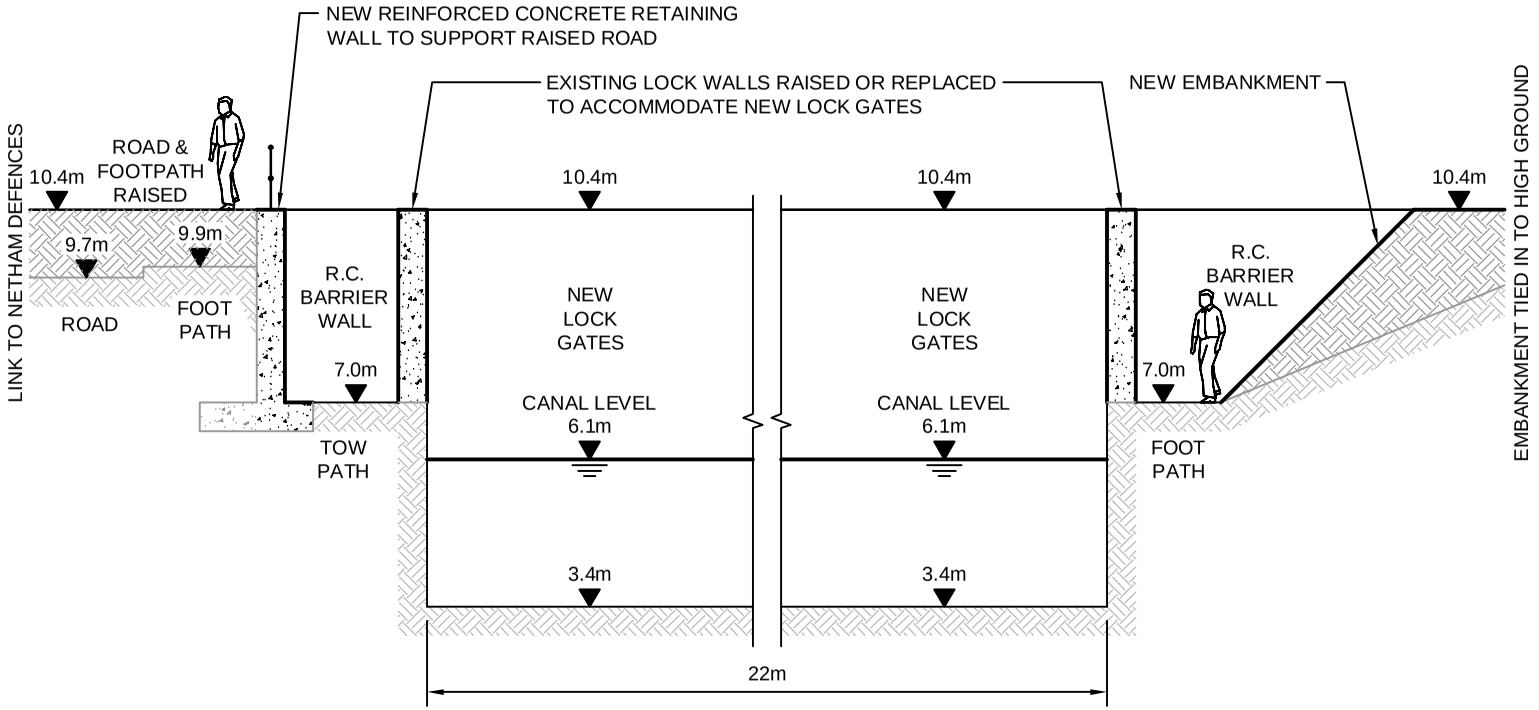
Drawing Title:

Netham Cross Section

Scale at A4: 1:150

Drawing No:	Rev:
Figure 9	2

Drawn:	Chk'd:	App'd:	Date:
BKW	NJC	JD	Nov. 2016



0 2.5 5.0 m

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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. All levels and dimensions are estimated as available topographical survey does not extend to this point.
2. Foundation details not shown.
3. It is assumed that access along lock side tow path and footpath can be severed or diverted so no flood gates or ramps are required.
4. Levels are referred to Ordnance Datum Newlyn

AECOM Internal Project No:

60478613

Drawing Title:

Netham Lock Cross Section

Scale at A4: 1:150

Drawing No:			Rev:
Figure 10			2
Drawn:	**Chk'd:**	**App'd:**	**Date:**
BKW	NJC	JD	Nov. 2016

APPENDIX D: STRUCTURAL ANALYSES

Date: 14th November 2016

To: Nancy Collins

From: Vasilis Stamatiou

Subject: **Bristol Avon Tidal Defence Strategy**
Concept Design of Defence Walls
Retaining Wall Geotechnical Design

Ref:

Revision History

Rev	Date	Remark
0	14/11/16	Draft Issue

Contents

Introduction

AECOM are nearing the end of a strategy to protect the city of Bristol from tidal inundation from the river Avon. Large scale options (eg barriers and walls) have been considered for a number of epochs and the preferred option is to construct tidal defence walls where ground levels are too low. These walls will be designed to be raised to the full 2115 1 in 200 year defence level but heights may be raised incrementally to take into account the potential inaccuracies of the climate change scenarios.

This technical presents a concept design of three wall types to assist with the costing of the strategy. The concept design considers only the maximum height that the wall would be built to.

Wall design has been carried for three sites, i.e. Cumberland Road, Clarence Road & Netham. These sites were selected as they are considered to have the biggest impact on the cost of the scheme.

Available Information

The available information consists of the following:

- Avon Tidal Defence Strategy - Ground Investigation Review

  This document summarizes the available ground investigation information and proposes design parameters for each of the three sites.

- Plan showing the extent of the proposed wall for each location (pdf file)
- Sketches of required alignment including the defence height (pdf file)
- Surveyed cross sections (dwg file)
- Elevation of ground levels taken from Lidar & Lidar data (Excel file)

Ground Conditions & Soil Parameters

The available ground investigation information has been previously reviewed and findings have been summarized in 'Avon Tidal Defence Strategy - Ground Investigation Review'. Previous ground investigation information and reports (both factual and interpretive), produced by others, but made available by Bristol City Council (the Client) were reviewed. Since geotechnical information is not available for all parts of the scheme the information has been supplemented with historical borehole information obtained from the British Geological Survey's (BGS) 'on line' database.

Section 4 of the 'Avon Tidal Defence Strategy - Ground Investigation Review' report presents Characteristic Values/Design Parameters for each of the three sites. These are reproduced below:

Table 1a: Cumberland Road (Section: Avon 01_0919) - Characteristic Values/Design Parameters

Unit	SPT N Values	N60 Value	Hand Penetrometer cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ')°	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Youngs Modulus (GPa)
Made Ground	0, >70 & 7	0, 79 & 8	-	-	-	30	0	-	1.9	-
Tidal Flat Deposits - CLAY	2	2	0, 7, 16,25,32, 38, 55	10	TBC	TBC	TBC	-	-	-
River Terrace Deposits – SAND & GRAVEL	20 & 181	23 & 204	-	-	-	33	0	-	2.0	-
Completely Weathered Bedrock - CLAY (MMG)	57	64	-	>300	TBC	TBC	TBC	-	-	-
Bedrock - SANDSTONE (MMG)	-	-	-	-	-	-	-	0.5 increasing to 26	2.31	-
Bedrock – CONGLOMERATE (MMG)	-	-	-	-	-	-	-	TBC	TBC	-

Table 1b: Clarence Road (Section: Avon 01_3157) - Characteristic Values/Design Parameters

Unit	SPT N Values	N60 Value	HP Cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ')°	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Young's Modulus (GPa)
River Wall/Retained material (unknown composition)	-	-	-	-	-	-	-	-	-	-
Superficial Deposit – SILT.	-	-	-	-	-	-	-	-	-	-
Completely Weathered Bedrock - CLAY (MMG)	-	-	-	-	-	-	-	-		-
Bedrock - MUDSTONE (MMG)	-	-	-	-	-	-	-	1-3	2.37	0.1

Table 1c: Netham (Section: Avon 01_6270) - Characteristic Values/Design Parameters

Unit	SPT N Values	N60 Value	HP Cu (kPa)	cu determined from SPT (kPa)	cu determined from lab (kPa)	Effective friction angle (φ')°	Cohesion c' (kPa)	UCS strength determined from the lab (MPa)	Bulk density (Mg/m3)	Young's Modulus (GPa)	Plasticity Index (%)
Made Ground	1-42	-	25	11	22	26	0	-	2	-	26
Tidal Flat Deposit - CLAY	1-5	-	-	10	28	26	0	-	1.9	-	27
River Terrace Deposit – SAND & GRAVEL	22	-	-	-	-	32	0	-	2	-	-
Bedrock – SANDSTONE (MMG)	-	-	-	-	-	-	-	16-52	2.4	-	-
Bedrock – MUDSTONE (CM)	-		-	-	-	-	-	3.5	2.3	0.19	23

The tables above do not include all the parameters required for the analysis of the proposed walls. This is more evident at Clarence Road where almost no information at all is available. As such, and in order to carry out the analysis required to enable sizing of the walls as part of the concept design, it is necessary to make some assumptions based on the information that is available to date. The following tables 2a, 2b & 2c present the soil profile and parameters adopted for design (all levels to mODN).

Table 2a: Cumberland Road – Soil Properties Adopted for Design

Layer	Depth	Density (kN/m^3)	c_u (kPa)	ϕ' (^{o})	c' (kPa)	E (kPa)
Made Ground	0.0m-6.0m	19.0	-	30	-	5,000
Tidal Flood Deposits	6.0m-12.0m	17.0	10	25	-	$300*c_u$
River Terrace Deposits	12.0m-15.0m	20.0	-	33	-	20,000
Weathered Rock/Rock	below 15.0m	21.0	250+50*z	-	-	$500*c_u$

Table 2b: Clarence Road – Soil Properties Adopted for Design

Layer	Depth	Density (kN/m^3)	c_u (kPa)	ϕ' (^{o})	c' (kPa)	E (kPa)
Fill Material	0.0m-3.5m	19.0	-	30	-	5,000
Superficial Deposits (Fill)	3.5m-4.5m	17.0	10	25	-	$300*c_u$
Weathered Rock/Rock	below 4.5m	21.0	250+50*z	-	-	$500*c_u$

Table 2c: Netham Road – Soil Properties Adopted for Design

Layer	Depth	Density (kN/m^3)	c_u (kPa)	ϕ' (^{o})	c' (kPa)	E (kPa)
Made Ground	0.0m-1.5m	19.0	20	26	-	$300*c_u$
Tidal Flood Deposits	1.5m-10.5m	17.0	10	26	-	$300*c_u$
River Terrace Deposits	10.5m-12.0m	20.0	-	33	-	20,000
Weathered Rock/Rock	below 12.0m	21.0	250+50*z	-	-	$500*c_u$

*where z is the depth below the top of the relevant layer

It is important to note that the soil profile and soil parameters are our best estimate based on the limited available information and they would need to be reviewed and updated in light of any additional information that becomes available. Furthermore the adopted soil profile is assumed to be representative of the whole extent of the retaining structure at each location and any variation in the soil profile or parameters is ignored at this stage.

Selection of Retaining Structure

The selection of a suitable retaining structure depends mainly on the retaining height, the ground conditions, constructability, performance requirements (e.g. allowable movement). The presence of rock means that driven piles (sheet piles, tubular piles etc.) would be very difficult and costly to install. Furthermore the design life of 100 years means that corrosion allowance would be significant, resulting in significantly thicker sections if a steel structure is selected. Cathodic protection, while feasible, would be a costly option. The retaining height is significant and the available space is limited therefore a gravity wall is not a preferred option either. The limited available space also means that an anchored wall is not feasible. Bored piles however can be installed to the required depth even when rock is encountered and do not require any significant excavation or filling as part of the construction with the exception of any excavation for the construction of the capping beam. Concrete bored piles are also stiffer than the steel equivalent and therefore defections will be smaller.

Due to access restrictions it is anticipated at some of the construction would need to be carried out from river side, e.g. from a barge. However bored piles can be also constructed from a barge if required.

Bored piles therefore have been selected as the most suitable option for the construction of these retaining structures. It is assumed that there will 150mm gap between adjacent piles.

Methodology

The calculations have been carried out using the commercially available software WALLAP version 6.6 developed by Geosolve. The analyses include a serviceability limit state analysis, ultimate limit state analyses. The ultimate limit state analyses consist of DA1-C1 and DA1-C2 as set out in Eurocode 7 and the corresponding UK national annex. The table below presents the partial factors adopted for each of the analyses.

Table 3: Partial Factors

Parameter	SLS	DA1-C1	DA1-C2
Permanent Action Unfavourable	1.0	1.35	1.0
Permanent Action Favourable	1.0	1.0	1.0
Variable Action Unfavourable	1.0	1.5	1.3
Variable Action Favourable	1.0	0	0
Angle of Internal Friction (tan φ)	1.0	1.0	1.25
Effective Cohesion (c')	1.0	1.0	1.40
Undrained Shear Strength (c_u)	1.0	1.0	1.40
Weight Density (unit weight)	1.0	1.0	1.0

Any existing services and utilities as well as existing retaining structures have not been taken into account in the analysis which is a conservative assumption.

Wall Geometry

The retaining height of the required walls and ground levels assumed for the design are based on the pdf files 'sketches of required alignment including the defence height'. It has been assumed that the river channel shape will not alter significantly during the design life. In order to model the walls in WALLAP it is necessary to simplify the geometry of the ground. The adopted wall geometry and ground levels and soil profile are shown in Figures 1, 2 & 3 below (all levels to mODN).

Figure 1. Wall Geometry - Cumberland Road

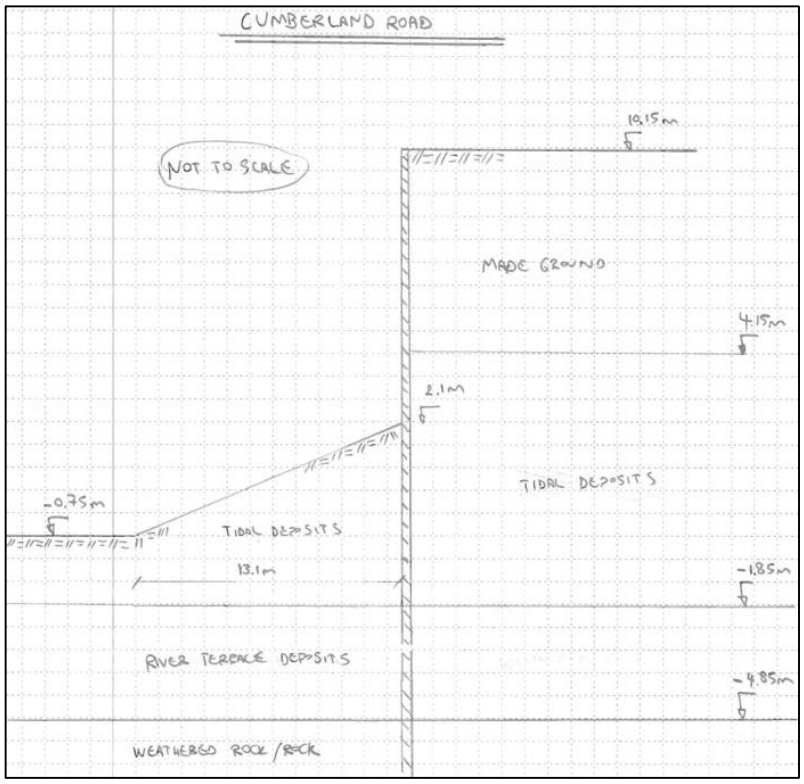


Figure 2. Wall Geometry - Clarence Road

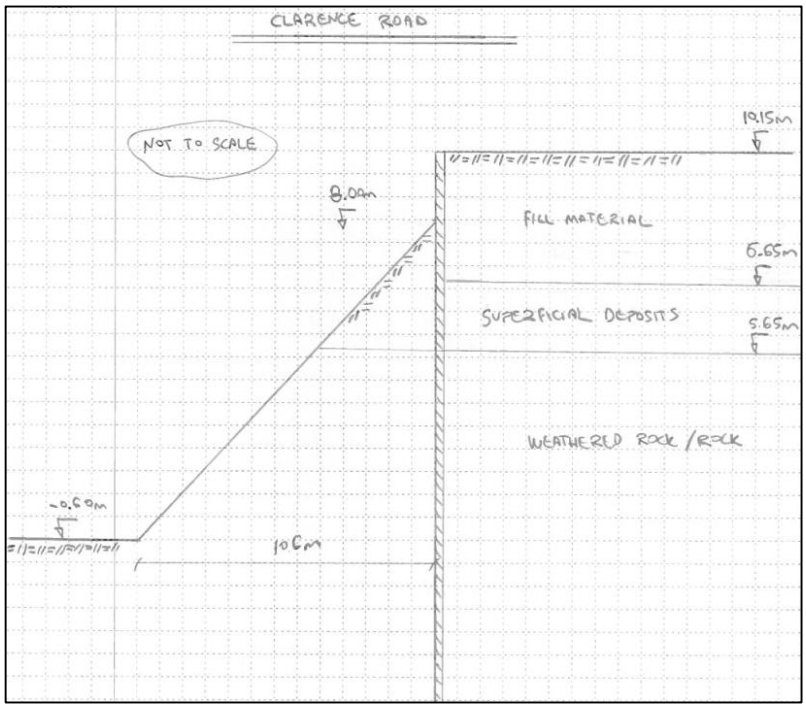
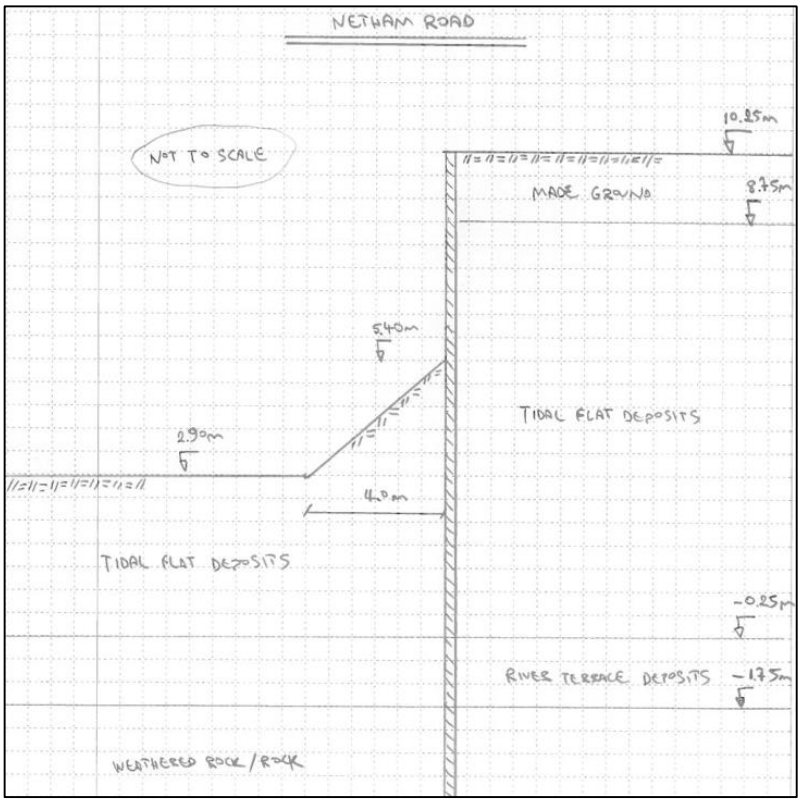


Figure 3. Wall Geometry - Netham Road



Water Levels & Loading

The water level on river side could reach the top of the wall, e.g. in case of a flood event. However for the design of the wall, the critical case is when the water is low; however the flood case (high water) was also analysed. In the low water case it is assumed that the water on the active (land) side of the wall is 1m higher than the water in the passive (river) side. Due to the presence of a 150mm gap between the piles it is considered that it is unlikely that the lag will be greater than 1m. However at Netham Road the wall retains a cohesive layer (i.e. Tidal Flat Deposits) that is relatively impermeable and for this wall the water level on the active side is assumed at the top of this layer (conservative assumption). The following table presents the adopted water levels (all levels to mODN). These were mainly based on the pdf file 'sketches of required alignment including the defence height'.

Table 4: Water Levels

Section	Initial	Design	Flood
Cumberland Road	Passive: 3.00m Active: 3.00m	Passive: 3.00m Active: 4.00m	Passive: 10.15 Active: 4.00m
Clarence Road	Passive: 1.90m Active: 1.90m	Passive: 1.90m Active: 2.90m	Passive: 10.15m Active: 2.90m
Netham Road	Passive: 3.60m Active: 3.60m	Passive: 3.60m Active: 8.75m	Passive: 10.25m Active: 8.75m

The adopted loadings were based on the current or proposed use of the area behind the wall. Where the wall is supporting a highway a surcharge loading equal to 20kPa has been assumed. Loading due to the presence of a footpath has been assumed equal to 10kPa. This loading also accounts for the occasional maintenance traffic. The table below summarises the adopted loadings.

Table 4: Partial Factors

Section	Distance from wall	Load
Cumberland Road	0.00m 7.50m	10kPa 20kPa
Clarence Road	0.00m	10kPa
Netham Road	0.00m	10kPa

Wall Analysis & Results

The wall analysis was carried out using WALLAP and results of the analysis are summarised in the table below.

Table 4: Partial Factors

Section	Pile Diameter	Pile Toe Level	SLS Deflection	SLS Bending	ULS1 Bending	ULS2 Bending
Cumberland Road	1,500mm	-13.00mODN	35mm	8,292kNm/m	8,291kNm/m	6,659kNm/m
Clarence Road	600mm	0.00mODN	4mm	202kNm/m	202kNm/m	204kNm/m
Netham Road	1,500mm	-9.00mODN	16mm	6,268kNm/m	6,279kNm/m	5,206kNm/m

Please note the following:

- The deflections reported in the table above are post construction deflections from the WALLAP analysis, multiplied by 0.7. This is because WALLAP over-estimates displacements. Displacements obtained by other more accurate methods (e.g. PLAXIS software) are typically in the order of half to ⅔rds of the WALLAP values.
- Spacing between piles is 150mm, therefore the c/c spacing of the piles is the diameter + 150mm.
- All bending moments are per m run. To obtain bending moments per pile these values need to multiplied by a value equal to the pile diameter + 150mm
- The pile toe level is dictated by the WALLAP analyses so that the overall FoS is >1.0 at all construction stages and/or loading combinations.

Detailed output from each of the analyses is included in Annex B, Annex C & Annex D (for Cumberland Road, Clarence Road and Netham Road respectively).

Conclusions & Recommendations

A retaining wall analysis was carried out as part of the concept design to assist with costing of the Bristol Tidal Defence Strategy. The results of the analysis suggest the following:

- Little ground investigation data is available and most of the parameters are best estimates from data in areas adjacent to the proposed location of the walls or typical values for the anticipated soil/rock layers.
- The level at which rock is encountered is critical to the design and at the Clarence Road area where trial pits suggest the rock is encountered at shallow depth, the required pile diameter is significantly smaller. This section however also has a smaller retained height.
- The reported deflections are relatively small and do not dictate the design.
- The structural design will confirm or otherwise the adequacy of the proposed piles. If larger piles are required, the analysis will need to be updated and it is anticipated that the resulting bending moments will be higher and the deflections smaller. The difference with the current analysis however will be small.
- Due to the lack of sufficient ground investigation information it is important to emphasise that this analysis is only appropriate for use in the concept design stage, e.g. to assist with costing. Additional ground information will be required at a later stage of the design.

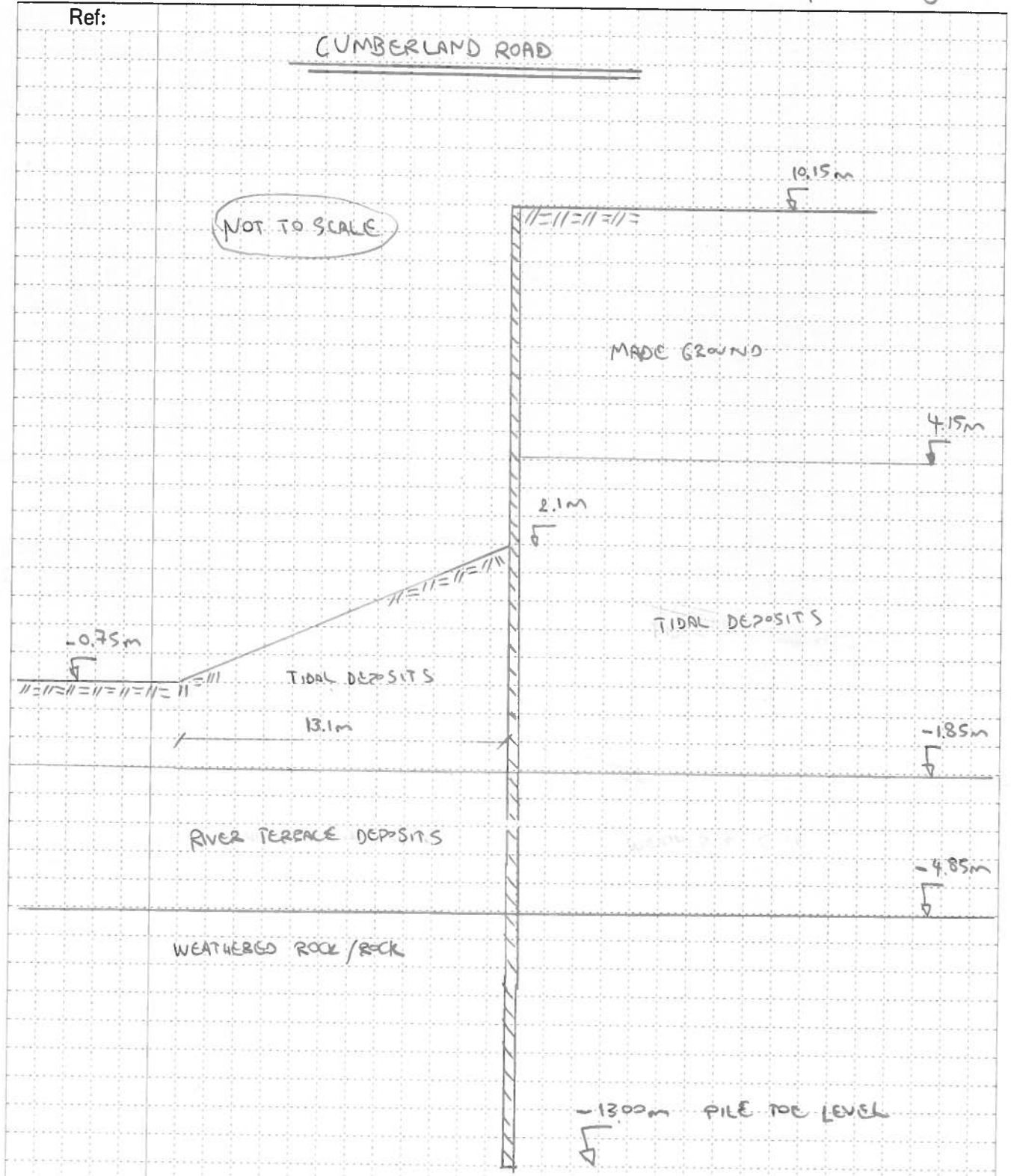
Annex A – Sketches of Proposed Walls

CALCULATION SHEET

AECOM

Project Title:	BRISTOL AVON TIDAL DEFENCE STRATEGY	Job No:	60478613
Subject:	RETAINING WALL CONCEPT DESIGN	Ref:	
		Date:	14/11/2016
Made by:	VST	Checked by:	Sheet No: 1 of: 3

Ref:



CALCULATION SHEET

AECOM

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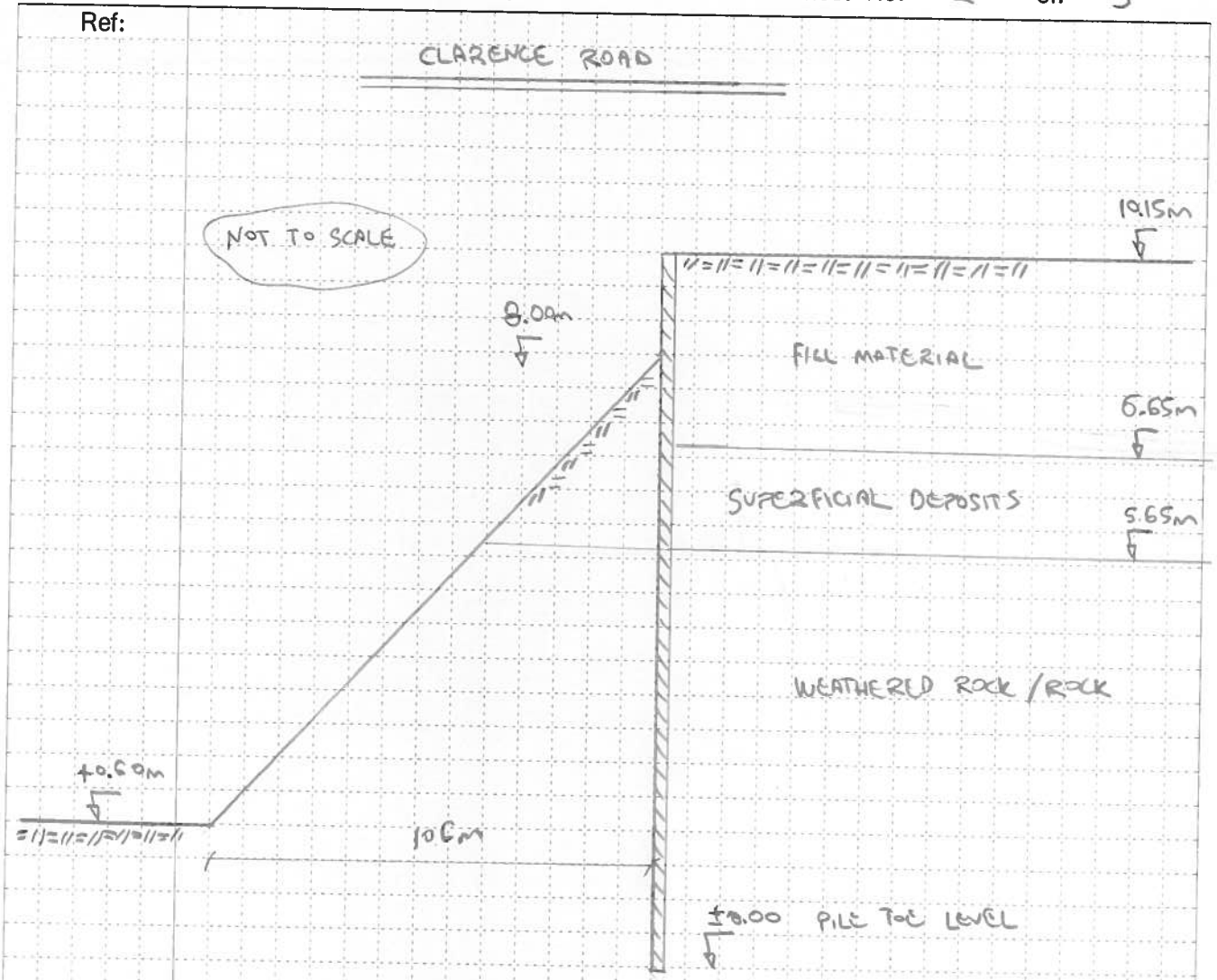
Subject:	RETAINING WALL CONCEPT DESIGN	Ref:	
		Date:	14/11/2016
Made by:	VST	Checked by:	
		Sheet No:	2 of: 3

Ref:



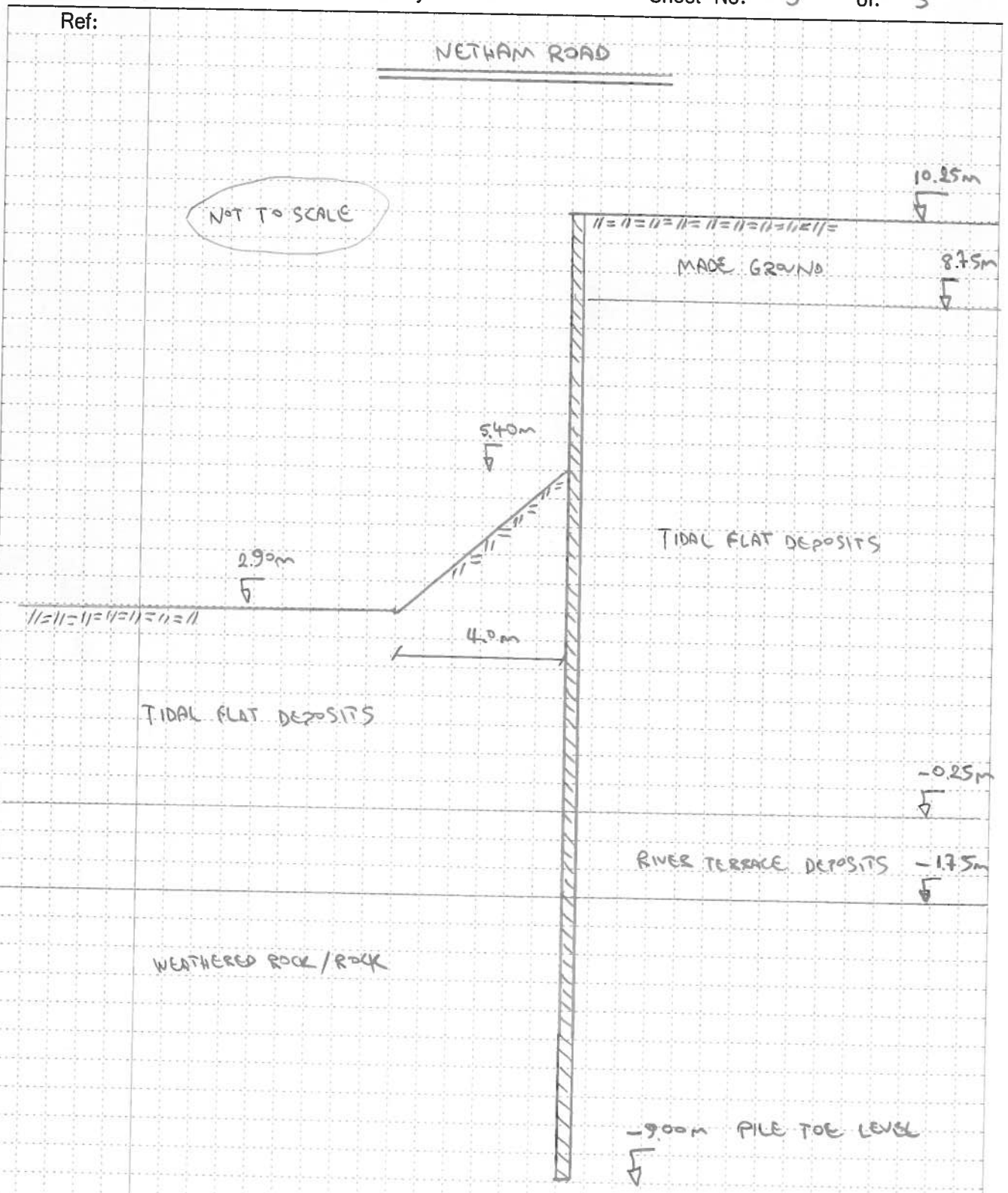
PILE DIAM. 600mm
PILE SPACING c/c 750mm

CALCULATION SHEET

AECOM

Project Title:	BRISTOL AVON TIDAL DEFENCE STRATEGY	Job No:	60478613
Subject:	RETAINING WALL CONCEPT DESIGN	Ref:	
		Date:	14/1/2016
Made by:	VST	Checked by:	Sheet No: 3 of: 3

Ref:



Annex B – WALLAP Results – Cumberland Road

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	10.15	1 Made ground (D)	7 Made ground (P)
2	4.15	3 Tidal deposits (U)	3 Tidal deposits (U)
3	-1.85	6 RT deposits	6 RT deposits
4	-4.85	5 WRock	5 WRock

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made ground (D)	19.00	5000	0.562	OC (0.250)	0.277 (0.000)	4.915 (0.000)	
2	Not defined							
3	Tidal deposits (U)	17.00	3000	0.577	NC (0.490)	1.000 (1.000)	1.000 (1.000)	10.00u
4	Tidal deposits (D)	17.00	2400	0.577	NC (0.150)	1.000 (1.000)	1.000 (1.000)	0.0d
5	WRock (-4.85)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	RT deposits	20.00	20000	0.455	OC (0.250)	0.256 (0.000)	5.303 (0.000)	
7	Made ground (P)	19.00	5000	0.562	OC (0.250)	0.277 (0.000)	4.915 (0.000)	

Additional soil parameters associated with Ka and Kp

No.	Soil type	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made ground (D)	30.00	0.826	0.00	30.00	0.826	0.00
2	Not defined						
3	Tidal deposits (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
4	Tidal deposits (D)	0.00	-0.674	0.00	0.00	-0.674	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	RT deposits	33.00	0.500	0.00	33.00	0.500	0.00
7	Made ground (P)	30.00	0.826	0.00	30.00	0.826	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	4.00	4.00	0.0	1	3.00	3.00	0.0	MC+WC
2	1	4.00	4.00	0.0	1	10.15	10.15	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall = -13.00
             Maximum finite element length =   1.20 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 0.15061 m4/m run
                                       E.I = 3.5212E+06 kN.m2/m run
                    Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.15	0.00(A)	7.50	100.00	10.00	=	N/A	1.00 P/U
2	10.15	7.50(A)	11.00	100.00	20.00	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
2	Apply water pressure profile no.1 (Mod. Conserv.) No analysis at this stage
3	Excavate to elevation 2.10 on PASSIVE side Toe of berm at elevation -0.75 Width of top of berm = 0.01 Width of toe of berm = 13.10
4	Apply surcharge no.1 at elevation 10.15
5	Apply surcharge no.2 at elevation 10.15
6	Change EI of wall to 2.5152E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
7	Apply water pressure profile no.2 (Mod. Conserv.)
8	Remove surcharge no.1 at elevation 10.15
9	Remove surcharge no.2 at elevation 10.15
10	Apply water pressure profile no.1 (Mod. Conserv.)
11	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
12	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
13	Apply surcharge no.1 at elevation 10.15
14	Apply surcharge no.2 at elevation 10.15
15	Apply water pressure profile no.2 (Mod. Conserv.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 25.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 40.00 m
Width of excavation on passive side of wall = 100.00 m

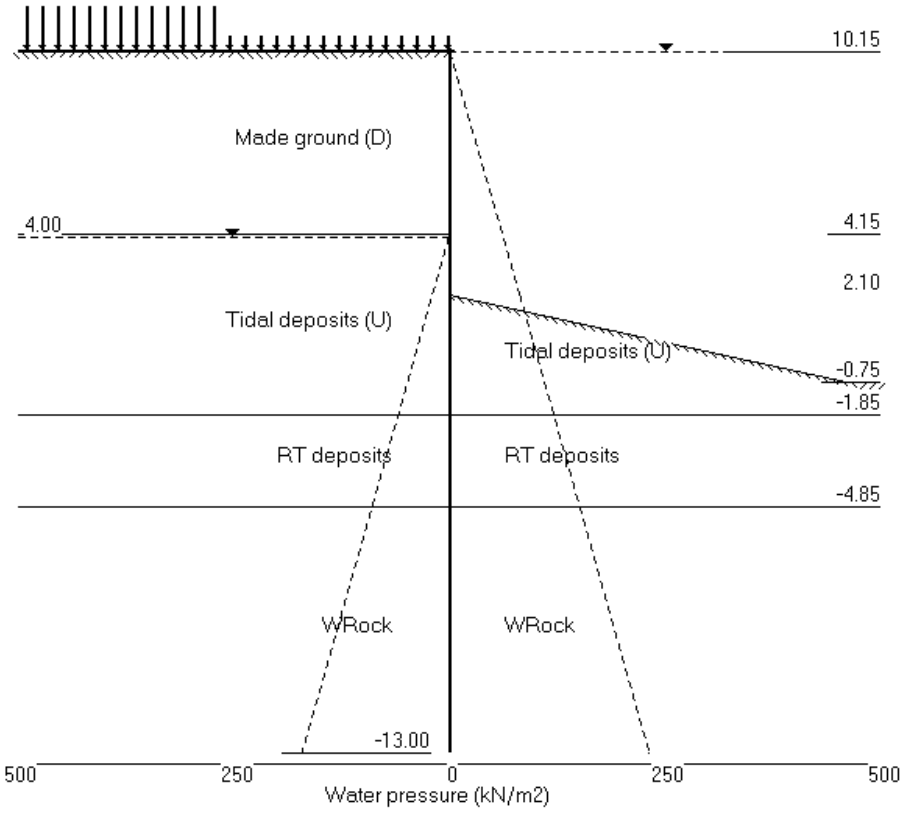
Distance to rigid boundary on active side = 100.00 m
Distance to rigid boundary on passive side = 100.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Excav. to elev. 2.10 on PASSIVE side	No	No	No
4	Apply surcharge no.1 at elev. 10.15	No	No	No
5	Apply surcharge no.2 at elev. 10.15	No	No	No
6	Change EI of wall to 2.5152E+06kN.m2/m	No	No	No
7	Apply water pressure profile no.2	No	No	No
8	Remove surcharge no.1 at elev. 10.15	No	No	No
9	Remove surcharge no.2 at elev. 10.15	No	No	No
10	Apply water pressure profile no.1	No	No	No
11	Change soil type 3 to soil type 4	No	No	No
12	Change soil type 4 to soil type 3	No	No	No
13	Apply surcharge no.1 at elev. 10.15	No	No	No
14	Apply surcharge no.2 at elev. 10.15	No	No	No
15	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.15 Apply water pressure profile no.2 (Mod. Conserv.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.15	10.15	Cant.	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.000	2.74E-17	0.0	-0.0		3521239
2	9.28	0.00	0.000	2.74E-17	0.0	0.0		3521239
3	8.40	0.00	0.000	2.78E-17	0.0	-0.0		3521239
4	7.20	0.00	0.000	3.05E-17	0.0	-0.0		3521239
5	6.00	0.00	0.000	3.77E-17	0.0	-0.0		3521239
6	5.08	0.00	0.000	4.73E-17	0.0	-0.0		3521239
7	4.15	0.00	0.000	6.18E-17	0.0	-0.0		3521239
8	4.00	0.00	0.000	6.46E-17	0.0	-0.0		3521239
9	3.00	0.00	0.000	8.73E-17	0.0	-0.0		3521239
10	2.10	0.00	0.000	1.13E-16	0.0	-0.0		3521239
11	1.05	0.00	0.000	1.50E-16	0.0	-0.0		3521239
12	0.00	0.00	0.000	1.95E-16	0.0	-0.0		3521239
13	-0.75	0.00	0.000	2.31E-16	0.0	-0.0		3521239
14	-1.85	0.00	0.000	2.91E-16	0.0	-0.0		3521239
15	-2.73	0.00	0.000	3.45E-16	0.0	-0.0		3521239
16	-3.60	0.00	0.000	4.05E-16	0.0	-0.0		3521239
17	-4.22	0.00	0.000	4.47E-16	0.0	-0.0		3521239
18	-4.85	0.00	0.000	4.82E-16	0.0	-0.0		3521239
19	-6.03	0.00	0.000	5.16E-16	0.0	-0.0		3521239
20	-7.20	0.00	0.000	5.14E-16	0.0	0.0		3521239
21	-8.40	0.00	0.000	4.95E-16	0.0	0.0		3521239
22	-9.60	0.00	0.000	4.71E-16	0.0	0.0		3521239
23	-10.80	0.00	0.000	4.47E-16	0.0	0.0		3521239
24	-11.90	0.00	0.000	4.25E-16	0.0	0.0		3521239
25	-13.00	0.00	-0.000	4.12E-16	0.0	0.0		---

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	ACTIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	370
2	9.28	0.00	16.62	4.61	81.70	9.34	9.34	370
3	8.40	0.00	33.25	9.21	163.41	18.69	18.69	370
4	7.20	0.00	56.05	15.53	275.46	31.50	31.50	370
5	6.00	0.00	78.85	21.85	387.51	44.31	44.31	370
6	5.08	0.00	96.42	26.72	473.88	54.19	54.19	370
7	4.15	0.00	114.00	31.59	560.26	64.07	64.07	370
		Total> 114.00	104.00	124.00	104.00		104.00a	338
8	4.00	Total> 116.55	106.55	126.55	106.55		106.55a	338
9	3.00	Total> 133.55	123.55	143.55	123.55		123.55a	338
10	2.10	Total> 148.85	138.85	158.85	138.85		138.85a	338
11	1.05	Total> 166.70	156.70	176.70	156.70		156.70a	338
12	0.00	Total> 184.55	174.55	194.55	174.55		174.55a	338
13	-0.75	Total> 197.30	187.30	207.30	187.30		187.30a	338
14	-1.85	Total> 216.00	206.00	226.00	206.00		206.00a	338
		48.50	167.50	42.96	888.23	76.21	124.71	1478
15	-2.73	57.25	176.25	45.20	934.63	80.19	137.44	1478
16	-3.60	66.00	185.00	47.45	981.03	84.18	150.18	1478
17	-4.22	72.25	191.25	49.05	1014.17	87.02	159.27	1478
18	-4.85	78.50	197.50	50.65	1047.32	89.86	168.36	1478
		Total> 276.00	75.00m	886.96	157.50		157.50	14064
19	-6.03	Total> 300.68	80.88m	1055.21	174.42		174.42	17369
20	-7.20	Total> 325.35	86.75m	1223.46	191.34		191.34	20674
21	-8.40	Total> 350.55	92.75m	1395.29	208.62		208.62	24049
22	-9.60	Total> 375.75	98.75m	1567.12	225.90		225.90	27424
23	-10.80	Total> 400.95	104.75m	1738.95	243.18		243.18	30800
24	-11.90	Total> 424.05	110.25m	1896.46	259.02		259.02	122028
25	-13.00	Total> 447.15	115.75m	2053.98	274.86		274.86	297080

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	370
2	9.28	0.00	16.62	4.61	81.70	9.34	9.34	370
3	8.40	0.00	33.25	9.21	163.41	18.69	18.69	370
4	7.20	0.00	56.05	15.53	275.46	31.50	31.50	370
5	6.00	0.00	78.85	21.85	387.51	44.31	44.31	370
6	5.08	0.00	96.42	26.72	473.88	54.19	54.19	370
7	4.15	0.00	114.00	31.59	560.26	64.07	64.07	370
		Total> 114.00	104.00	124.00	104.00		104.00a	338
8	4.00	Total> 116.55	106.55	126.55	106.55		106.55a	338
9	3.00	Total> 133.55	123.55	143.55	123.55		123.55a	338
10	2.10	Total> 148.85	138.85	158.85	138.85		138.85a	338
11	1.05	Total> 166.70	156.70	176.70	156.70		156.70a	338
12	0.00	Total> 184.55	174.55	194.55	174.55		174.55a	338
13	-0.75	Total> 197.30	187.30	207.30	187.30		187.30a	338
14	-1.85	Total> 216.00	206.00	226.00	206.00		206.00a	338
		48.50	167.50	42.96	888.23	76.21	124.71	1478
15	-2.73	57.25	176.25	45.20	934.63	80.19	137.44	1478
16	-3.60	66.00	185.00	47.45	981.03	84.18	150.18	1478

(continued)

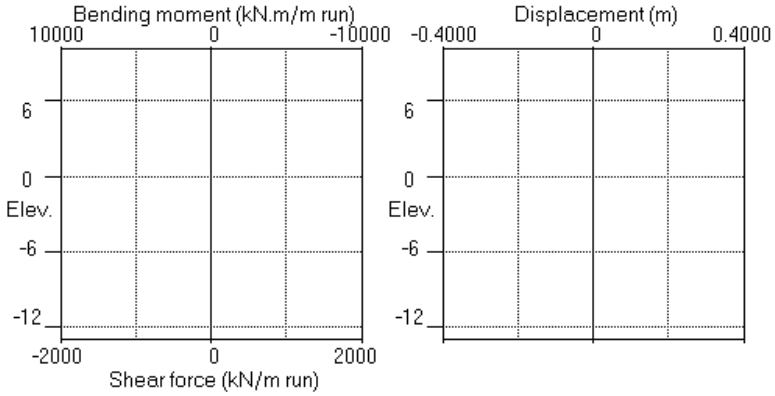
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
17	-4.22	72.25	191.25	49.05	1014.17	87.02	159.27	1478
18	-4.85	78.50	197.50	50.65	1047.32	89.86	168.36	1478
		Total> 276.00		75.00m	886.96	157.50	157.50	14064
19	-6.03	Total> 300.68		80.88m	1055.21	174.42	174.42	17369
20	-7.20	Total> 325.35		86.75m	1223.46	191.34	191.34	20674
21	-8.40	Total> 350.55		92.75m	1395.29	208.62	208.62	24049
22	-9.60	Total> 375.75		98.75m	1567.12	225.90	225.90	27424
23	-10.80	Total> 400.95		104.75m	1738.95	243.18	243.18	30800
24	-11.90	Total> 424.05		110.25m	1896.46	259.02	259.02	122028
25	-13.00	Total> 447.15		115.75m	2053.98	274.86	274.86	297080

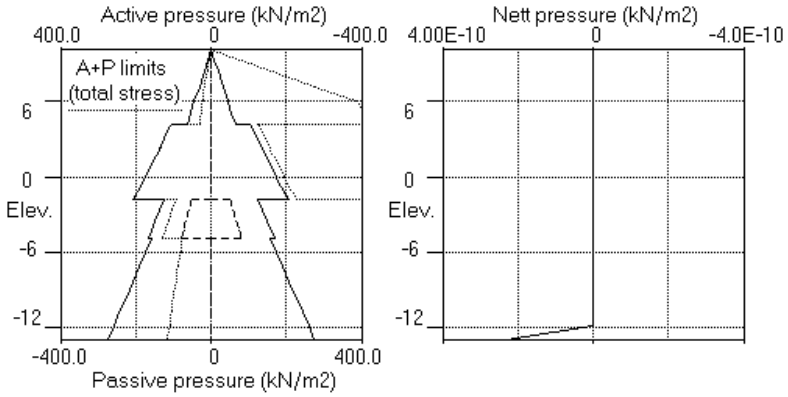
Note: 206.00a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
3	10.15	2.10	Cant.	1.529	-10.43	-10.60	12.70

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.207	1.32E-02	0.0	-0.0		3521239
2	9.28	4.61	0.196	1.32E-02	2.0	0.6		3521239
3	8.40	9.21	0.184	1.32E-02	8.1	4.7		3521239
4	7.20	15.53	0.168	1.32E-02	22.9	22.5		3521239
5	6.00	21.85	0.152	1.32E-02	45.3	62.7		3521239
6	5.08	26.72	0.140	1.32E-02	67.8	114.7		3521239
7	4.15	31.59	0.128	1.31E-02	94.8	189.6		3521239
		104.00	0.128	1.31E-02	94.8	189.6		
8	4.00	106.55	0.126	1.31E-02	110.6	205.0		3521239
9	3.00	123.55	0.113	1.31E-02	225.6	371.6		3521239
10	2.10	129.85	0.101	1.29E-02	339.6	625.6		3521239
		119.85	0.101	1.29E-02	339.6	625.6		
11	1.05	119.85	0.087	1.27E-02	465.5	1048.3		3521239
12	0.00	119.85	0.074	1.23E-02	591.3	1603.1		3521239
13	-0.75	119.85	0.065	1.19E-02	681.2	2080.3		3521239
14	-1.85	119.85	0.052	1.11E-02	813.1	2902.2		3521239
		-96.25	0.052	1.11E-02	813.1	2902.2		
15	-2.73	-115.94	0.043	1.03E-02	720.2	3591.5		3521239
16	-3.60	-90.50	0.034	9.39E-03	629.9	4177.0		3521239
17	-4.22	-74.05	0.029	8.61E-03	578.5	4553.0		3521239
18	-4.85	-59.18	0.024	7.77E-03	536.9	4900.0		3521239
		-609.59	0.024	7.77E-03	536.9	4900.0		
19	-6.03	-485.00	0.015	6.10E-03	-106.2	5110.0		3521239
20	-7.20	-334.74	0.009	4.47E-03	-587.8	4650.2		3521239
21	-8.40	-196.13	0.005	3.05E-03	-906.3	3701.1		3521239
22	-9.60	-15.11	0.002	2.00E-03	-1033.1	2500.1		3521239
23	-10.80	209.35	-0.000	1.35E-03	-916.5	1257.8		3521239

(continued)

Stage No.3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
24	-11.90	414.11	-0.002	1.10E-03	-573.6	378.4		3521239
25	-13.00	628.86	-0.003	1.04E-03	0.0	0.0		---

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	533
2	9.28	0.00	16.62	4.61	81.70	4.61	4.61a	533
3	8.40	0.00	33.25	9.21	163.41	9.21	9.21a	533
4	7.20	0.00	56.05	15.53	275.46	15.53	15.53a	533
5	6.00	0.00	78.85	21.85	387.51	21.85	21.85a	533
6	5.08	0.00	96.42	26.72	473.88	26.72	26.72a	533
7	4.15	0.00	114.00	31.59	560.26	31.59	31.59a	533
		Total> 114.00	104.00	124.00	104.00	104.00a		461
8	4.00	Total> 116.55	106.55	126.55	106.55	106.55a		461
9	3.00	Total> 133.55	123.55	143.55	123.55	123.55a		461
10	2.10	Total> 148.85	138.85	158.85	138.85	138.85a		461
11	1.05	Total> 166.70	156.70	176.70	156.70	156.70a		461
12	0.00	Total> 184.55	174.55	194.55	174.55	174.55a		461
13	-0.75	Total> 197.30	187.30	207.30	187.30	187.30a		461
14	-1.85	Total> 216.00	206.00	226.00	206.00	206.00a		461
		58.50	157.50	40.40	835.20	40.40	98.90a	2134
15	-2.73	67.25	166.25	42.64	881.60	42.64	109.89a	2134
16	-3.60	76.00	175.00	44.88	928.00	44.88	120.88a	2134
17	-4.22	82.25	181.25	46.49	961.15	46.49	128.74a	2134
18	-4.85	88.50	187.50	48.09	994.29	48.09	136.59a	2134
		Total> 276.00	75.00m	886.96	75.00	75.00a		19212
19	-6.03	Total> 300.68	80.88m	1055.21	80.88	80.88a		23726
20	-7.20	Total> 325.35	86.75m	1223.46	86.75	86.75a		28241
21	-8.40	Total> 350.55	92.75m	1395.29	92.75	92.75a		32852
22	-9.60	Total> 375.75	98.75m	1567.12	162.06	162.06		37463
23	-10.80	Total> 400.95	104.75m	1738.95	278.35	278.35		130401
24	-11.90	Total> 424.05	110.25m	1896.46	488.61	488.61		143500
25	-13.00	Total> 447.15	115.75m	2053.98	708.86	708.86		156600

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.28	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	2.10	9.00	0.00	0.00	0.00	0.00	9.00	0.0
		Total> 9.00	9.00w	19.00	19.00	19.00p		657

(continued)

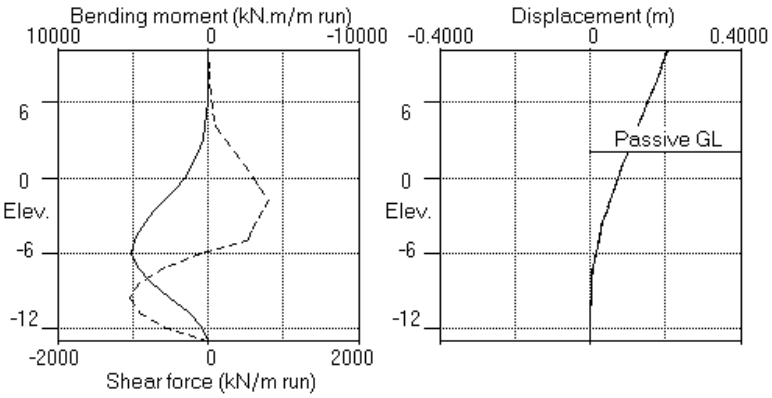
Stage No.3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

Node no.	Y coord	PASSIVE side ------- Effective stresses ------- Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
11	1.05	Total>	26.85	16.85	36.85	36.85	36.85p	657
12	0.00	Total>	44.70	34.70	54.70	54.70	54.70p	657
13	-0.75	Total>	57.45	47.45	67.45	67.45	67.45p	657
14	-1.85	Total>	76.15	66.15	86.15	86.15	86.15p	657
		48.50	27.65	7.09	146.64	146.64	195.14p	3142
15	-2.73	57.25	36.41	9.34	193.06	168.58	225.83	3142
16	-3.60	66.00	45.16	11.58	239.48	145.38	211.38	3142
17	-4.22	72.25	51.41	13.19	272.65	130.53	202.78	3142
18	-4.85	78.50	57.67	14.79	305.82	117.27	195.77	3142
		Total>	136.17	39.25m	747.13	684.59	684.59	27393
19	-6.03	Total>	160.86	45.13m	915.39	565.88	565.88	33831
20	-7.20	Total>	185.55	51.00m	1083.66	421.49	421.49	40268
21	-8.40	Total>	210.77	57.00m	1255.51	288.88	288.88	46843
22	-9.60	Total>	235.99	63.00m	1427.37	177.17	177.17	53417
23	-10.80	Total>	261.22	69.00m	1599.23	69.00	69.00a	130401
24	-11.90	Total>	284.36	74.50m	1756.77	74.50	74.50a	143500
25	-13.00	Total>	307.50	80.00m	1914.32	80.00	80.00a	156600

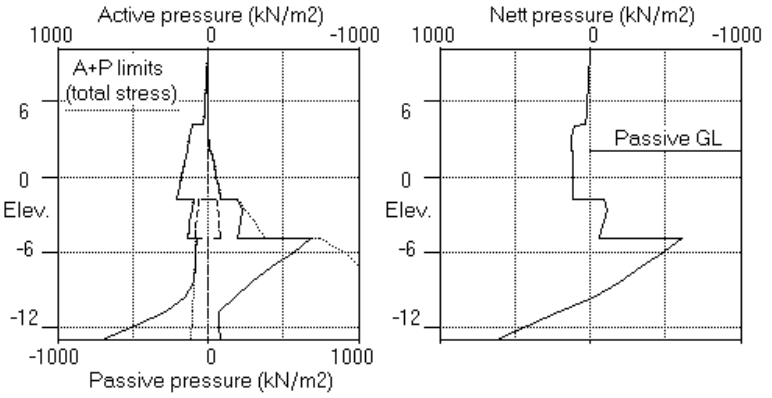
Note: 80.00a Soil pressure at active limit
195.14p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 2.10 on PASSIVE side



Stage No.3 Excav. to elev. 2.10 on PASSIVE side



Units: kN,m

Stage No. 11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetration
11	10.15	2.10	Cant.	1.405	-10.41	-11.10	13.20

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.243	1.54E-02	0.0	-0.0		2515171
2	9.28	4.61	0.229	1.54E-02	2.0	4.7		2515171
3	8.40	9.21	0.216	1.54E-02	8.1	8.8		2515171
4	7.20	15.53	0.197	1.54E-02	22.9	26.7		2515171
5	6.00	21.85	0.179	1.53E-02	45.3	67.0		2515171
6	5.08	26.72	0.164	1.53E-02	67.8	119.0		2515171
7	4.15	31.59	0.150	1.53E-02	94.8	193.9		2515171
		114.00	0.150	1.53E-02	94.8	193.9		
8	4.00	116.55	0.148	1.53E-02	112.1	209.3		2515171
9	3.00	133.55	0.133	1.52E-02	237.1	386.0		2515171
10	2.10	139.85	0.119	1.51E-02	360.1	654.0		2515171
11	1.05	147.20	0.103	1.48E-02	510.9	1110.6		2515171
12	0.00	154.55	0.088	1.44E-02	669.3	1729.3		2515171
13	-0.75	159.80	0.077	1.40E-02	787.2	2275.2		2515171
		156.57	0.077	1.40E-02	787.2	2275.2		
14	-1.85	163.03	0.062	1.31E-02	962.9	3237.2		2515171
		-96.25	0.062	1.31E-02	962.9	3237.2		
15	-2.73	-140.42	0.051	1.22E-02	859.4	4056.2		2515171
16	-3.60	-110.10	0.041	1.11E-02	749.8	4756.6		2515171
17	-4.22	-90.43	0.034	1.02E-02	687.1	5203.6		2515171
18	-4.85	-72.59	0.028	9.25E-03	636.2	5615.4		2515171
		-672.13	0.028	9.25E-03	636.2	5615.4		
19	-6.03	-577.74	0.018	7.28E-03	-98.1	5906.9		2515171
20	-7.20	-397.40	0.011	5.35E-03	-671.0	5375.8		2515171
21	-8.40	-228.03	0.005	3.66E-03	-1046.3	4291.4		2515171
22	-9.60	-23.35	0.002	2.40E-03	-1197.1	2909.7		2515171
23	-10.80	241.14	-0.001	1.63E-03	-1066.4	1464.8		2515171
24	-11.90	483.10	-0.002	1.33E-03	-668.1	439.7		2515171
25	-13.00	731.64	-0.004	1.26E-03	-0.0	0.0		---

(continued)

Stage No.11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	ACTIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	507
2	9.28	0.00	16.62	4.61	81.70	4.61	4.61a	507
3	8.40	0.00	33.25	9.21	163.41	9.21	9.21a	507
4	7.20	0.00	56.05	15.53	275.46	15.53	15.53a	507
5	6.00	0.00	78.85	21.85	387.51	21.85	21.85a	507
6	5.08	0.00	96.42	26.72	473.88	26.72	26.72a	507
7	4.15	0.00	114.00	31.59	560.26	31.59	31.59a	507
		0.00	114.00	114.00	114.00	114.00	114.00	225
8	4.00	0.00	116.55	116.55	116.55	116.55	116.55	225
9	3.00	10.00	123.55	123.55	123.55	123.55	133.55	225
10	2.10	19.00	129.85	129.85	129.85	129.85	148.85	225
11	1.05	29.50	137.20	137.20	137.20	137.20	166.70	225
12	0.00	40.00	144.55	144.55	144.55	144.55	184.55	225
13	-0.75	47.50	149.80	149.80	149.80	149.80	197.30	225
14	-1.85	58.50	157.50	157.50	157.50	157.50	216.00	225
		58.50	157.50	40.40	835.20	40.40	98.90a	2029
15	-2.73	67.25	166.25	42.64	881.60	42.64	109.89a	2029
16	-3.60	76.00	175.00	44.88	928.00	44.88	120.88a	2029
17	-4.22	82.25	181.25	46.49	961.15	46.49	128.74a	2029
18	-4.85	88.50	187.50	48.09	994.29	48.09	136.59a	2029
		Total> 276.00		75.00m	886.96	75.00	75.00a	18374
19	-6.03	Total> 300.68		80.88m	1055.21	80.88	80.88a	22692
20	-7.20	Total> 325.35		86.75m	1223.46	86.75	86.75a	27010
21	-8.40	Total> 350.55		92.75m	1395.29	92.75	92.75a	31419
22	-9.60	Total> 375.75		98.75m	1567.12	158.19	158.19	35829
23	-10.80	Total> 400.95		104.75m	1738.95	310.14	310.14	101448
24	-11.90	Total> 424.05		110.25m	1896.46	557.60	557.60	111640
25	-13.00	Total> 447.15		115.75m	2053.98	811.64	811.64	121831

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.28	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	2.10	9.00	0.00	0.00	0.00	0.00	9.00	0.0
		9.00	0.00	0.00	0.00	0.00	9.00	340
11	1.05	19.50	7.35	-0.01	0.00b	0.00	19.50p	340
12	0.00	30.00	14.70	-0.01	-0.00b	-0.00	30.00p	340
13	-0.75	37.50	19.95	-0.01	0.00b	0.00	37.50p	340
		37.50	19.95	3.22	3.23b	3.23	40.73p	340
14	-1.85	48.50	27.65	4.46	4.47b	4.47	52.97p	340
		48.50	27.65	7.09	146.64	146.64	195.14p	3040
15	-2.73	57.25	36.41	9.34	193.06	193.06	250.31p	3040
16	-3.60	66.00	45.16	11.58	239.48	164.99	230.99	3040

(continued)

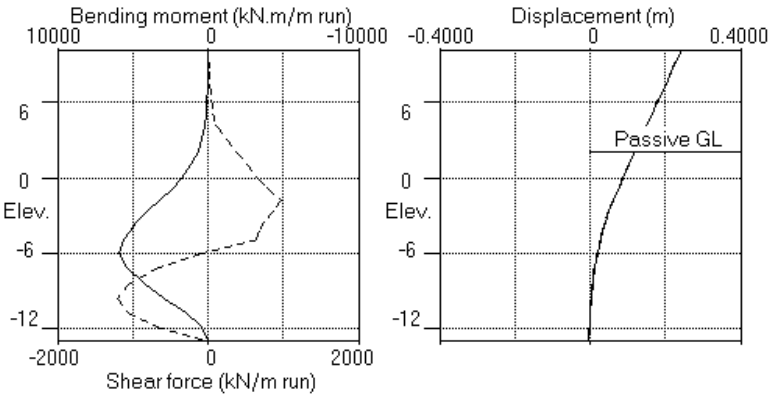
Stage No.11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
17	-4.22	72.25	51.41	13.19	272.65	146.92	219.17	3040
18	-4.85	78.50	57.67	14.79	305.82	130.68	209.18	3040
		Total> 136.17	39.25m	747.13	747.13		747.13p	26561
19	-6.03	Total> 160.86	45.13m	915.39	658.61		658.61	32803
20	-7.20	Total> 185.55	51.00m	1083.66	484.15		484.15	39045
21	-8.40	Total> 210.77	57.00m	1255.51	320.78		320.78	45420
22	-9.60	Total> 235.99	63.00m	1427.37	181.54		181.54	51794
23	-10.80	Total> 261.22	69.00m	1599.23	69.00		69.00a	101448
24	-11.90	Total> 284.36	74.50m	1756.77	74.50		74.50a	111640
25	-13.00	Total> 307.50	80.00m	1914.32	80.00		80.00a	121831

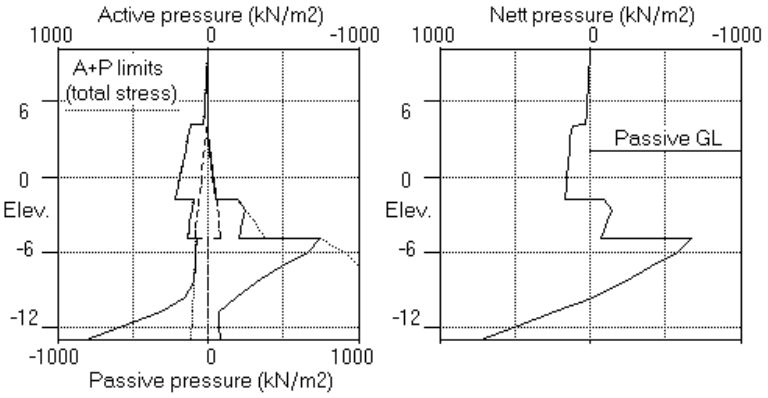
Note: 80.00a Soil pressure at active limit
747.13p Soil pressure at passive limit
4.47b Passive limit reduced because of berm

Units: kN,m

Stage No.11 Change soil type 3 to soil type 4



Stage No.11 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State

All loads and soil strengths are unfactored

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.15	10.15	Cant.	Conditions not suitable for FoS calc.			
2	10.15	10.15		No analysis at this stage			
3	10.15	2.10	Cant.	1.529	-10.43	-10.60	12.70
4	10.15	2.10	Cant.	1.454	-10.41	-10.81	12.91
5	10.15	2.10	Cant.	1.438	-10.42	-10.86	12.96
6	10.15	2.10		No analysis at this stage			
7	10.15	2.10	Cant.	3.443	-10.31	-5.99	8.09
8	10.15	2.10	Cant.	3.902	-10.37	-5.24	7.34
9	10.15	2.10	Cant.	4.020	-10.36	-4.99	7.09
10	10.15	2.10	Cant.	1.529	-10.43	-10.60	12.70
11	10.15	2.10	Cant.	1.405	-10.41	-11.10	13.20
12	10.15	2.10		No analysis at this stage			
13	10.15	2.10	Cant.	1.454	-10.41	-10.81	12.91
14	10.15	2.10	Cant.	1.438	-10.42	-10.86	12.96
15	10.15	2.10	Cant.	3.443	-10.31	-5.99	8.09

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	10.15	0.257	0.000	0	-0	0	-0	0	0	0	0
2	9.28	0.242	0.000	19	0	26	0	34	0	45	0
3	8.40	0.228	0.000	62	-0	83	-0	62	0	83	0
4	7.20	0.208	0.000	156	-0	210	-0	92	0	124	0
5	6.00	0.188	0.000	279	-0	377	-0	111	0	150	0
6	5.08	0.173	0.000	387	-0	523	-0	120	0	161	0
7	4.15	0.158	0.000	500	-0	674	-0	122	0	164	0
8	4.00	0.156	0.000	519	-0	700	-0	132	0	179	0
9	3.00	0.140	0.000	692	-0	934	-0	257	0	347	0
10	2.10	0.125	0.000	912	-0	1232	-0	383	0	518	0
11	1.05	0.108	0.000	1258	-0	1699	-0	535	0	722	0
12	0.00	0.092	0.000	1865	-0	2517	-0	693	0	936	0
13	-0.75	0.081	0.000	2428	-0	3278	-0	809	0	1092	0
14	-1.85	0.065	0.000	3411	-0	4605	-0	979	0	1321	0
15	-2.73	0.053	0.000	4245	-0	5730	-0	877	0	1184	0
16	-3.60	0.043	0.000	4961	-0	6697	-0	766	0	1034	0
17	-4.22	0.036	0.000	5417	-0	7313	-0	701	0	946	0
18	-4.85	0.029	0.000	5837	-0	7880	-0	648	0	875	0
19	-6.03	0.019	0.000	6142	-0	8292	-0	0	-120	0	-162
20	-7.20	0.011	0.000	5588	0	7543	0	0	-701	0	-947
21	-8.40	0.006	0.000	4455	0	6015	0	0	-1092	0	-1474
22	-9.60	0.002	0.000	3014	0	4069	0	0	-1245	0	-1680
23	-10.80	0.000	-0.001	1515	0	2046	0	0	-1105	0	-1492
24	-11.90	0.000	-0.002	454	0	614	0	0	-691	0	-933
25	-13.00	0.000	-0.004	0	0	0	0	0	-0	0	-0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
no.	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	0	-11.90	-0	-3.60	0	-0	0	-13.00	0	10.15	0	0
2	No calculation at this stage											
3	5110	-6.03	-0	10.15	6898	-0	813	-1.85	-1033	-9.60	1098	-1395
4	5453	-6.03	-0	10.15	7361	-0	857	-1.85	-1100	-9.60	1156	-1485
5	5541	-6.03	-0	10.15	7480	-0	871	-1.85	-1118	-9.60	1176	-1510
6	No calculation at this stage											
7	3982	-6.03	-0	10.15	5376	-0	595	-1.85	-815	-9.60	803	-1101
8	3796	-6.03	-0	10.15	5125	-0	573	-1.85	-783	-9.60	773	-1057
9	3761	-6.03	-0	10.15	5077	-0	564	-1.85	-776	-9.60	761	-1047
10	5379	-6.03	-0	10.15	7261	-0	840	-1.85	-1087	-9.60	1134	-1467
11	5907	-6.03	-0	10.15	7974	-0	963	-1.85	-1197	-9.60	1300	-1616
12	No calculation at this stage											
13	6085	-6.03	-0	10.15	8215	-0	971	-1.85	-1232	-9.60	1311	-1663
14	6142	-6.03	-0	10.15	8292	-0	979	-1.85	-1245	-9.60	1321	-1680
15	4422	-6.03	-0	10.15	5970	-0	653	-1.85	-910	-9.60	881	-1228

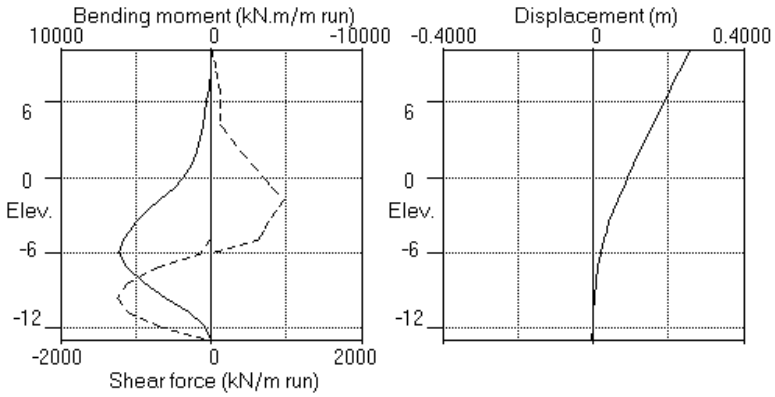
Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	10.15	-0.000	-13.00	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.207	10.15	-0.003	-13.00	Excav. to elev. 2.10 on PASSIVE side
4	0.222	10.15	-0.003	-13.00	Apply surcharge no.1 at elev. 10.15
5	0.225	10.15	-0.003	-13.00	Apply surcharge no.2 at elev. 10.15
6	No calculation at this stage				Change EI of wall to 2.5152E+06kN.m2/m run
7	0.156	10.15	-0.003	-13.00	Apply water pressure profile no.2
8	0.145	10.15	-0.003	-13.00	Remove surcharge no.1 at elev. 10.15
9	0.144	10.15	-0.003	-13.00	Remove surcharge no.2 at elev. 10.15
10	0.218	10.15	-0.003	-13.00	Apply water pressure profile no.1
11	0.243	10.15	-0.004	-13.00	Change soil type 3 to soil type 4
12	No calculation at this stage				Change soil type 4 to soil type 3
13	0.254	10.15	-0.004	-13.00	Apply surcharge no.1 at elev. 10.15
14	0.257	10.15	-0.004	-13.00	Apply surcharge no.2 at elev. 10.15
15	0.181	10.15	-0.003	-13.00	Apply water pressure profile no.2

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	10.15	1 Made ground (D)	7 Made ground (P)
2	4.15	3 Tidal deposits (U)	3 Tidal deposits (U)
3	-1.85	6 RT deposits	6 RT deposits
4	-4.85	5 WRock	5 WRock

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made ground (D)	19.00	5000	0.562	OC (0.250)	0.277 (0.000)	4.915 (0.000)	
2	Not defined							
3	Tidal deposits (U)	17.00	3000	0.577	NC (0.490)	1.000 (1.000)	1.000 (1.000)	10.00u
4	Tidal deposits (D)	17.00	2400	0.577	NC (0.150)	1.000 (1.000)	1.000 (1.000)	0.0d
5	WRock (-4.85)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	RT deposits	20.00	20000	0.455	OC (0.250)	0.256 (0.000)	5.303 (0.000)	
7	Made ground (P)	19.00	5000	0.562	OC (0.250)	0.277 (0.000)	4.915 (0.000)	

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made ground (D)	30.00	0.826	0.00	30.00	0.826	0.00
2	Not defined						
3	Tidal deposits (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
4	Tidal deposits (D)	0.00	-0.674	0.00	0.00	-0.674	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	RT deposits	33.00	0.500	0.00	33.00	0.500	0.00
7	Made ground (P)	30.00	0.826	0.00	30.00	0.826	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	4.00	4.00	0.0	1	3.00	3.00	0.0	MC+WC
2	1	4.00	4.00	0.0	1	10.15	10.15	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall = -13.00
             Maximum finite element length =   1.20 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 0.15061 m4/m run
                                       E.I = 3.5212E+06 kN.m2/m run
                     Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.15	0.00(A)	7.50	100.00	10.00	=	N/A	1.00 P/U
2	10.15	7.50(A)	11.00	100.00	20.00	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
2	Apply water pressure profile no.1 (Mod. Conserv.) No analysis at this stage
3	Excavate to elevation 2.10 on PASSIVE side Toe of berm at elevation -0.75 Width of top of berm = 0.01 Width of toe of berm = 13.10
4	Apply surcharge no.1 at elevation 10.15
5	Apply surcharge no.2 at elevation 10.15
6	Change EI of wall to 2.5152E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
7	Apply water pressure profile no.2 (Mod. Conserv.)
8	Remove surcharge no.1 at elevation 10.15
9	Remove surcharge no.2 at elevation 10.15
10	Apply water pressure profile no.1 (Mod. Conserv.)
11	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
12	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
13	Apply surcharge no.1 at elevation 10.15
14	Apply surcharge no.2 at elevation 10.15
15	Apply water pressure profile no.2 (Mod. Conserv.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: ULS DA1 Combination 1
  Water pressures : Moderately Conservative
  Partial factor on   C'         = 1.000
  Partial factor on Phi'         = 1.000
  Partial factor on   Cu         = 1.000
  Partial factor on Soil Modulus = 1.000
  Partial factor on Permanent Unfavourable loads = 1.000
  Partial factor on Permanent Favourable loads   = 1.000
  Partial factor on Variable Unfavourable loads  = 1.100
  Design factor on calculated Bending Moments    = 1.350


 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
  Non-linear Modulus Parameter (L) = 25.00 m
```

Boundary conditions:
 Length of wall (normal to plane of analysis) = 1000.00 m

 Width of excavation on active side of wall = 40.00 m
 Width of excavation on passive side of wall = 100.00 m

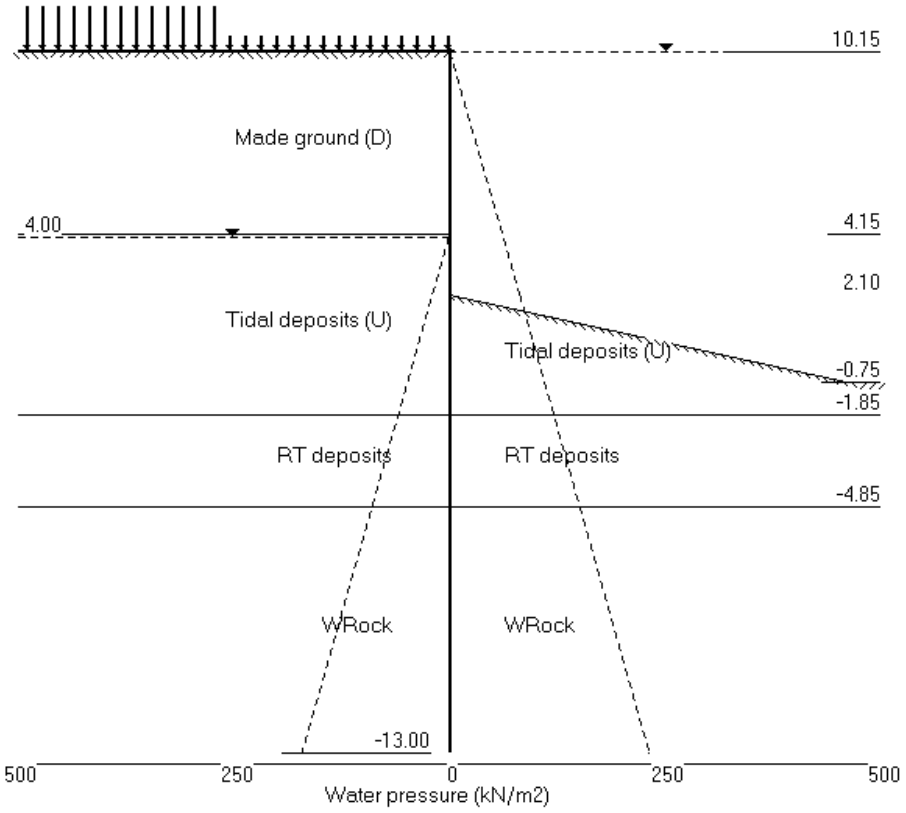
 Distance to rigid boundary on active side = 100.00 m
 Distance to rigid boundary on passive side = 100.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Excav. to elev. 2.10 on PASSIVE side	No	No	No
4	Apply surcharge no.1 at elev. 10.15	No	No	No
5	Apply surcharge no.2 at elev. 10.15	No	No	No
6	Change EI of wall to 2.5152E+06kN.m2/m	No	No	No
7	Apply water pressure profile no.2	No	No	No
8	Remove surcharge no.1 at elev. 10.15	No	No	No
9	Remove surcharge no.2 at elev. 10.15	No	No	No
10	Apply water pressure profile no.1	No	No	No
11	Change soil type 3 to soil type 4	No	No	No
12	Change soil type 4 to soil type 3	No	No	No
13	Apply surcharge no.1 at elev. 10.15	No	No	No
14	Apply surcharge no.2 at elev. 10.15	No	No	No
15	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.15 Apply water pressure profile no.2 (Mod. Conserv.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.000	2.74E-17	0.0	-0.0		3521239
2	9.28	0.00	0.000	2.74E-17	0.0	0.0		3521239
3	8.40	0.00	0.000	2.78E-17	0.0	-0.0		3521239
4	7.20	0.00	0.000	3.05E-17	0.0	-0.0		3521239
5	6.00	0.00	0.000	3.77E-17	0.0	-0.0		3521239
6	5.08	0.00	0.000	4.73E-17	0.0	-0.0		3521239
7	4.15	0.00	0.000	6.18E-17	0.0	-0.0		3521239
8	4.00	0.00	0.000	6.46E-17	0.0	-0.0		3521239
9	3.00	0.00	0.000	8.73E-17	0.0	-0.0		3521239
10	2.10	0.00	0.000	1.13E-16	0.0	-0.0		3521239
11	1.05	0.00	0.000	1.50E-16	0.0	-0.0		3521239
12	0.00	0.00	0.000	1.95E-16	0.0	-0.0		3521239
13	-0.75	0.00	0.000	2.31E-16	0.0	-0.0		3521239
14	-1.85	0.00	0.000	2.91E-16	0.0	-0.0		3521239
15	-2.73	0.00	0.000	3.45E-16	0.0	-0.0		3521239
16	-3.60	0.00	0.000	4.05E-16	0.0	-0.0		3521239
17	-4.22	0.00	0.000	4.47E-16	0.0	-0.0		3521239
18	-4.85	0.00	0.000	4.82E-16	0.0	-0.0		3521239
19	-6.03	0.00	0.000	5.16E-16	0.0	-0.0		3521239
20	-7.20	0.00	0.000	5.14E-16	0.0	0.0		3521239
21	-8.40	0.00	0.000	4.95E-16	0.0	0.0		3521239
22	-9.60	0.00	0.000	4.71E-16	0.0	0.0		3521239
23	-10.80	0.00	0.000	4.47E-16	0.0	0.0		3521239
24	-11.90	0.00	0.000	4.25E-16	0.0	0.0		3521239
25	-13.00	0.00	-0.000	4.12E-16	0.0	0.0		---

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	370
2	9.28	0.00	16.62	4.61	81.70	9.34	9.34	370
3	8.40	0.00	33.25	9.21	163.41	18.69	18.69	370
4	7.20	0.00	56.05	15.53	275.46	31.50	31.50	370
5	6.00	0.00	78.85	21.85	387.51	44.31	44.31	370
6	5.08	0.00	96.42	26.72	473.88	54.19	54.19	370
7	4.15	0.00	114.00	31.59	560.26	64.07	64.07	370
		Total>	114.00	103.99	124.01	103.99	103.99a	338

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	ACTIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
8	4.00	Total>	116.55	106.54	126.56	106.54	106.54a	338
9	3.00	Total>	133.55	123.54	143.56	123.54	123.54a	338
10	2.10	Total>	148.85	138.84	158.86	138.84	138.84a	338
11	1.05	Total>	166.70	156.69	176.71	156.69	156.69a	338
12	0.00	Total>	184.55	174.53	194.57	174.53	174.53a	338
13	-0.75	Total>	197.30	187.28	207.32	187.28	187.28a	338
14	-1.85	Total>	216.00	205.98	226.02	205.98	205.98a	338
		48.50	167.50	42.96	888.24	76.21	124.71	1478
15	-2.73	57.25	176.25	45.20	934.64	80.19	137.44	1478
16	-3.60	66.00	185.00	47.45	981.04	84.18	150.18	1478
17	-4.22	72.25	191.25	49.05	1014.19	87.02	159.27	1478
18	-4.85	78.50	197.50	50.65	1047.33	89.86	168.36	1478
		Total>	276.00	75.00m	887.01	157.50	157.50	14064
19	-6.03	Total>	300.68	80.88m	1055.26	174.42	174.42	17369
20	-7.20	Total>	325.35	86.75m	1223.52	191.34	191.34	20674
21	-8.40	Total>	350.55	92.75m	1395.35	208.62	208.62	24049
22	-9.60	Total>	375.75	98.75m	1567.18	225.90	225.90	27424
23	-10.80	Total>	400.95	104.75m	1739.02	243.18	243.18	30800
24	-11.90	Total>	424.05	110.25m	1896.53	259.02	259.02	122028
25	-13.00	Total>	447.15	115.75m	2054.05	274.86	274.86	297080

Node no.	Y coord	PASSIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	370
2	9.28	0.00	16.62	4.61	81.70	9.34	9.34	370
3	8.40	0.00	33.25	9.21	163.41	18.69	18.69	370
4	7.20	0.00	56.05	15.53	275.46	31.50	31.50	370
5	6.00	0.00	78.85	21.85	387.51	44.31	44.31	370
6	5.08	0.00	96.42	26.72	473.88	54.19	54.19	370
7	4.15	0.00	114.00	31.59	560.26	64.07	64.07	370
		Total>	114.00	103.99	124.01	103.99	103.99a	338
8	4.00	Total>	116.55	106.54	126.56	106.54	106.54a	338
9	3.00	Total>	133.55	123.54	143.56	123.54	123.54a	338
10	2.10	Total>	148.85	138.84	158.86	138.84	138.84a	338
11	1.05	Total>	166.70	156.69	176.71	156.69	156.69a	338
12	0.00	Total>	184.55	174.53	194.57	174.53	174.53a	338
13	-0.75	Total>	197.30	187.28	207.32	187.28	187.28a	338
14	-1.85	Total>	216.00	205.98	226.02	205.98	205.98a	338
		48.50	167.50	42.96	888.24	76.21	124.71	1478
15	-2.73	57.25	176.25	45.20	934.64	80.19	137.44	1478
16	-3.60	66.00	185.00	47.45	981.04	84.18	150.18	1478
17	-4.22	72.25	191.25	49.05	1014.19	87.02	159.27	1478
18	-4.85	78.50	197.50	50.65	1047.33	89.86	168.36	1478
		Total>	276.00	75.00m	887.01	157.50	157.50	14064
19	-6.03	Total>	300.68	80.88m	1055.26	174.42	174.42	17369
20	-7.20	Total>	325.35	86.75m	1223.52	191.34	191.34	20674
21	-8.40	Total>	350.55	92.75m	1395.35	208.62	208.62	24049
22	-9.60	Total>	375.75	98.75m	1567.18	225.90	225.90	27424
23	-10.80	Total>	400.95	104.75m	1739.02	243.18	243.18	30800

(continued)

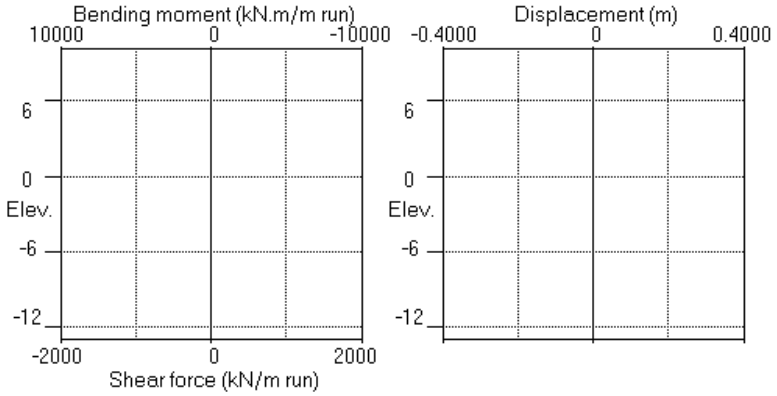
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
24	-11.90	Total> 424.05		110.25m	1896.53	259.02	259.02	122028
25	-13.00	Total> 447.15		115.75m	2054.05	274.86	274.86	297080

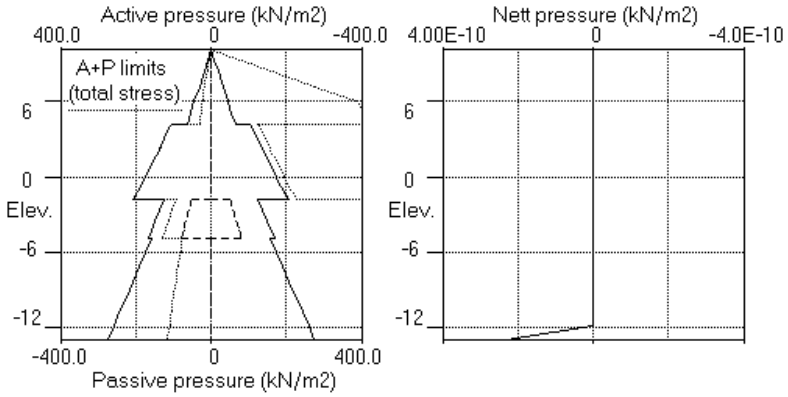
Note: 205.98a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.207	1.32E-02	0.0	-0.0		3521239
2	9.28	4.61	0.196	1.32E-02	2.0	0.6		3521239
3	8.40	9.21	0.184	1.32E-02	8.1	4.7		3521239
4	7.20	15.53	0.168	1.32E-02	22.9	22.5		3521239
5	6.00	21.85	0.152	1.32E-02	45.3	62.7		3521239
6	5.08	26.72	0.140	1.32E-02	67.8	114.7		3521239
7	4.15	31.59	0.128	1.31E-02	94.8	189.6		3521239
		103.99	0.128	1.31E-02	94.8	189.6		
8	4.00	106.54	0.126	1.31E-02	110.6	204.9		3521239
9	3.00	123.54	0.113	1.31E-02	225.6	371.6		3521239
10	2.10	129.84	0.101	1.29E-02	339.6	625.5		3521239
		119.84	0.101	1.29E-02	339.6	625.5		
11	1.05	119.84	0.087	1.27E-02	465.4	1048.2		3521239
12	0.00	119.83	0.074	1.23E-02	591.3	1603.0		3521239
13	-0.75	119.83	0.065	1.19E-02	681.1	2080.1		3521239
14	-1.85	119.83	0.052	1.11E-02	813.0	2901.9		3521239
		-96.25	0.052	1.11E-02	813.0	2901.9		
15	-2.73	-115.93	0.043	1.03E-02	720.1	3591.1		3521239
16	-3.60	-90.49	0.034	9.39E-03	629.8	4176.6		3521239
17	-4.22	-74.04	0.029	8.61E-03	578.4	4552.5		3521239
18	-4.85	-59.17	0.024	7.77E-03	536.8	4899.5		3521239
		-609.52	0.024	7.77E-03	536.8	4899.5		
19	-6.03	-484.95	0.015	6.10E-03	-106.2	5109.5		3521239
20	-7.20	-334.70	0.009	4.47E-03	-587.8	4649.8		3521239
21	-8.40	-196.11	0.005	3.05E-03	-906.2	3700.8		3521239
22	-9.60	-15.10	0.002	2.00E-03	-1033.0	2499.9		3521239
23	-10.80	209.33	-0.000	1.35E-03	-916.4	1257.7		3521239
24	-11.90	414.06	-0.002	1.10E-03	-573.6	378.3		3521239
25	-13.00	628.79	-0.003	1.04E-03	0.0	0.0		---

(continued)

Stage No.3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	533
2	9.28	0.00	16.62	4.61	81.70	4.61	4.61a	533
3	8.40	0.00	33.25	9.21	163.41	9.21	9.21a	533
4	7.20	0.00	56.05	15.53	275.46	15.53	15.53a	533
5	6.00	0.00	78.85	21.85	387.51	21.85	21.85a	533
6	5.08	0.00	96.42	26.72	473.88	26.72	26.72a	533
7	4.15	0.00	114.00	31.59	560.26	31.59	31.59a	533
		Total>	114.00	103.99	124.01	103.99	103.99a	461
8	4.00	Total>	116.55	106.54	126.56	106.54	106.54a	461
9	3.00	Total>	133.55	123.54	143.56	123.54	123.54a	461
10	2.10	Total>	148.85	138.84	158.86	138.84	138.84a	461
11	1.05	Total>	166.70	156.69	176.71	156.69	156.69a	461
12	0.00	Total>	184.55	174.54	194.56	174.54	174.54a	461
13	-0.75	Total>	197.30	187.29	207.31	187.29	187.29a	461
14	-1.85	Total>	216.00	205.98	226.02	205.98	205.98a	461
		58.50	157.50	40.40	835.21	40.40	98.90a	2134
15	-2.73	67.25	166.25	42.64	881.61	42.64	109.89a	2134
16	-3.60	76.00	175.00	44.88	928.01	44.88	120.88a	2134
17	-4.22	82.25	181.25	46.49	961.16	46.49	128.74a	2134
18	-4.85	88.50	187.50	48.09	994.30	48.09	136.59a	2134
		Total>	276.00	75.00m	887.01	75.00	75.00a	19212
19	-6.03	Total>	300.68	80.88m	1055.26	80.88	80.88a	23726
20	-7.20	Total>	325.35	86.75m	1223.51	86.75	86.75a	28241
21	-8.40	Total>	350.55	92.75m	1395.35	92.75	92.75a	32852
22	-9.60	Total>	375.75	98.75m	1567.18	162.06	162.06	37463
23	-10.80	Total>	400.95	104.75m	1739.02	278.33	278.33	130405
24	-11.90	Total>	424.05	110.25m	1896.53	488.56	488.56	143505
25	-13.00	Total>	447.15	115.75m	2054.04	708.79	708.79	156605

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.28	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	2.10	9.00	0.00	0.00	0.00	0.00	9.00	0.0
		Total>	9.00	9.00w	19.00	19.00	19.00p	657
11	1.05	Total>	26.85	16.85	36.85	36.85	36.85p	657
12	0.00	Total>	44.70	34.70	54.70	54.70	54.70p	657
13	-0.75	Total>	57.45	47.45	67.45	67.45	67.45p	657
14	-1.85	Total>	76.15	66.15	86.16	86.16	86.16p	657
		48.50	27.65	7.09	146.65	146.65	195.15p	3142
15	-2.73	57.25	36.41	9.34	193.06	168.56	225.81	3142

(continued)

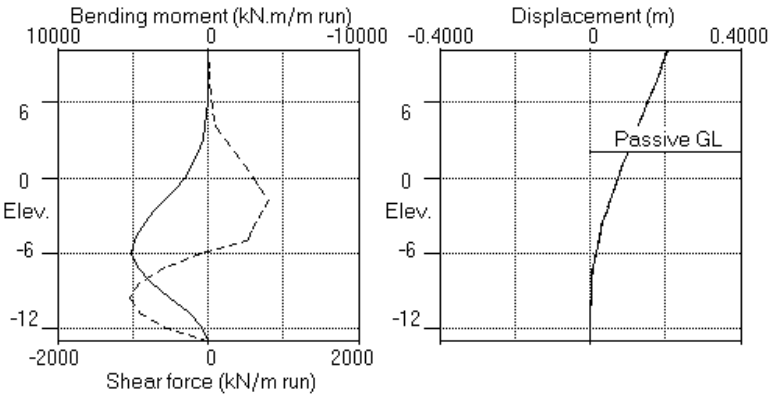
Stage No.3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

Node no.	Y coord	PASSIVE side ------- Effective stresses ------- Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
16	-3.60	66.00	45.16	11.58	239.49	145.37	211.37	3142
17	-4.22	72.25	51.41	13.19	272.65	130.52	202.77	3142
18	-4.85	78.50	57.67	14.79	305.82	117.26	195.76	3142
		Total> 136.17	39.25m	747.14	684.52	684.52		27393
19	-6.03	Total> 160.86	45.13m	915.41	565.82	565.82		33831
20	-7.20	Total> 185.55	51.00m	1083.68	421.45	421.45		40268
21	-8.40	Total> 210.77	57.00m	1255.53	288.86	288.86		46843
22	-9.60	Total> 235.99	63.00m	1427.39	177.17	177.17		53417
23	-10.80	Total> 261.22	69.00m	1599.26	69.00	69.00a		130405
24	-11.90	Total> 284.36	74.50m	1756.81	74.50	74.50a		143505
25	-13.00	Total> 307.50	80.00m	1914.36	80.00	80.00a		156605

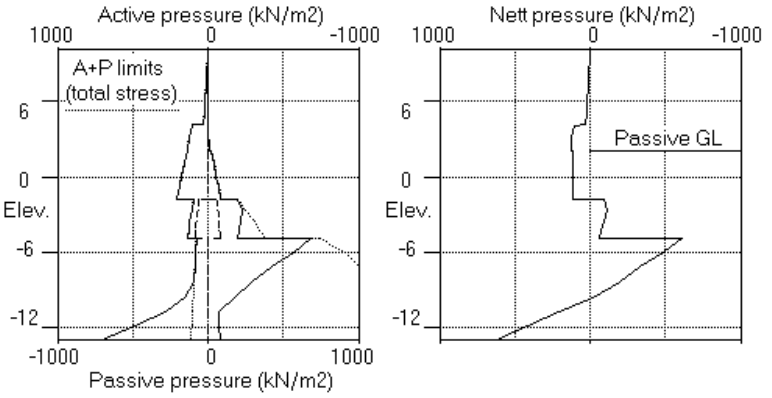
Note: 80.00a Soil pressure at active limit
195.15p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 2.10 on PASSIVE side



Stage No.3 Excav. to elev. 2.10 on PASSIVE side



Units: kN,m

Stage No. 11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.243	1.54E-02	0.0	-0.0		2515171
2	9.28	4.61	0.229	1.54E-02	2.0	4.7		2515171
3	8.40	9.21	0.216	1.54E-02	8.1	8.8		2515171
4	7.20	15.53	0.197	1.54E-02	22.9	26.7		2515171
5	6.00	21.85	0.179	1.53E-02	45.3	67.0		2515171
6	5.08	26.72	0.164	1.53E-02	67.8	119.0		2515171
7	4.15	31.59	0.150	1.53E-02	94.8	193.9		2515171
		113.99	0.150	1.53E-02	94.8	193.9		
8	4.00	116.54	0.148	1.53E-02	112.1	209.3		2515171
9	3.00	133.54	0.133	1.52E-02	237.1	386.0		2515171
10	2.10	139.84	0.119	1.51E-02	360.1	653.9		2515171
11	1.05	147.19	0.103	1.48E-02	510.8	1110.5		2515171
12	0.00	154.54	0.088	1.44E-02	669.2	1729.1		2515171
13	-0.75	159.79	0.077	1.40E-02	787.1	2275.0		2515171
		156.56	0.077	1.40E-02	787.1	2275.0		
14	-1.85	163.01	0.062	1.31E-02	962.8	3236.9		2515171
		-96.25	0.062	1.31E-02	962.8	3236.9		
15	-2.73	-140.41	0.051	1.22E-02	859.3	4058.2		2515171
16	-3.60	-110.09	0.041	1.11E-02	749.7	4756.2		2515171
17	-4.22	-90.42	0.034	1.02E-02	687.1	5203.2		2515171
18	-4.85	-72.59	0.028	9.25E-03	636.1	5614.9		2515171
		-672.14	0.028	9.25E-03	636.1	5614.9		
19	-6.03	-577.67	0.018	7.28E-03	-98.2	5906.4		2515171
20	-7.20	-397.35	0.011	5.35E-03	-671.0	5375.3		2515171
21	-8.40	-228.00	0.005	3.66E-03	-1046.2	4291.0		2515171
22	-9.60	-23.33	0.002	2.40E-03	-1197.0	2909.4		2515171
23	-10.80	241.12	-0.001	1.63E-03	-1066.3	1464.6		2515171
24	-11.90	483.04	-0.002	1.33E-03	-668.0	439.6		2515171
25	-13.00	731.55	-0.004	1.26E-03	-0.0	0.0		---

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	507
2	9.28	0.00	16.62	4.61	81.70	4.61	4.61a	507
3	8.40	0.00	33.25	9.21	163.41	9.21	9.21a	507
4	7.20	0.00	56.05	15.53	275.46	15.53	15.53a	507
5	6.00	0.00	78.85	21.85	387.51	21.85	21.85a	507

(continued)

Stage No.11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
6	5.08	0.00	96.42	26.72	473.88	26.72	26.72a	507
7	4.15	0.00	114.00	31.59	560.26	31.59	31.59a	507
		0.00	114.00	113.99	114.01	113.99	113.99a	225
8	4.00	0.00	116.55	116.54	116.56	116.54	116.54a	225
9	3.00	10.00	123.55	123.54	123.56	123.54	133.54a	225
10	2.10	19.00	129.85	129.84	129.86	129.84	148.84a	225
11	1.05	29.50	137.20	137.19	137.21	137.19	166.69a	225
12	0.00	40.00	144.55	144.54	144.56	144.54	184.54a	225
13	-0.75	47.50	149.80	149.79	149.81	149.79	197.29a	225
14	-1.85	58.50	157.50	157.48	157.52	157.48	215.98a	225
		58.50	157.50	40.40	835.21	40.40	98.90a	2030
15	-2.73	67.25	166.25	42.64	881.61	42.64	109.89a	2030
16	-3.60	76.00	175.00	44.88	928.01	44.88	120.88a	2030
17	-4.22	82.25	181.25	46.49	961.16	46.49	128.74a	2030
18	-4.85	88.50	187.50	48.09	994.30	48.09	136.59a	2030
		Total> 276.00	75.00m	887.01	75.00	75.00a	18375	
19	-6.03	Total> 300.68	80.88m	1055.26	80.88	80.88a	22693	
20	-7.20	Total> 325.35	86.75m	1223.51	86.75	86.75a	27012	
21	-8.40	Total> 350.55	92.75m	1395.35	92.75	92.75a	31422	
22	-9.60	Total> 375.75	98.75m	1567.18	158.20	158.20	35832	
23	-10.80	Total> 400.95	104.75m	1739.02	310.12	310.12	101434	
24	-11.90	Total> 424.05	110.25m	1896.53	557.54	557.54	111624	
25	-13.00	Total> 447.15	115.75m	2054.04	811.55	811.55	121814	

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.28	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	2.10	9.00	0.00	0.00	0.00	0.00	9.00	0.0
		9.00	0.00	0.00	0.00	0.00	9.00	340
11	1.05	19.50	7.35	-0.01	0.00b	0.00	19.50p	340
12	0.00	30.00	14.70	-0.01	-0.00b	-0.00	30.00p	340
13	-0.75	37.50	19.95	-0.01	0.00b	0.00	37.50p	340
		37.50	19.95	3.22	3.23b	3.23	40.73p	340
14	-1.85	48.50	27.65	4.46	4.47b	4.47	52.97p	340
		48.50	27.65	7.09	146.65	146.65	195.15p	3040
15	-2.73	57.25	36.41	9.34	193.06	193.05	250.30	3040
16	-3.60	66.00	45.16	11.58	239.49	164.98	230.98	3040
17	-4.22	72.25	51.41	13.19	272.65	146.91	219.16	3040
18	-4.85	78.50	57.67	14.79	305.82	130.68	209.18	3040
		Total> 136.17	39.25m	747.14	747.14	747.14p	26566	
19	-6.03	Total> 160.86	45.13m	915.41	658.55	658.55	32809	
20	-7.20	Total> 185.55	51.00m	1083.68	484.10	484.10	39052	

(continued)

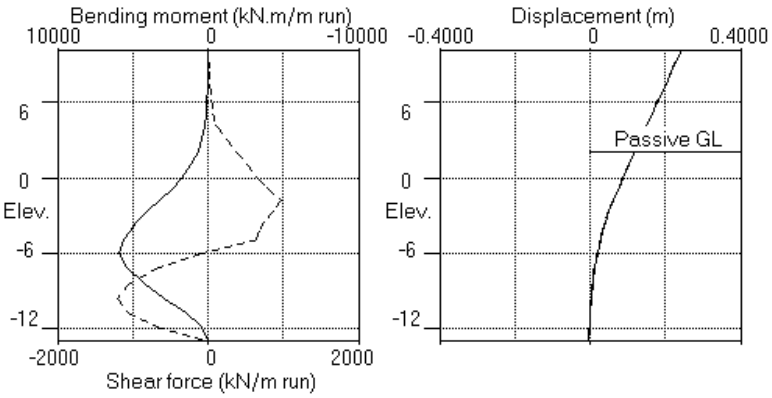
Stage No.11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	-8.40	Total>	210.77	57.00m	1255.53	320.75	320.75	45427
22	-9.60	Total>	235.99	63.00m	1427.39	181.53	181.53	51803
23	-10.80	Total>	261.22	69.00m	1599.26	69.00	69.00a	101434
24	-11.90	Total>	284.36	74.50m	1756.81	74.50	74.50a	111624
25	-13.00	Total>	307.50	80.00m	1914.36	80.00	80.00a	121814

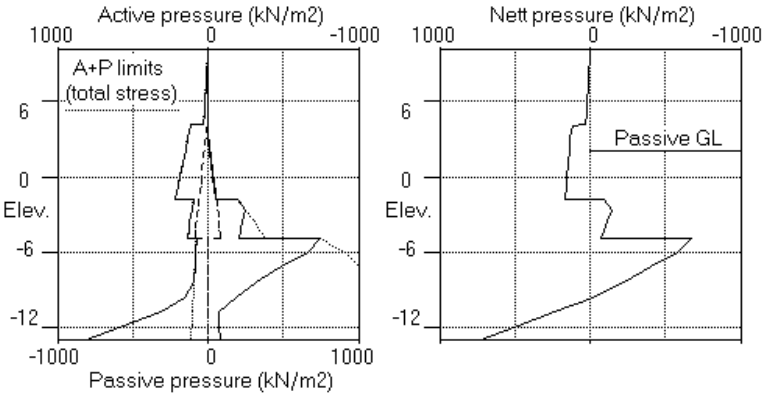
Note: 80.00a Soil pressure at active limit
747.14p Soil pressure at passive limit
4.47b Passive limit reduced because of berm

Units: kN,m

Stage No.11 Change soil type 3 to soil type 4



Stage No.11 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	10.15	0.257	0.000	0	-0	0	-0	0	0	0	0
2	9.28	0.242	0.000	19	0	26	0	34	0	45	0
3	8.40	0.228	0.000	62	-0	83	-0	62	0	83	0
4	7.20	0.208	0.000	156	-0	210	-0	92	0	124	0
5	6.00	0.188	0.000	279	-0	377	-0	111	0	150	0
6	5.08	0.173	0.000	387	-0	523	-0	120	0	161	0
7	4.15	0.158	0.000	499	-0	674	-0	122	0	164	0
8	4.00	0.156	0.000	518	-0	700	-0	132	0	179	0
9	3.00	0.140	0.000	692	-0	934	-0	257	0	346	0
10	2.10	0.125	0.000	912	-0	1231	-0	383	0	518	0
11	1.05	0.108	0.000	1258	-0	1698	-0	535	0	722	0
12	0.00	0.092	0.000	1864	-0	2517	-0	693	0	936	0
13	-0.75	0.081	0.000	2428	-0	3277	-0	809	0	1092	0
14	-1.85	0.065	0.000	3411	-0	4605	-0	979	0	1321	0
15	-2.73	0.053	0.000	4247	-0	5733	-0	877	0	1184	0
16	-3.60	0.043	0.000	4961	-0	6697	-0	766	0	1034	0
17	-4.22	0.036	0.000	5417	-0	7313	-0	701	0	946	0
18	-4.85	0.029	0.000	5836	-0	7879	-0	648	0	875	0
19	-6.03	0.019	0.000	6142	-0	8291	-0	0	-120	0	-162
20	-7.20	0.011	0.000	5587	0	7543	0	0	-701	0	-947
21	-8.40	0.006	0.000	4455	0	6014	0	0	-1091	0	-1473
22	-9.60	0.002	0.000	3014	0	4069	0	0	-1244	0	-1680
23	-10.80	0.000	-0.001	1515	0	2045	0	0	-1105	0	-1491
24	-11.90	0.000	-0.002	454	0	613	0	0	-691	0	-933
25	-13.00	0.000	-0.004	0	0	0	0	0	-0	0	-0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
no.	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	0	-11.90	-0	-3.60	0	-0	0	-13.00	0	10.15	0	0
2	No calculation at this stage											
3	5109	-6.03	-0	10.15	6898	-0	813	-1.85	-1033	-9.60	1097	-1395
4	5452	-6.03	-0	10.15	7360	-0	857	-1.85	-1100	-9.60	1156	-1485
5	5540	-6.03	-0	10.15	7479	-0	871	-1.85	-1118	-9.60	1176	-1509
6	No calculation at this stage											
7	3982	-6.03	-0	10.15	5375	-0	595	-1.85	-815	-9.60	803	-1101
8	3796	-6.03	-0	10.15	5124	-0	573	-1.85	-783	-9.60	773	-1057
9	3760	-6.03	-0	10.15	5077	-0	564	-1.85	-776	-9.60	761	-1047
10	5378	-6.03	-0	10.15	7261	-0	840	-1.85	-1087	-9.60	1134	-1467
11	5906	-6.03	-0	10.15	7974	-0	963	-1.85	-1197	-9.60	1300	-1616
12	No calculation at this stage											
13	6084	-6.03	-0	10.15	8214	-0	971	-1.85	-1232	-9.60	1311	-1663
14	6142	-6.03	-0	10.15	8291	-0	979	-1.85	-1244	-9.60	1321	-1680
15	4422	-6.03	-0	10.15	5969	-0	653	-1.85	-909	-9.60	881	-1228

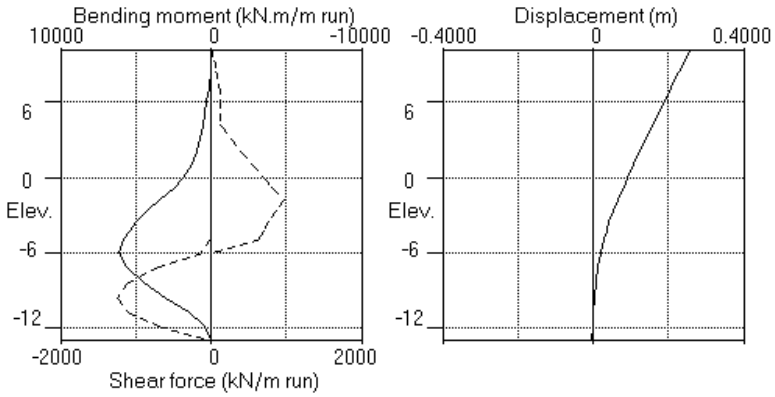
Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	10.15	-0.000	-13.00	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.207	10.15	-0.003	-13.00	Excav. to elev. 2.10 on PASSIVE side
4	0.222	10.15	-0.003	-13.00	Apply surcharge no.1 at elev. 10.15
5	0.225	10.15	-0.003	-13.00	Apply surcharge no.2 at elev. 10.15
6	No calculation at this stage				Change EI of wall to 2.5152E+06kN.m2/m run
7	0.156	10.15	-0.003	-13.00	Apply water pressure profile no.2
8	0.145	10.15	-0.003	-13.00	Remove surcharge no.1 at elev. 10.15
9	0.144	10.15	-0.003	-13.00	Remove surcharge no.2 at elev. 10.15
10	0.218	10.15	-0.003	-13.00	Apply water pressure profile no.1
11	0.243	10.15	-0.004	-13.00	Change soil type 3 to soil type 4
12	No calculation at this stage				Change soil type 4 to soil type 3
13	0.254	10.15	-0.004	-13.00	Apply surcharge no.1 at elev. 10.15
14	0.257	10.15	-0.004	-13.00	Apply surcharge no.2 at elev. 10.15
15	0.181	10.15	-0.003	-13.00	Apply water pressure profile no.2

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	10.15	1 Made ground (D)	7 Made ground (P)
2	4.15	3 Tidal deposits (U)	3 Tidal deposits (U)
3	-1.85	6 RT deposits	6 RT deposits
4	-4.85	5 WRock	5 WRock

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made ground (D)	19.00	5000	0.562	OC (0.250)	0.277 (0.000)	4.915 (0.000)	
2	Not defined							
3	Tidal deposits (U)	17.00	3000	0.577	NC (0.490)	1.000 (1.000)	1.000 (1.000)	10.00u
4	Tidal deposits (D)	17.00	2400	0.577	NC (0.150)	1.000 (1.000)	1.000 (1.000)	0.0d
5	WRock (-4.85)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	RT deposits	20.00	20000	0.455	OC (0.250)	0.256 (0.000)	5.303 (0.000)	
7	Made ground (P)	19.00	5000	0.562	OC (0.250)	0.277 (0.000)	4.915 (0.000)	

Additional soil parameters associated with Ka and Kp

No.	Soil type	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made ground (D)	30.00	0.826	0.00	30.00	0.826	0.00
2	Not defined						
3	Tidal deposits (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
4	Tidal deposits (D)	0.00	-0.674	0.00	0.00	-0.674	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	RT deposits	33.00	0.500	0.00	33.00	0.500	0.00
7	Made ground (P)	30.00	0.826	0.00	30.00	0.826	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	3.80	3.80

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	4.80	4.80	0.0	1	3.80	3.80	0.0	MC+WC
2	1	4.80	4.80	0.0	1	7.00	7.00	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall = -13.00
             Maximum finite element length =   1.20 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 0.15061 m4/m run
                                       E.I = 3.5212E+06 kN.m2/m run
                     Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.15	0.00(A)	7.50	100.00	10.00	=	N/A	1.00 P/U
2	10.15	7.50(A)	11.00	100.00	20.00	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
2	Apply water pressure profile no.1 (Worst Cred.) No analysis at this stage
3	Excavate to elevation 2.10 on PASSIVE side Toe of berm at elevation -0.75 Width of top of berm = 0.01 Width of toe of berm = 13.10
4	Apply surcharge no.1 at elevation 10.15
5	Apply surcharge no.2 at elevation 10.15
6	Change EI of wall to 2.5152E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
7	Apply water pressure profile no.2 (Worst Cred.)
8	Remove surcharge no.1 at elevation 10.15
9	Remove surcharge no.2 at elevation 10.15
10	Apply water pressure profile no.1 (Worst Cred.)
11	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
12	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
13	Apply surcharge no.1 at elevation 10.15
14	Apply surcharge no.2 at elevation 10.15
15	Apply water pressure profile no.2 (Worst Cred.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: ULS DA1 Combination 2
  Water pressures : Worst Credible
  Partial factor on   C'         = 1.250
  Partial factor on Phi'         = 1.250
  Partial factor on   Cu         = 1.400
  Partial factor on Soil Modulus = 1.000
  Partial factor on Permanent Unfavourable loads = 1.000
  Partial factor on Permanent Favourable loads   = 1.000
  Partial factor on Variable Unfavourable loads  = 1.300

 Stability analysis:
  Method of analysis  -  Strength Factor method
  Overall factor on soil strength for calculating wall depth = 1.00

 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
```

Non-linear Modulus Parameter (L) = 25.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 40.00 m
Width of excavation on passive side of wall = 100.00 m

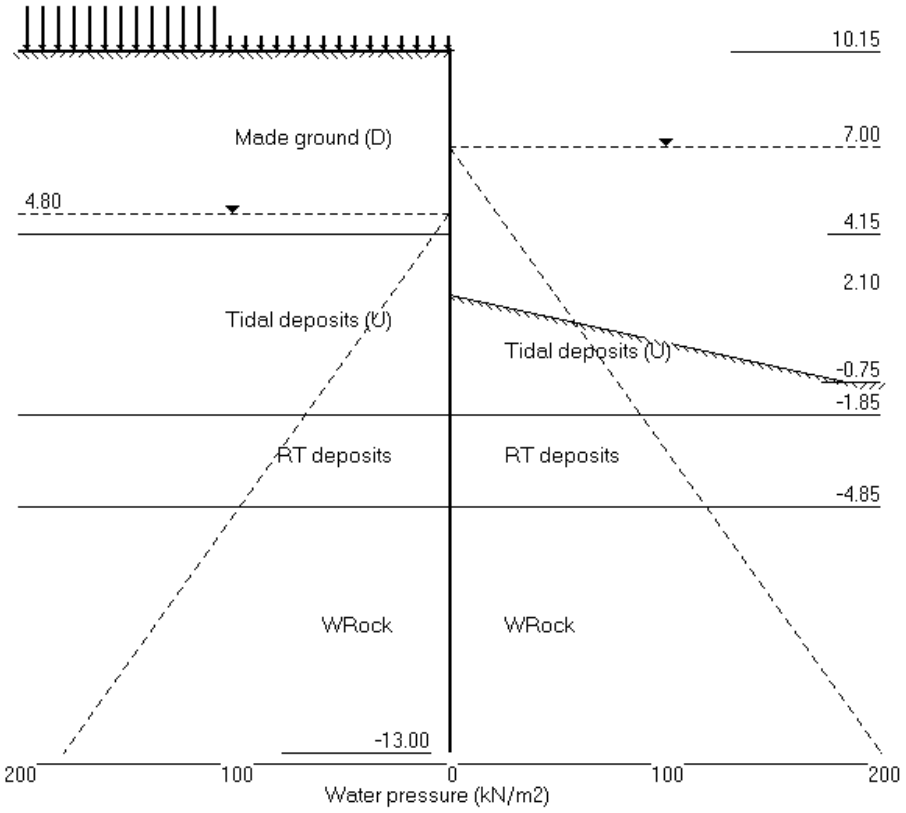
Distance to rigid boundary on active side = 100.00 m
Distance to rigid boundary on passive side = 100.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Excav. to elev. 2.10 on PASSIVE side	No	No	No
4	Apply surcharge no.1 at elev. 10.15	No	No	No
5	Apply surcharge no.2 at elev. 10.15	No	No	No
6	Change EI of wall to 2.5152E+06kN.m2/m	No	No	No
7	Apply water pressure profile no.2	No	No	No
8	Remove surcharge no.1 at elev. 10.15	No	No	No
9	Remove surcharge no.2 at elev. 10.15	No	No	No
10	Apply water pressure profile no.1	No	No	No
11	Change soil type 3 to soil type 4	No	No	No
12	Change soil type 4 to soil type 3	No	No	No
13	Apply surcharge no.1 at elev. 10.15	No	No	No
14	Apply surcharge no.2 at elev. 10.15	No	No	No
15	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.15 Apply water pressure profile no.2 (Worst Cred.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.15	10.15	Cant.	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.000	4.88E-16	0.0	0.0		3521239
2	9.28	0.00	0.000	4.88E-16	0.0	-0.0		3521239
3	8.40	0.00	0.000	4.89E-16	0.0	-0.0		3521239
4	7.70	0.00	0.000	4.93E-16	0.0	-0.0		3521239
5	7.00	0.00	0.000	5.00E-16	0.0	-0.0		3521239
6	5.90	0.00	0.000	5.23E-16	0.0	-0.0		3521239
7	4.80	0.00	0.000	5.62E-16	0.0	-0.0		3521239
8	4.15	0.00	0.000	5.96E-16	0.0	-0.0		3521239
9	3.80	0.00	0.000	6.17E-16	0.0	-0.0		3521239
10	2.95	0.00	0.000	6.79E-16	0.0	-0.0		3521239
11	2.10	0.00	0.000	7.54E-16	0.0	-0.0		3521239
12	1.05	0.00	0.000	8.50E-16	0.0	-0.0		3521239
13	0.00	0.00	0.000	9.37E-16	0.0	-0.0		3521239
14	-0.75	0.00	0.000	9.92E-16	0.0	-0.0		3521239
15	-1.85	0.00	0.000	1.06E-15	0.0	-0.0		3521239
16	-2.73	0.00	0.000	1.10E-15	0.0	-0.0		3521239
17	-3.60	0.00	0.000	1.11E-15	0.0	-0.0		3521239
18	-4.22	0.00	0.000	1.11E-15	0.0	0.0		3521239
19	-4.85	0.00	0.000	1.08E-15	0.0	0.0		3521239
20	-6.03	-0.00	0.000	9.82E-16	-0.0	0.0		3521239
21	-7.20	-0.00	0.000	8.33E-16	-0.0	0.0		3521239
22	-8.40	0.00	0.000	6.60E-16	-0.0	0.0		3521239
23	-9.60	0.00	0.000	4.99E-16	-0.0	0.0		3521239
24	-10.80	0.00	0.000	3.91E-16	-0.0	0.0		3521239
25	-11.90	0.00	0.000	3.48E-16	-0.0	0.0		3521239
26	-13.00	0.00	0.000	3.38E-16	-0.0	0.0		---

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	ACTIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	420
2	9.28	0.00	16.62	5.78	58.47	9.34	9.34	420
3	8.40	0.00	33.25	11.56	116.93	18.69	18.69	420
4	7.70	0.00	46.55	16.18	163.70	26.16	26.16	420
5	7.00	0.00	59.85	20.80	210.48	33.64	33.64	420
6	5.90	0.00	80.75	28.07	283.97	45.38	45.38	420
7	4.80	0.00	101.65	35.33	357.47	57.13	57.13	420
8	4.15	0.00	114.00	39.62	400.91	64.07	64.07	420
		Total> 114.00		106.85	121.15	106.85	106.85a	375
9	3.80	Total> 119.95		112.80	127.10	112.80	112.80a	375
10	2.95	Total> 134.40		127.24	141.56	127.24	127.24a	375
11	2.10	Total> 148.85		141.69	156.01	141.69	141.69a	375
12	1.05	Total> 166.70		159.54	173.86	159.54	159.54a	375
13	0.00	Total> 184.55		177.39	191.71	177.39	177.39a	375
14	-0.75	Total> 197.30		190.14	204.46	190.14	190.14a	375
15	-1.85	Total> 216.00		208.84	223.16	208.84	208.84a	375
		56.50	159.50	51.96	597.34	72.57	129.07	1681
16	-2.73	65.25	168.25	54.81	630.10	76.55	141.80	1681
17	-3.60	74.00	177.00	57.66	662.87	80.54	154.54	1681
18	-4.22	80.25	183.25	59.69	686.28	83.38	163.63	1681
19	-4.85	86.50	189.50	61.73	709.69	86.22	172.72	1681
		Total> 276.00		75.00m	712.45	162.30	162.30	15616
20	-6.03	Total> 300.68		80.88m	839.68	179.22	179.22	19286
21	-7.20	Total> 325.35		86.75m	966.91	196.14	196.14	22955
22	-8.40	Total> 350.55		92.75m	1096.85	213.42	213.42	26703
23	-9.60	Total> 375.75		98.75m	1226.79	230.70	230.70	30451
24	-10.80	Total> 400.95		104.75m	1356.73	247.98	247.98	34199
25	-11.90	Total> 424.05		110.25m	1475.84	263.82	263.82	37634
26	-13.00	Total> 447.15		115.75m	1594.95	279.66	279.66	41070

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	420
2	9.28	0.00	16.62	5.78	58.47	9.34	9.34	420
3	8.40	0.00	33.25	11.56	116.93	18.69	18.69	420
4	7.70	0.00	46.55	16.18	163.70	26.16	26.16	420
5	7.00	0.00	59.85	20.80	210.48	33.64	33.64	420
6	5.90	0.00	80.75	28.07	283.97	45.38	45.38	420
7	4.80	0.00	101.65	35.33	357.47	57.13	57.13	420
8	4.15	0.00	114.00	39.62	400.91	64.07	64.07	420
		Total> 114.00		106.85	121.15	106.85	106.85a	375
9	3.80	Total> 119.95		112.80	127.10	112.80	112.80a	375
10	2.95	Total> 134.40		127.24	141.56	127.24	127.24a	375
11	2.10	Total> 148.85		141.69	156.01	141.69	141.69a	375
12	1.05	Total> 166.70		159.54	173.86	159.54	159.54a	375
13	0.00	Total> 184.55		177.39	191.71	177.39	177.39a	375
14	-0.75	Total> 197.30		190.14	204.46	190.14	190.14a	375
15	-1.85	Total> 216.00		208.84	223.16	208.84	208.84a	375
		56.50	159.50	51.96	597.34	72.57	129.07	1681

(continued)

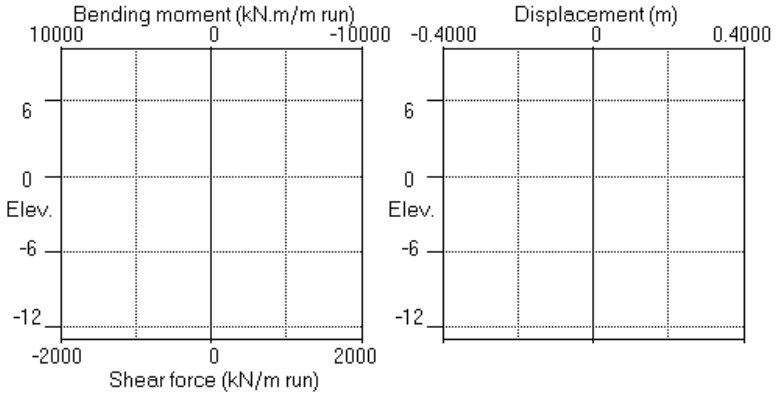
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
16	-2.73	65.25	168.25	54.81	630.10	76.55	141.80	1681
17	-3.60	74.00	177.00	57.66	662.87	80.54	154.54	1681
18	-4.22	80.25	183.25	59.69	686.28	83.38	163.63	1681
19	-4.85	86.50	189.50	61.73	709.69	86.22	172.72	1681
		Total> 276.00		75.00m	712.45	162.30	162.30	15616
20	-6.03	Total> 300.68		80.88m	839.68	179.22	179.22	19286
21	-7.20	Total> 325.35		86.75m	966.91	196.14	196.14	22955
22	-8.40	Total> 350.55		92.75m	1096.85	213.42	213.42	26703
23	-9.60	Total> 375.75		98.75m	1226.79	230.70	230.70	30451
24	-10.80	Total> 400.95		104.75m	1356.73	247.98	247.98	34199
25	-11.90	Total> 424.05		110.25m	1475.84	263.82	263.82	37634
26	-13.00	Total> 447.15		115.75m	1594.95	279.66	279.66	41070

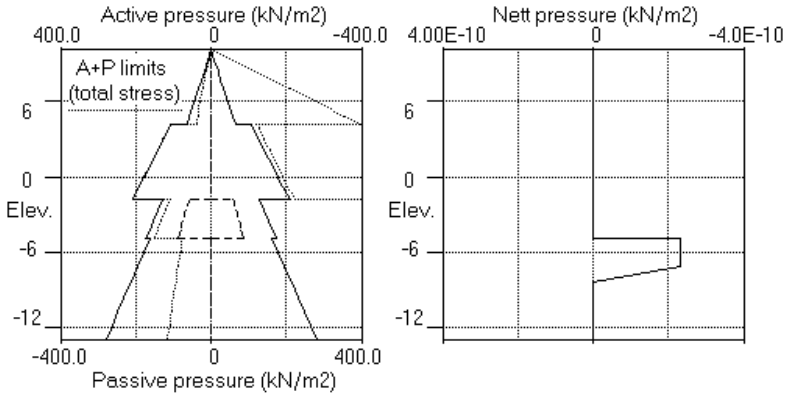
Note: 208.84a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetration
3	10.15	2.10	Cant.	1.188	-10.41	-12.04	14.14

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.233	1.48E-02	0.0	0.0		3521239
2	9.28	5.78	0.220	1.48E-02	2.5	0.7		3521239
3	8.40	11.56	0.207	1.48E-02	10.1	5.9		3521239
4	7.70	16.18	0.197	1.48E-02	19.8	16.2		3521239
5	7.00	20.80	0.186	1.48E-02	32.8	34.4		3521239
6	5.90	28.07	0.170	1.48E-02	59.6	84.5		3521239
7	4.80	35.33	0.154	1.47E-02	94.5	168.5		3521239
8	4.15	43.87	0.144	1.47E-02	120.3	238.0		3521239
		106.85	0.144	1.47E-02	120.3	238.0		
9	3.80	112.80	0.139	1.46E-02	158.7	286.8		3521239
10	2.95	118.75	0.127	1.46E-02	257.1	463.1		3521239
11	2.10	124.69	0.114	1.44E-02	360.6	725.3		3521239
		117.55	0.114	1.44E-02	360.6	725.3		
12	1.05	117.55	0.099	1.41E-02	484.0	1168.7		3521239
13	0.00	117.55	0.084	1.37E-02	607.4	1741.7		3521239
14	-0.75	117.55	0.074	1.33E-02	695.6	2230.3		3521239
15	-1.85	117.54	0.060	1.24E-02	824.9	3066.5		3521239
		-44.87	0.060	1.24E-02	824.9	3066.5		
16	-2.73	-74.80	0.049	1.16E-02	772.5	3767.3		3521239
17	-3.60	-95.70	0.040	1.06E-02	697.9	4427.7		3521239
18	-4.22	-76.63	0.033	9.80E-03	644.1	4845.2		3521239
19	-4.85	-59.24	0.027	8.91E-03	601.6	5232.7		3521239
		-505.58	0.027	8.91E-03	601.6	5232.7		
20	-6.03	-573.17	0.018	7.08E-03	-32.2	5714.2		3521239
21	-7.20	-409.01	0.011	5.25E-03	-609.2	5278.6		3521239
22	-8.40	-245.11	0.006	3.62E-03	-1001.7	4250.4		3521239
23	-9.60	-43.73	0.002	2.41E-03	-1175.0	2900.9		3521239
24	-10.80	232.74	-0.000	1.66E-03	-1061.5	1469.9		3521239

(continued)

Stage No.3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
25	-11.90	479.15	-0.002	1.36E-03	-670.0	445.0		3521239
26	-13.00	739.05	-0.004	1.29E-03	0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	531
2	9.28	0.00	16.62	5.78	58.47	5.78	5.78a	531
3	8.40	0.00	33.25	11.56	116.93	11.56	11.56a	531
4	7.70	0.00	46.55	16.18	163.70	16.18	16.18a	531
5	7.00	0.00	59.85	20.80	210.48	20.80	20.80a	531
6	5.90	0.00	80.75	28.07	283.97	28.07	28.07a	531
7	4.80	0.00	101.65	35.33	357.47	35.33	35.33a	531
8	4.15	6.50	107.50	37.37	378.05	37.37	43.87a	531
		Total> 114.00	106.85	121.15	106.85	106.85a		460
9	3.80	Total> 119.95	112.80	127.10	112.80	112.80a		460
10	2.95	Total> 134.40	127.25	141.55	127.25	127.25a		460
11	2.10	Total> 148.85	141.69	156.01	141.69	141.69a		460
12	1.05	Total> 166.70	159.54	173.86	159.54	159.54a		460
13	0.00	Total> 184.55	177.39	191.71	177.39	177.39a		460
14	-0.75	Total> 197.30	190.14	204.46	190.14	190.14a		460
15	-1.85	Total> 216.00	208.84	223.16	208.84	208.84a		460
		66.50	149.50	48.70	559.88	48.70	115.20a	2126
16	-2.73	75.25	158.25	51.55	592.65	51.55	126.80a	2126
17	-3.60	84.00	167.00	54.40	625.42	54.40	138.40a	2126
18	-4.22	90.25	173.25	56.43	648.83	56.43	146.68a	2126
19	-4.85	96.50	179.50	58.47	672.24	58.47	154.97a	2126
		Total> 276.00	75.00m	712.44	75.00	75.00a		19148
20	-6.03	Total> 300.68	80.88m	839.68	80.88	80.88a		23648
21	-7.20	Total> 325.35	86.75m	966.91	86.75	86.75a		28147
22	-8.40	Total> 350.55	92.75m	1096.85	92.75	92.75a		32743
23	-9.60	Total> 375.75	98.75m	1226.79	158.10	158.10		37338
24	-10.80	Total> 400.95	104.75m	1356.73	305.74	305.74		127748
25	-11.90	Total> 424.05	110.25m	1475.84	557.65	557.65		140581
26	-13.00	Total> 447.15	115.75m	1594.95	823.05	823.05		153414

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.28	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	5.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	4.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	2.95	8.50	0.00	0.00	0.00	0.00	8.50	0.0

(continued)

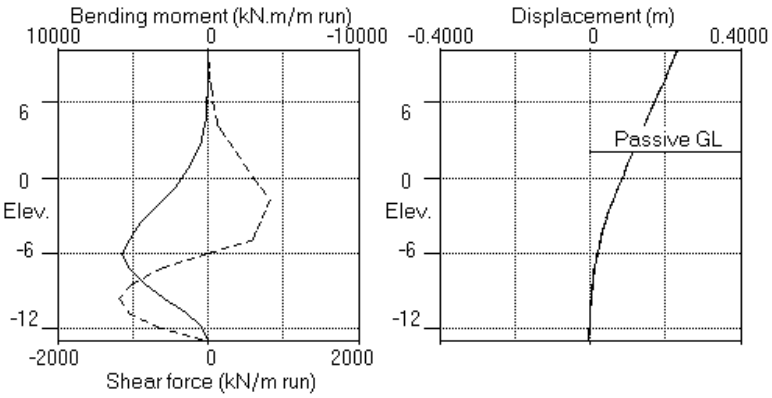
Stage No.3 Excavate to elevation 2.10 on PASSIVE side
Toe of berm at elevation -0.75
Width of top of berm = 0.01
Width of toe of berm = 13.10

Node no.	Y coord	PASSIVE side ------- Effective stresses ------- Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
11	2.10	17.00	0.00	0.00	0.00	0.00	17.00	0.0
		Total> 17.00	17.00w	24.14	24.14		24.14p	651
12	1.05	Total> 34.85	27.71	41.99	41.99		41.99p	651
13	0.00	Total> 52.70	45.56	59.84	59.84		59.84p	651
14	-0.75	Total> 65.45	58.31	72.60	72.60		72.60p	651
15	-1.85	Total> 84.15	77.01	91.30	91.30		91.30p	651
		56.50	27.65	9.01	103.56	103.56	160.06p	3110
16	-2.73	65.25	36.41	11.86	136.34	136.34	201.59p	3110
17	-3.60	74.00	45.16	14.71	169.13	160.10	234.10	3110
18	-4.22	80.25	51.41	16.75	192.55	143.07	223.32	3110
19	-4.85	86.50	57.67	18.78	215.97	127.71	214.21	3110
		Total> 144.17	43.25m	580.58	580.58		580.58p	27137
20	-6.03	Total> 168.85	49.13m	707.83	654.05		654.05	33514
21	-7.20	Total> 193.54	55.00m	835.07	495.76		495.76	39891
22	-8.40	Total> 218.76	61.00m	965.03	337.86		337.86	46404
23	-9.60	Total> 243.99	67.00m	1095.00	201.83		201.83	52917
24	-10.80	Total> 269.22	73.00m	1224.96	73.00		73.00a	127748
25	-11.90	Total> 292.35	78.50m	1344.11	78.50		78.50a	140581
26	-13.00	Total> 315.49	84.00m	1463.26	84.00		84.00a	153414

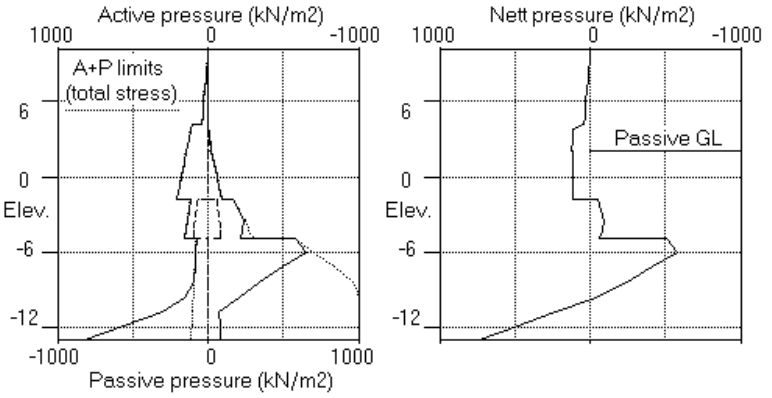
Note: 84.00a Soil pressure at active limit
580.58p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 2.10 on PASSIVE side



Stage No.3 Excav. to elev. 2.10 on PASSIVE side



Units: kN,m

Stage No. 11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
11	10.15	2.10	Cant.	1.094	-10.40	-12.48	14.58

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.269	1.68E-02	0.0	0.0		2515171
2	9.28	5.78	0.254	1.68E-02	2.5	1.7		2515171
3	8.40	11.56	0.239	1.68E-02	10.1	6.9		2515171
4	7.70	16.18	0.227	1.68E-02	19.8	17.2		2515171
5	7.00	20.80	0.215	1.68E-02	32.8	35.5		2515171
6	5.90	28.07	0.197	1.68E-02	59.6	85.6		2515171
7	4.80	35.33	0.178	1.67E-02	94.5	169.7		2515171
8	4.15	43.87	0.167	1.67E-02	120.3	239.2		2515171
		113.99	0.167	1.67E-02	120.3	239.2		
9	3.80	119.94	0.162	1.67E-02	161.2	288.4		2515171
10	2.95	125.89	0.147	1.66E-02	265.7	469.5		2515171
11	2.10	131.84	0.133	1.65E-02	375.2	741.6		2515171
12	1.05	139.19	0.116	1.62E-02	517.5	1209.2		2515171
13	0.00	146.54	0.099	1.58E-02	667.5	1830.7		2515171
14	-0.75	151.79	0.088	1.53E-02	779.4	2373.1		2515171
		148.56	0.088	1.53E-02	779.4	2373.1		
15	-1.85	155.01	0.071	1.44E-02	946.3	3321.7		2515171
		-44.87	0.071	1.44E-02	946.3	3321.7		
16	-2.73	-74.80	0.059	1.35E-02	894.0	4129.0		2515171
17	-3.60	-104.73	0.047	1.24E-02	815.4	4894.7		2515171
18	-4.22	-95.98	0.040	1.15E-02	752.7	5384.7		2515171
19	-4.85	-75.59	0.033	1.05E-02	699.1	5836.4		2515171
		-505.58	0.033	1.05E-02	699.1	5836.4		
20	-6.03	-626.95	0.022	8.44E-03	33.7	6433.5		2515171
21	-7.20	-500.62	0.013	6.34E-03	-628.7	6035.4		2515171
22	-8.40	-301.93	0.007	4.44E-03	-1110.3	4921.7		2515171
23	-9.60	-83.83	0.002	2.99E-03	-1341.7	3406.5		2515171
24	-10.80	250.40	-0.001	2.09E-03	-1241.8	1747.0		2515171
25	-11.90	559.92	-0.003	1.73E-03	-796.1	534.4		2515171
26	-13.00	887.51	-0.005	1.64E-03	0.0	0.0		---

(continued)

Stage No.11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	ACTIVE side						
		Effective stresses				Earth pressure	Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	482
2	9.28	0.00	16.62	5.78	58.47	5.78	5.78a	482
3	8.40	0.00	33.25	11.56	116.93	11.56	11.56a	482
4	7.70	0.00	46.55	16.18	163.70	16.18	16.18a	482
5	7.00	0.00	59.85	20.80	210.48	20.80	20.80a	482
6	5.90	0.00	80.75	28.07	283.97	28.07	28.07a	482
7	4.80	0.00	101.65	35.33	357.47	35.33	35.33a	482
8	4.15	6.50	107.50	37.37	378.05	37.37	43.87a	482
		6.50	107.50	107.49	107.51	107.49	113.99a	214
9	3.80	10.00	109.95	109.94	109.96	109.94	119.94a	214
10	2.95	18.50	115.90	115.89	115.91	115.89	134.39a	214
11	2.10	27.00	121.85	121.84	121.86	121.84	148.84a	214
12	1.05	37.50	129.20	129.19	129.21	129.19	166.69a	214
13	0.00	48.00	136.55	136.54	136.56	136.54	184.54a	214
14	-0.75	55.50	141.80	141.79	141.81	141.79	197.29a	214
15	-1.85	66.50	149.50	149.49	149.51	149.49	215.99a	214
		66.50	149.50	48.70	559.88	48.70	115.20a	1928
16	-2.73	75.25	158.25	51.55	592.65	51.55	126.80a	1928
17	-3.60	84.00	167.00	54.40	625.42	54.40	138.40a	1928
18	-4.22	90.25	173.25	56.43	648.83	56.43	146.68a	1928
19	-4.85	96.50	179.50	58.47	672.24	58.47	154.97a	1928
		Total> 276.00		75.00m	712.44	75.00	75.00a	17561
20	-6.03	Total> 300.68		80.88m	839.68	80.88	80.88a	21688
21	-7.20	Total> 325.35		86.75m	966.91	86.75	86.75a	25815
22	-8.40	Total> 350.55		92.75m	1096.85	92.75	92.75a	30030
23	-9.60	Total> 375.75		98.75m	1226.79	141.14	141.14	34245
24	-10.80	Total> 400.95		104.75m	1356.73	323.40	323.40	130951
25	-11.90	Total> 424.05		110.25m	1475.84	638.42	638.42	144105
26	-13.00	Total> 447.15		115.75m	1594.95	971.51	971.51	157260

Node no.	Y coord	PASSIVE side						
		Effective stresses				Earth pressure	Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.28	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	5.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	4.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	2.95	8.50	0.00	0.00	0.00	0.00	8.50	0.0
11	2.10	17.00	0.00	0.00	0.00	0.00	17.00	0.0
		17.00	0.00	0.00	0.00	0.00	17.00	317
12	1.05	27.50	7.35	-0.01	0.00b	0.00	27.50p	317
13	0.00	38.00	14.70	-0.01	-0.00b	-0.00	38.00p	317
14	-0.75	45.50	19.95	-0.01	-0.00b	-0.00	45.50p	317
		45.50	19.95	3.22	3.23b	3.23	48.73p	317
15	-1.85	56.50	27.65	4.46	4.47b	4.47	60.97p	317
		56.50	27.65	9.01	103.56	103.56	160.06p	2837

(continued)

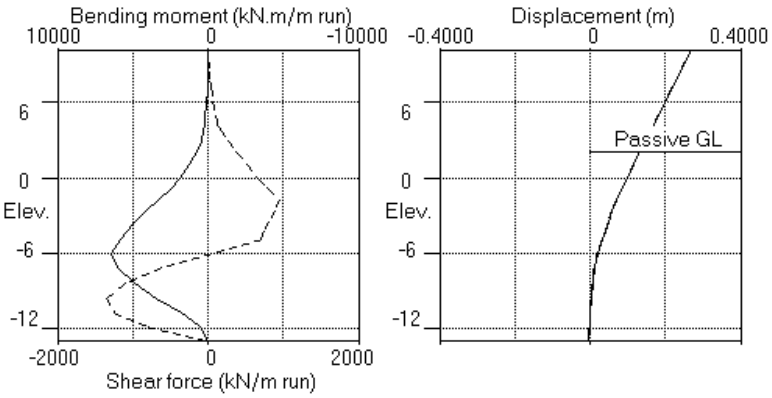
Stage No.11 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
16	-2.73	65.25	36.41	11.86	136.34	136.34	201.59p	2837
17	-3.60	74.00	45.16	14.71	169.13	169.13	243.13p	2837
18	-4.22	80.25	51.41	16.75	192.55	162.42	242.67	2837
19	-4.85	86.50	57.67	18.78	215.97	144.06	230.56	2837
		Total> 144.17	43.25m	580.58	580.58		580.58p	24906
20	-6.03	Total> 168.85	49.13m	707.83	707.83		707.83p	30759
21	-7.20	Total> 193.54	55.00m	835.07	587.37		587.37	36612
22	-8.40	Total> 218.76	61.00m	965.03	394.68		394.68	42589
23	-9.60	Total> 243.99	67.00m	1095.00	224.96		224.96	48567
24	-10.80	Total> 269.22	73.00m	1224.96	73.00		73.00a	130951
25	-11.90	Total> 292.35	78.50m	1344.11	78.50		78.50a	144105
26	-13.00	Total> 315.49	84.00m	1463.26	84.00		84.00a	157260

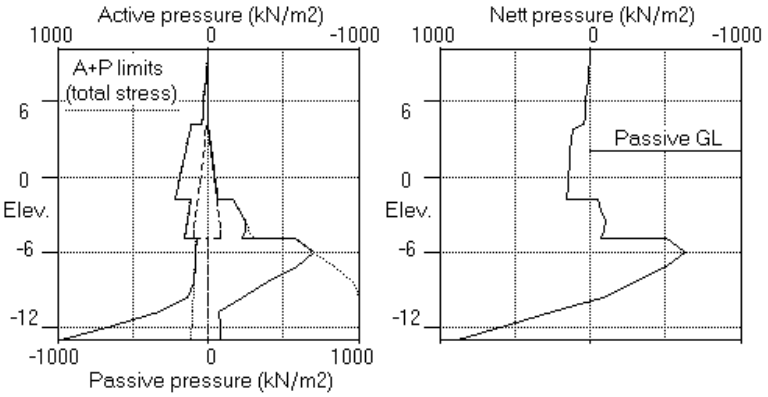
Note: 84.00a Soil pressure at active limit
707.83p Soil pressure at passive limit
4.47b Passive limit reduced because of berm

Units: kN,m

Stage No.11 Change soil type 3 to soil type 4



Stage No.11 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: ULS DA1 Combination 2
Water pressures : Worst Credible
Partial factor on C' = 1.250
Partial factor on Phi' = 1.250
Partial factor on Cu = 1.400
Partial factor on Soil Modulus = 1.000
Partial factor on Permanent Unfavourable loads = 1.000
Partial factor on Permanent Favourable loads = 1.000
Partial factor on Variable Unfavourable loads = 1.300

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = -13.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.15	10.15	Cant.	Conditions not suitable for FoS calc.			
2	10.15	10.15		No analysis at this stage			
3	10.15	2.10	Cant.	1.188	-10.41	-12.04	14.14
4	10.15	2.10	Cant.	1.129	-10.40	-12.28	14.38
5	10.15	2.10	Cant.	1.116	-10.40	-12.34	14.44
6	10.15	2.10		No analysis at this stage			
7	10.15	2.10	Cant.	1.470	-10.34	-10.87	12.97
8	10.15	2.10	Cant.	1.581	-10.36	-10.58	12.68
9	10.15	2.10	Cant.	1.608	-10.35	-10.51	12.61
10	10.15	2.10	Cant.	1.188	-10.41	-12.04	14.14
11	10.15	2.10	Cant.	1.094	-10.40	-12.48	14.58
12	10.15	2.10		No analysis at this stage			
13	10.15	2.10	Cant.	1.129	-10.40	-12.28	14.38
14	10.15	2.10	Cant.	1.116	-10.40	-12.34	14.44
15	10.15	2.10	Cant.	1.470	-10.34	-10.87	12.97

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 100.00 from wall
Passive side 100.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	10.15	0.285	0.000	0.0	0.0	0.0	0.0
2	9.28	0.269	0.000	7.8	-0.0	16.1	0.0
3	8.40	0.254	0.000	30.6	-0.0	36.7	0.0
4	7.70	0.241	0.000	63.1	-0.0	56.4	0.0
5	7.00	0.228	0.000	110.3	-0.0	79.0	0.0
6	5.90	0.209	0.000	217.2	-0.0	114.1	0.0
7	4.80	0.189	0.000	359.9	-0.0	144.1	0.0
8	4.15	0.177	0.000	459.0	-0.0	160.9	0.0
9	3.80	0.171	0.000	521.2	-0.0	194.9	0.0
10	2.95	0.156	0.000	723.1	-0.0	288.4	0.0
11	2.10	0.141	0.000	1000.0	-0.0	401.0	0.0
12	1.05	0.123	0.000	1451.4	-0.0	542.4	0.0
13	0.00	0.105	0.000	2029.7	-0.0	690.1	0.0
14	-0.75	0.092	0.000	2543.9	-0.0	797.1	0.0
15	-1.85	0.075	0.000	3507.1	-0.0	954.4	0.0
16	-2.73	0.062	0.000	4322.3	-0.0	903.9	0.0
17	-3.60	0.050	0.000	5097.6	-0.0	827.3	0.0
18	-4.22	0.042	0.000	5595.3	0.0	763.7	0.0
19	-4.85	0.035	0.000	6052.9	0.0	707.4	0.0
20	-6.03	0.023	0.000	6659.8	0.0	42.0	-32.2
21	-7.20	0.014	0.000	6271.5	0.0	0.0	-651.8
22	-8.40	0.007	0.000	5125.0	0.0	0.0	-1148.4
23	-9.60	0.003	0.000	3552.4	0.0	0.0	-1394.9
24	-10.80	0.000	-0.001	1823.9	0.0	0.0	-1294.1
25	-11.90	0.000	-0.003	558.9	0.0	0.0	-831.0
26	-13.00	0.000	-0.005	0.0	0.0	0.0	-0.0

Summary of results (continued)

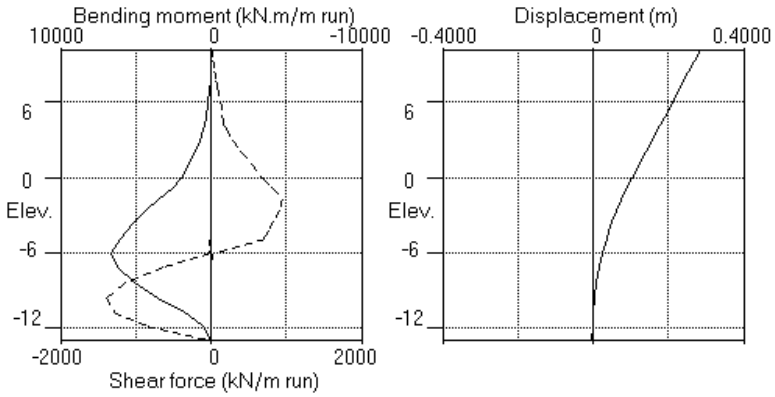
Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	elev.	minimum kN.m/m	elev.	Shear force maximum kN/m	elev.	minimum kN/m	elev.
1	0.0	-8.40	-0.0	2.10	0.0	10.15	-0.0	-8.40
2	No calculation at this stage							
3	5714.2	-6.03	0.0	10.15	824.9	-1.85	-1175.0	-9.60
4	6152.5	-6.03	0.0	10.15	872.1	-1.85	-1265.5	-9.60
5	6259.5	-6.03	0.0	10.15	886.8	-1.85	-1291.5	-9.60
6	No calculation at this stage							
7	5681.0	-6.03	0.0	10.15	770.9	-1.85	-1176.3	-9.60
8	5541.1	-6.03	0.0	10.15	751.1	-1.85	-1151.4	-9.60
9	5508.9	-6.03	0.0	10.15	742.6	-1.85	-1144.8	-9.60
10	6105.8	-6.03	0.0	10.15	858.4	-1.85	-1261.0	-9.60
11	6433.5	-6.03	0.0	10.15	946.3	-1.85	-1341.7	-9.60
12	No calculation at this stage							
13	6607.5	-6.03	0.0	10.15	947.8	-1.85	-1381.0	-9.60
14	6659.8	-6.03	0.0	10.15	954.4	-1.85	-1394.9	-9.60
15	6046.6	-6.03	0.0	10.15	826.1	-1.85	-1272.5	-9.60

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	10.15	0.000	10.15	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.233	10.15	-0.004	-13.00	Excav. to elev. 2.10 on PASSIVE side
4	0.253	10.15	-0.004	-13.00	Apply surcharge no.1 at elev. 10.15
5	0.258	10.15	-0.004	-13.00	Apply surcharge no.2 at elev. 10.15
6	No calculation at this stage				Change EI of wall to 2.5152E+06kN.m2/m run
7	0.234	10.15	-0.004	-13.00	Apply water pressure profile no.2
8	0.227	10.15	-0.004	-13.00	Remove surcharge no.1 at elev. 10.15
9	0.225	10.15	-0.004	-13.00	Remove surcharge no.2 at elev. 10.15
10	0.250	10.15	-0.004	-13.00	Apply water pressure profile no.1
11	0.269	10.15	-0.005	-13.00	Change soil type 3 to soil type 4
12	No calculation at this stage				Change soil type 4 to soil type 3
13	0.282	10.15	-0.005	-13.00	Apply surcharge no.1 at elev. 10.15
14	0.285	10.15	-0.005	-13.00	Apply surcharge no.2 at elev. 10.15
15	0.260	10.15	-0.005	-13.00	Apply water pressure profile no.2

Bending moment, shear force, displacement envelopes



Annex C – WALLAP Results – Clarence Road

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	8.85	1 Fill (D)	7 Fill (P)
2	6.65	3 Silt (U)	3 Silt (U)
3	5.15	5 WRock	5 WRock

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Fill (D)	19.00	30000	0.426	OC (0.250)	0.222 (0.000)	6.064 (0.000)	
2	Not defined							
3	Silt (U)	17.00	3000	0.577	NC (0.490)	1.000 (2.443)	1.000 (2.444)	10.00u
4	Silt (D)	17.00	2400	0.577	NC (0.150)	0.352 (1.389)	3.421 (5.191)	0.0d
5	WRock (5.15)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	Not defined							
7	Fill (P)	19.00	30000	0.426	OC (0.250)	0.222 (0.000)	6.064 (0.000)	

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Fill (D)	35.00	0.816	0.00	33.00	0.820	0.00
2	Not defined						
3	Silt (U)	0.00	0.600	0.00	0.00	0.600	0.00
4	Silt (D)	25.00	0.650	0.00	25.00	0.650	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	Not defined						
7	Fill (P)	35.00	0.816	0.00	33.00	0.820	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	1.90	1.90

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	2.90	2.90	0.0	1	1.90	1.90	0.0	MC+WC
2	1	2.90	2.90	0.0	1	10.15	10.15	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall =  0.00
             Maximum finite element length =  0.60 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 8.4820E-03 m4/m run
                                       E.I = 198309 kN.m2/m run
                    Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.15	0.00(A)	7.50	100.00	10.00	=	N/A	1.00 P/U
2	8.85	1.20(A)	100.00	100.00	24.70	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined Allow wall to relax with new modulus value
2	Apply water pressure profile no.1 (Mod. Conserv.) No analysis at this stage
3	Apply surcharge no.2 at elevation 8.85
4	Excavate to elevation 8.00 on PASSIVE side Toe of berm at elevation 0.60 Width of top of berm = 0.01 Width of toe of berm = 10.60
5	Change EI of wall to 141654 kN.m2/m run Yield moment not defined No adjustments to wall displacements
6	Remove surcharge no.2 at elevation 8.85 No analysis at this stage
7	Fill to elevation 10.15 on ACTIVE side with soil type 1
8	Apply surcharge no.1 at elevation 10.15
9	Apply water pressure profile no.2 (Mod. Conserv.)
10	Remove surcharge no.1 at elevation 10.15
11	Apply water pressure profile no.1 (Mod. Conserv.)
12	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
13	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
14	Apply surcharge no.1 at elevation 10.15
15	Apply water pressure profile no.2 (Mod. Conserv.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: Serviceability Limit State
  All loads and soil strengths are unfactored

 Stability analysis:
  Method of analysis  -  Strength Factor method
  Factor on soil strength for calculating wall depth = 1.00

 Parameters for undrained strata:
  Minimum equivalent fluid density            =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
  Non-linear Modulus Parameter (L) = 10.00 m

 Boundary conditions:
  Length of wall (normal to plane of analysis) = 1000.00 m

  Width of excavation on active  side of wall  = 48.00 m
```

Width of excavation on passive side of wall = 48.00 m

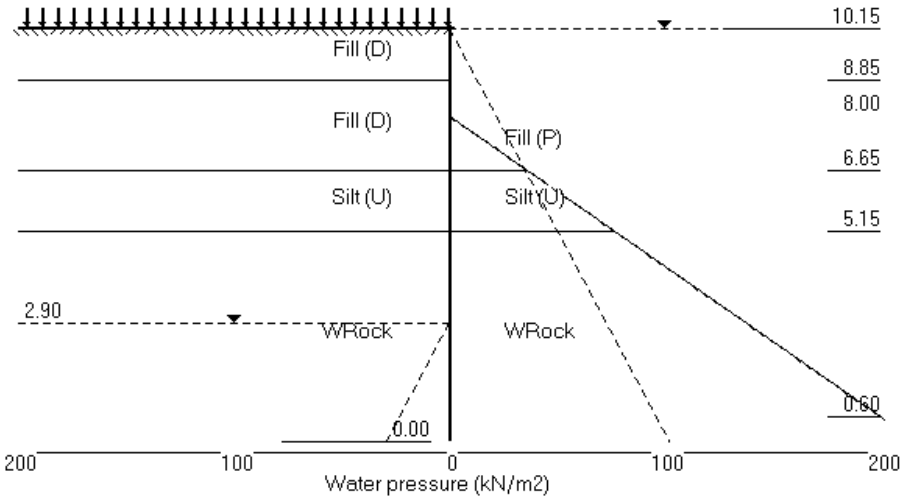
Distance to rigid boundary on active side = 48.00 m
Distance to rigid boundary on passive side = 48.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Apply surcharge no.2 at elev. 8.85	No	No	No
4	Excav. to elev. 8.00 on PASSIVE side	No	No	No
5	Change EI of wall to 141654kN.m2/m run	No	No	No
6	Remove surcharge no.2 at elev. 8.85	No	No	No
7	Fill to elev. 10.15 on ACTIVE side	No	No	No
8	Apply surcharge no.1 at elev. 10.15	No	No	No
9	Apply water pressure profile no.2	No	No	No
10	Remove surcharge no.1 at elev. 10.15	No	No	No
11	Apply water pressure profile no.1	No	No	No
12	Change soil type 3 to soil type 4	No	No	No
13	Change soil type 4 to soil type 3	No	No	No
14	Apply surcharge no.1 at elev. 10.15	No	No	No
15	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.15 Apply water pressure profile no.2 (Mod. Conserv.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	8.85	8.85		Wall tending to move from right to left			

Note: To obtain a Factor of Safety for the case of wall failing from right to left you should reverse the data (Ctrl+K) and re-analyse.

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
2	9.82	0.00	-0.000	-4.08E-18	0.0	-0.0		3521239
3	9.50	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
4	9.18	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
5	8.85	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
6	8.43	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
7	8.00	0.00	-0.000	-4.09E-18	0.0	0.0		3521239
8	7.66	0.00	-0.000	-4.10E-18	0.0	0.0		3521239
9	7.33	0.00	-0.000	-4.13E-18	0.0	0.0		3521239
10	6.99	0.00	-0.000	-4.17E-18	0.0	0.0		3521239
11	6.65	0.00	-0.000	-4.24E-18	0.0	0.0		3521239
12	6.33	0.00	-0.000	-4.33E-18	0.0	0.0		3521239
13	6.00	0.00	-0.000	-4.44E-18	0.0	0.0		3521239
14	5.58	0.00	-0.000	-4.63E-18	0.0	0.0		3521239
15	5.15	0.00	-0.000	-4.85E-18	0.0	0.0		3521239
16	4.68	0.00	-0.000	-5.17E-18	0.0	0.0		3521239
17	4.20	0.00	-0.000	-5.59E-18	0.0	0.0		3521239
18	3.60	0.00	-0.000	-6.32E-18	0.0	0.0		3521239
19	3.25	0.00	-0.000	-6.87E-18	0.0	0.0		3521239
20	2.90	0.00	-0.000	-7.53E-18	0.0	0.0		3521239
21	2.40	0.00	0.000	-8.69E-18	0.0	0.0		3521239
22	1.90	0.00	0.000	-1.00E-17	0.0	0.0		3521239
23	1.55	0.00	0.000	-1.12E-17	0.0	0.0		3521239
24	1.20	0.00	0.000	-1.23E-17	0.0	0.0		3521239
25	0.60	0.00	0.000	-1.34E-17	0.0	0.0		3521239

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
26	0.00	0.00	0.000	-1.35E-17	0.0	-0.0		---

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7176
6	8.43	0.00	8.08	1.79	48.97	3.44	3.44	7176
7	8.00	0.00	16.15	3.58	97.94	6.88	6.88	7176
8	7.66	0.00	22.56	5.00	136.82	9.61	9.61	7176
9	7.33	0.00	28.98	6.42	175.71	12.34	12.34	7176
10	6.99	0.00	35.39	7.84	214.60	15.08	15.08	7176
11	6.65	0.00	41.80	9.26	253.48	17.81	17.81	7176
		Total>	41.80	17.37	66.24	24.12	24.12	1047
12	6.33	Total>	47.33	22.89	71.76	27.31	27.31	1047
13	6.00	Total>	52.85	28.42	77.29	30.49	30.49	1047
14	5.58	Total>	60.08	35.64	84.51	35.64	35.64a	1047
15	5.15	Total>	67.30	42.87	91.74	42.87	42.87a	1047
		Total>	67.30	18.50m	678.26	26.92	26.92	43630
16	4.68	Total>	77.28	20.88m	746.28	30.91	30.91	47775
17	4.20	Total>	87.25	23.25m	814.29	34.90	34.90	51920
18	3.60	Total>	99.85	26.25m	900.21	39.94	39.94	57156
19	3.25	Total>	107.20	28.00m	950.33	42.88	42.88	60210
20	2.90	Total>	114.55	29.75m	1000.44	45.82	45.82	63264
21	2.40	Total>	125.05	32.25m	1072.04	50.02	50.02	137677
22	1.90	Total>	135.55	34.75m	1143.63	54.22	54.22	146559
23	1.55	Total>	142.90	36.50m	1193.75	59.26	59.26	152777
24	1.20	Total>	150.25	38.25m	1243.87	64.30	64.30	158995
25	0.60	Total>	162.85	41.25m	1329.78	72.94	72.94	169654
26	0.00	Total>	175.45	44.25m	1415.70	81.58	81.58	180313

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7176
6	8.43	0.00	8.08	1.79	48.97	3.44	3.44	7176
7	8.00	0.00	16.15	3.58	97.94	6.88	6.88	7176
8	7.66	0.00	22.56	5.00	136.82	9.61	9.61	7176
9	7.33	0.00	28.98	6.42	175.71	12.34	12.34	7176
10	6.99	0.00	35.39	7.84	214.60	15.08	15.08	7176
11	6.65	0.00	41.80	9.26	253.48	17.81	17.81	7176
		Total>	41.80	17.37	66.24	24.12	24.12	1047

(continued)

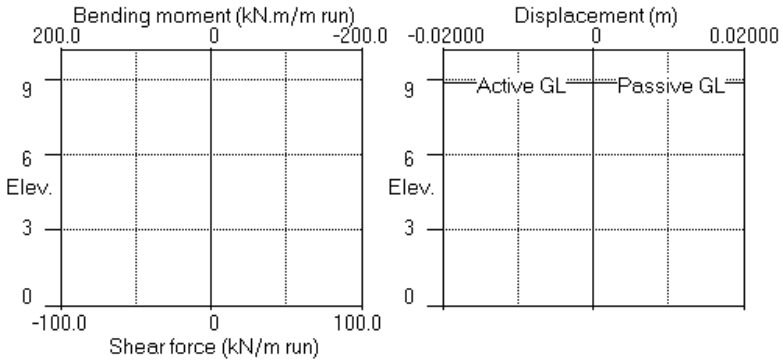
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
12	6.33	Total>	47.33	22.89	71.76	27.31	27.31	1047
13	6.00	Total>	52.85	28.42	77.29	30.49	30.49	1047
14	5.58	Total>	60.08	35.64	84.51	35.64	35.64a	1047
15	5.15	Total>	67.30	42.87	91.74	42.87	42.87a	1047
		Total>	67.30	18.50m	678.26	26.92	26.92	43630
16	4.68	Total>	77.28	20.88m	746.28	30.91	30.91	47775
17	4.20	Total>	87.25	23.25m	814.29	34.90	34.90	51920
18	3.60	Total>	99.85	26.25m	900.21	39.94	39.94	57156
19	3.25	Total>	107.20	28.00m	950.33	42.88	42.88	60210
20	2.90	Total>	114.55	29.75m	1000.44	45.82	45.82	63264
21	2.40	Total>	125.05	32.25m	1072.04	50.02	50.02	137677
22	1.90	Total>	135.55	34.75m	1143.63	54.22	54.22	146559
23	1.55	Total>	142.90	36.50m	1193.75	59.26	59.26	152777
24	1.20	Total>	150.25	38.25m	1243.87	64.30	64.30	158995
25	0.60	Total>	162.85	41.25m	1329.78	72.94	72.94	169654
26	0.00	Total>	175.45	44.25m	1415.70	81.58	81.58	180313

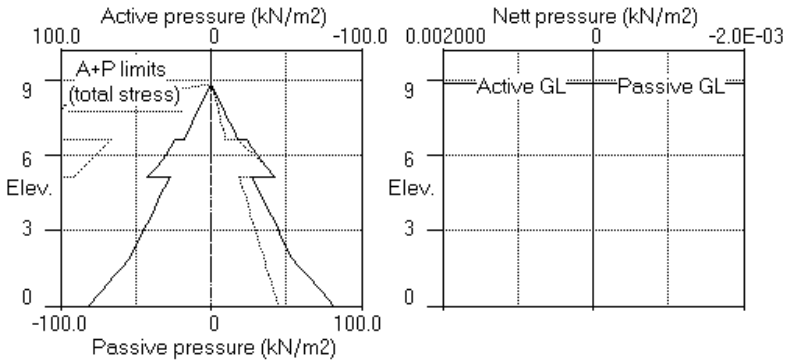
Note: 42.87a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
4	8.85	8.00	Cant.	9.957	0.63	4.92	3.08

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.002	1.78E-04	0.0	0.0		3521239
2	9.82	0.00	0.002	1.78E-04	0.0	-0.0		3521239
3	9.50	0.00	0.002	1.78E-04	0.0	-0.0		3521239
4	9.18	0.00	0.002	1.78E-04	0.0	-0.0		3521239
5	8.85	0.00	0.001	1.78E-04	0.0	0.0		3521239
6	8.43	1.88	0.001	1.78E-04	0.4	0.1		3521239
7	8.00	4.08	0.001	1.78E-04	1.7	0.6		3521239
8	7.66	-0.23	0.001	1.78E-04	2.3	1.3		3521239
		-0.07	0.001	1.78E-04	2.3	1.3		
9	7.33	-4.21	0.001	1.78E-04	1.6	2.0		3521239
		-4.14	0.001	1.78E-04	1.6	2.0		
10	6.99	-7.49	0.001	1.78E-04	-0.4	2.5		3521239
11	6.65	-6.05	0.001	1.78E-04	-2.7	1.9		3521239
		24.21	0.001	1.78E-04	-2.7	1.9		
12	6.33	25.72	0.001	1.77E-04	5.5	2.4		3521239
13	6.00	27.37	0.001	1.77E-04	14.1	5.5		3521239
		28.84	0.001	1.77E-04	14.1	5.5		
14	5.58	34.63	0.001	1.76E-04	27.6	14.3		3521239
		36.15	0.001	1.76E-04	27.6	14.3		
15	5.15	42.99	0.001	1.73E-04	44.4	29.4		3521239
		-26.52	0.001	1.73E-04	44.4	29.4		
16	4.68	-27.40	0.001	1.68E-04	31.6	47.5		3521239
17	4.20	-27.76	0.001	1.61E-04	18.5	59.3		3521239
18	3.60	-25.21	0.001	1.50E-04	2.6	66.5		3521239
19	3.25	-21.77	0.000	1.44E-04	-5.6	65.9		3521239
20	2.90	-18.04	0.000	1.37E-04	-12.6	62.6		3521239
21	2.40	-12.25	0.000	1.29E-04	-20.2	54.0		3521239

(continued)

Stage No.4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
22	1.90	-5.92	0.000	1.22E-04	-24.7	42.5		3521239
23	1.55	-1.16	0.000	1.18E-04	-25.9	33.4		3521239
24	1.20	3.90	0.000	1.15E-04	-25.5	24.3		3521239
25	0.60	13.38	0.000	1.12E-04	-20.3	9.7		3521239
26	0.00	54.23	0.000	1.12E-04	0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7387
6	8.43	0.00	8.48	1.88	51.42	1.88	1.88a	7387
7	8.00	0.00	18.42	4.08	111.73	4.08	4.08a	7387
8	7.66	0.00	26.97	5.98	163.54	5.98	5.98a	7387
9	7.33	0.00	35.55	7.88	215.58	7.88	7.88a	7387
10	6.99	0.00	43.93	9.73	266.39	10.24	10.24	7387
11	6.65	0.00	52.04	11.53	315.56	13.96	13.96	7387
		Total> 52.04	27.61	76.48	33.29	33.29	1074	
12	6.33	Total> 58.95	34.52	83.39	37.93	37.93	1074	
13	6.00	Total> 65.66	41.23	90.10	42.36	42.36	1074	
14	5.58	Total> 74.17	49.74	98.61	49.74	49.74a	1074	
15	5.15	Total> 82.45	58.02	106.89	58.02	58.02a	1074	
		Total> 82.45	18.50m	693.41	18.50	18.50a	44748	
16	4.68	Total> 93.39	20.88m	762.39	20.88	20.88a	48999	
17	4.20	Total> 104.17	23.25m	831.21	23.25	23.25a	53250	
18	3.60	Total> 117.59	26.25m	917.95	28.63	28.63	58620	
19	3.25	Total> 125.34	28.00m	968.47	33.46	33.46	61752	
20	2.90	Total> 133.06	29.75m	1018.95	38.40	38.40	64884	
21	2.40	Total> 144.01	32.25m	1091.00	45.66	45.66	69359	
22	1.90	Total> 154.90	34.75m	1162.98	53.15	53.15	73834	
23	1.55	Total> 162.49	36.50m	1213.34	60.64	60.64	76966	
24	1.20	Total> 170.06	38.25m	1263.68	68.27	68.27	80099	
25	0.60	Total> 182.99	41.25m	1349.93	81.72	81.72	85468	
26	0.00	Total> 195.88	44.25m	1436.13	110.85	110.85	1360345	

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7864

(continued)

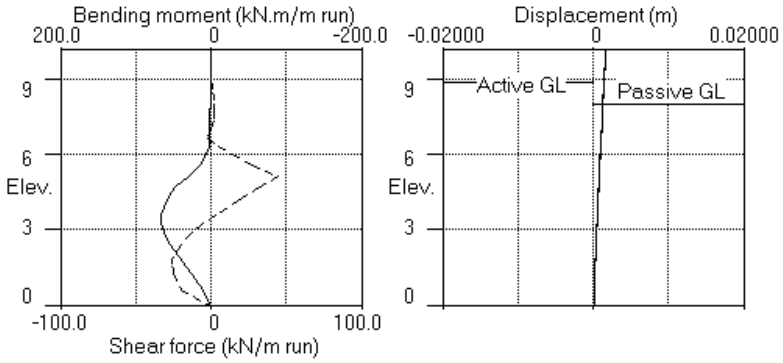
Stage No.4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
8	7.66	0.00	6.41	1.42	6.21b	6.21	6.21p	7864
		0.00	6.41	1.42	6.04b	6.04	6.04p	7864
9	7.33	0.00	12.83	2.84	12.08b	12.08	12.08p	7864
		0.00	12.83	2.84	12.02b	12.02	12.02p	7864
10	6.99	0.00	19.24	4.26	18.03b	17.73	17.73	7864
		0.00	19.24	4.26	17.98b	17.73	17.73	7864
11	6.65	0.00	25.65	5.68	23.98b	20.01	20.01	7864
		Total>	25.65	6.75m	22.78b	9.08	9.08	1135
12	6.33	Total>	31.18	8.37m	25.30b	12.20	12.20	1135
		Total>	31.18	8.37m	13.63b	12.20	12.20	1135
13	6.00	Total>	36.70	12.27	14.99b	14.99	14.99p	1135
		Total>	36.70	12.27	13.51b	13.51	13.51p	1135
14	5.58	Total>	43.93	15.10	15.11b	15.11	15.11p	1135
		Total>	43.93	13.58	13.59b	13.59	13.59p	1135
15	5.15	Total>	51.15	15.02	15.03b	15.03	15.03p	1135
		Total>	51.15	14.25m	662.11	45.02	45.02	47299
16	4.68	Total>	61.13	16.63m	730.13	48.28	48.28	51792
17	4.20	Total>	71.10	19.00m	798.15	51.01	51.01	56285
18	3.60	Total>	83.71	22.00m	884.06	53.84	53.84	61961
19	3.25	Total>	91.06	23.75m	934.18	55.22	55.22	65272
20	2.90	Total>	98.41	25.50m	984.30	56.44	56.44	68583
21	2.40	Total>	108.91	28.00m	1055.90	57.91	57.91	73313
22	1.90	Total>	119.41	30.50m	1127.50	59.07	59.07	78043
23	1.55	Total>	126.77	32.25m	1177.62	61.80	61.80	81354
24	1.20	Total>	134.12	34.00m	1227.74	64.37	64.37	84665
25	0.60	Total>	146.72	37.00m	1313.66	68.34	68.34	90340
26	0.00	Total>	159.33	40.00m	1399.58	56.62	56.62	1360345

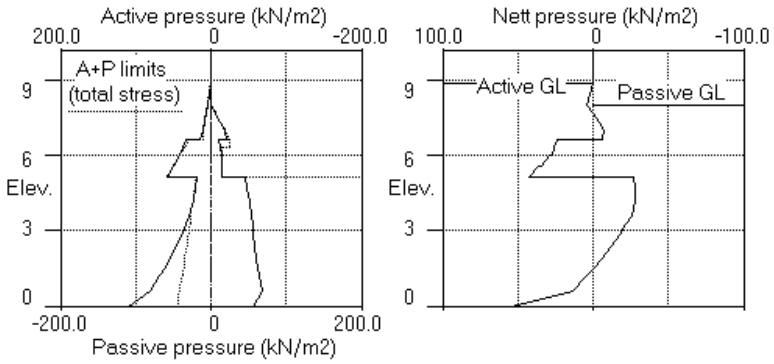
Note: 23.25a Soil pressure at active limit
15.03p Soil pressure at passive limit
15.03b Passive limit reduced because of berm

Units: kN,m

Stage No.4 Excav. to elev. 8.00 on PASSIVE side



Stage No.4 Excav. to elev. 8.00 on PASSIVE side



Units: kN,m

Stage No. 7 Fill to elevation 10.15 on ACTIVE side with soil type 1

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
7	10.15	8.00	Cant.	6.852	1.00	4.22	3.78

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.009	1.51E-03	0.0	0.0		141654
2	9.82	1.37	0.008	1.51E-03	0.2	0.0		141654
3	9.50	2.74	0.008	1.51E-03	0.9	0.2		141654
4	9.18	4.10	0.007	1.51E-03	2.0	0.7		141654
5	8.85	5.47	0.007	1.51E-03	3.6	1.5		141654
6	8.43	7.26	0.006	1.50E-03	6.3	3.7		141654
7	8.00	9.05	0.006	1.48E-03	9.7	7.1		141654
8	7.66	4.27	0.005	1.46E-03	12.0	10.8		141654
		4.43	0.005	1.46E-03	12.0	10.8		
9	7.33	-0.19	0.005	1.44E-03	12.7	15.0		141654
		-0.12	0.005	1.44E-03	12.7	15.0		
10	6.99	-4.71	0.004	1.40E-03	11.9	19.4		141654
		-4.67	0.004	1.40E-03	11.9	19.4		
11	6.65	-9.24	0.004	1.36E-03	9.5	23.1		141654
		31.46	0.004	1.36E-03	9.5	23.1		
12	6.33	32.66	0.003	1.30E-03	19.9	27.8		141654
		34.68	0.003	1.30E-03	19.9	27.8		
13	6.00	38.13	0.003	1.24E-03	31.8	36.1		141654
		39.61	0.003	1.24E-03	31.8	36.1		
14	5.58	45.23	0.002	1.13E-03	49.8	53.4		141654
		46.75	0.002	1.13E-03	49.8	53.4		
15	5.15	52.54	0.002	1.00E-03	70.9	78.9		141654
		-85.59	0.002	1.00E-03	70.9	78.9		
16	4.68	-66.85	0.001	8.20E-04	34.7	102.9		141654
17	4.20	-49.95	0.001	6.32E-04	7.0	111.8		141654
18	3.60	-33.30	0.001	4.22E-04	-18.0	107.9		141654
19	3.25	-25.17	0.001	3.23E-04	-28.2	99.6		141654
20	2.90	-13.80	0.000	2.43E-04	-35.1	88.2		141654
21	2.40	-1.48	0.000	1.63E-04	-38.9	68.9		141654
22	1.90	6.31	0.000	1.18E-04	-37.7	49.3		141654

(continued)

Stage No.7 Fill to elevation 10.15 on ACTIVE side with soil type 1

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
23	1.55	10.15	0.000	1.02E-04	-34.8	36.5		141654
24	1.20	13.49	0.000	9.49E-05	-30.7	25.0		141654
25	0.60	19.37	0.000	9.22E-05	-20.8	9.0		141654
26	0.00	49.94	0.000	9.30E-05	0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	8752
2	9.82	0.00	6.17	1.37	37.45	1.37	1.37a	8752
3	9.50	0.00	12.35	2.74	74.89	2.74	2.74a	8752
4	9.18	0.00	18.52	4.10	112.34	4.10	4.10a	8752
5	8.85	0.00	24.70	5.47	149.79	5.47	5.47a	8752
6	8.43	0.00	32.77	7.26	198.76	7.26	7.26a	8752
7	8.00	0.00	40.85	9.05	247.72	9.05	9.05a	8752
8	7.66	0.00	47.26	10.47	286.61	10.47	10.47a	8752
9	7.33	0.00	53.67	11.89	325.50	11.89	11.89a	8752
10	6.99	0.00	60.09	13.31	364.38	13.31	13.31a	8752
11	6.65	0.00	66.50	14.74	403.27	14.74	14.74a	8752
		Total>	66.50	42.07	90.94	44.60	44.60	1250
12	6.33	Total>	72.02	47.59	96.46	48.32	48.32	1250
13	6.00	Total>	77.55	53.12	101.99	53.12	53.12a	1250
14	5.58	Total>	84.77	60.34	109.21	60.34	60.34a	1250
15	5.15	Total>	92.00	67.57	116.44	67.57	67.57a	1250
		Total>	92.00	25.00m	702.96	25.00	25.00a	52068
16	4.68	Total>	101.97	27.37m	770.98	27.37	27.37a	57014
17	4.20	Total>	111.95	29.75m	838.99	29.75	29.75a	61961
18	3.60	Total>	124.55	32.75m	924.91	32.75	32.75a	68209
19	3.25	Total>	131.90	34.50m	975.03	35.66	35.66	71854
20	2.90	Total>	139.25	36.25m	1025.14	43.74	43.74	75498
21	2.40	Total>	149.75	38.75m	1096.74	53.91	53.91	113514
22	1.90	Total>	160.25	41.25m	1168.33	61.94	61.94	120838
23	1.55	Total>	167.60	43.00m	1218.45	68.86	68.86	125964
24	1.20	Total>	174.95	44.75m	1268.57	75.51	75.51	131091
25	0.60	Total>	187.55	47.75m	1354.48	86.99	86.99	139879
26	0.00	Total>	200.15	50.75m	1440.40	110.84	110.84	642698

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	11520
8	7.66	0.00	6.41	1.42	6.21b	6.21	6.21p	11520
		0.00	6.41	1.42	6.04b	6.04	6.04p	11520
9	7.33	0.00	12.83	2.84	12.08b	12.08	12.08p	11520
		0.00	12.83	2.84	12.02b	12.02	12.02p	11520

(continued)

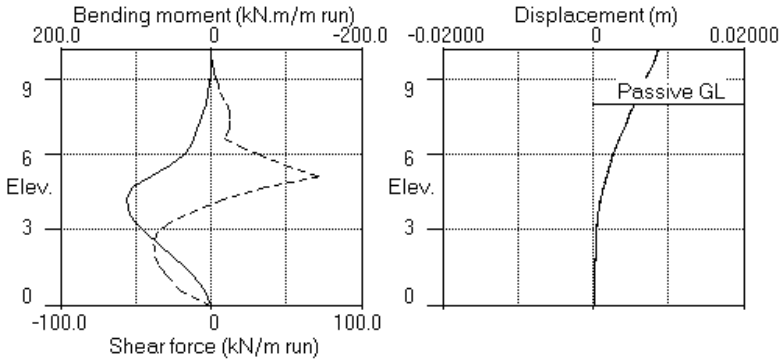
Stage No.7 Fill to elevation 10.15 on ACTIVE side with soil type 1

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
10	6.99	0.00	19.24	4.26	18.03b	18.03	18.03p	11520
		0.00	19.24	4.26	17.98b	17.98	17.98p	11520
11	6.65	0.00	25.65	5.68	23.98b	23.98	23.98p	11520
		Total>	25.65	6.75m	22.78b	13.14	13.14	1610
12	6.33	Total>	31.18	8.37m	25.30b	15.66	15.66	1610
		Total>	31.18	8.37m	13.63b	13.63	13.63p	1610
13	6.00	Total>	36.70	12.27	14.99b	14.99	14.99p	1610
		Total>	36.70	12.27	13.51b	13.51	13.51p	1610
14	5.58	Total>	43.93	15.10	15.11b	15.11	15.11p	1610
		Total>	43.93	13.58	13.59b	13.59	13.59p	1610
15	5.15	Total>	51.15	15.02	15.03b	15.03	15.03p	1610
		Total>	51.15	14.25m	662.11	110.59	110.59	67069
16	4.68	Total>	61.13	16.63m	730.13	94.22	94.22	73440
17	4.20	Total>	71.10	19.00m	798.15	79.70	79.70	79812
18	3.60	Total>	83.71	22.00m	884.06	66.05	66.05	87860
19	3.25	Total>	91.06	23.75m	934.18	60.83	60.83	92555
20	2.90	Total>	98.41	25.50m	984.30	57.54	57.54	97250
21	2.40	Total>	108.91	28.00m	1055.90	55.40	55.40	113514
22	1.90	Total>	119.41	30.50m	1127.50	55.63	55.63	120838
23	1.55	Total>	126.77	32.25m	1177.62	58.70	58.70	125964
24	1.20	Total>	134.12	34.00m	1227.74	62.02	62.02	131091
25	0.60	Total>	146.72	37.00m	1313.66	67.62	67.62	139879
26	0.00	Total>	159.33	40.00m	1399.58	60.90	60.90	642698

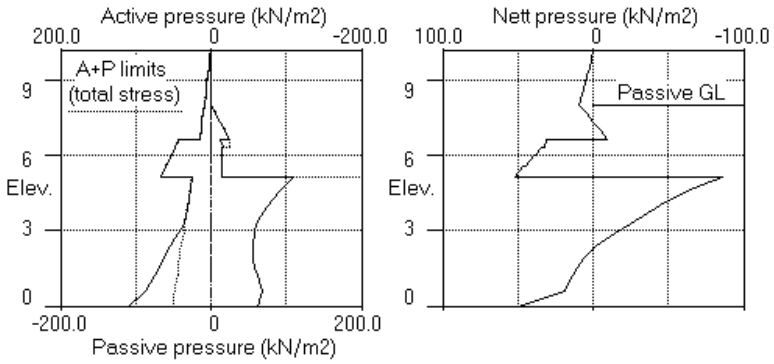
Note: 32.75a Soil pressure at active limit
15.03p Soil pressure at passive limit
15.03b Passive limit reduced because of berm

Units: kN,m

Stage No.7 Fill to elev. 10.15 on ACTIVE side



Stage No.7 Fill to elev. 10.15 on ACTIVE side



Units: kN,m

Stage No. 12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
12	10.15	8.00	Cant.	7.180	0.97	4.50	3.50

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.013	2.30E-03	0.0	0.0		141654
2	9.82	4.78	0.012	2.30E-03	0.8	0.3		141654
3	9.50	6.00	0.011	2.30E-03	2.5	0.8		141654
4	9.18	7.22	0.010	2.30E-03	4.7	1.9		141654
5	8.85	8.45	0.010	2.29E-03	7.2	3.9		141654
6	8.43	10.06	0.009	2.27E-03	11.2	7.8		141654
7	8.00	11.68	0.008	2.24E-03	15.8	13.6		141654
8	7.66	7.03	0.007	2.20E-03	18.9	19.5		141654
		7.20	0.007	2.20E-03	18.9	19.5		
9	7.33	2.47	0.006	2.15E-03	20.6	26.2		141654
		2.54	0.006	2.15E-03	20.6	26.2		
10	6.99	-2.17	0.005	2.09E-03	20.6	33.4		141654
		-2.13	0.005	2.09E-03	20.6	33.4		
11	6.65	-3.27	0.005	2.00E-03	19.7	40.5		141654
		40.26	0.005	2.00E-03	19.7	40.5		
12	6.33	44.54	0.004	1.91E-03	33.5	49.1		141654
		30.01	0.004	1.91E-03	33.5	49.1		
13	6.00	32.31	0.003	1.79E-03	43.6	61.5		141654
14	5.58	35.31	0.003	1.60E-03	58.0	83.0		141654
15	5.15	38.31	0.002	1.37E-03	73.6	111.0		141654
		-108.47	0.002	1.37E-03	73.6	111.0		
16	4.68	-81.39	0.002	1.09E-03	28.5	132.7		141654
17	4.20	-56.77	0.001	8.11E-04	-4.3	137.3		141654
18	3.60	-33.55	0.001	5.09E-04	-31.4	126.2		141654
19	3.25	-22.59	0.001	3.69E-04	-41.2	113.5		141654
20	2.90	-8.60	0.000	2.61E-04	-46.6	97.7		141654
21	2.40	5.80	0.000	1.57E-04	-47.3	73.3		141654
22	1.90	13.22	0.000	1.02E-04	-42.6	50.3		141654
23	1.55	15.91	0.000	8.54E-05	-37.5	36.3		141654

(continued)

Stage No.12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
24	1.20	17.89	0.000	7.93E-05	-31.6	24.1		141654
25	0.60	20.39	0.000	7.97E-05	-20.1	8.4		141654
26	0.00	46.57	0.000	8.18E-05	0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	100299
2	9.82	0.00	6.17	1.37	37.45	4.78	4.78	6936
3	9.50	0.00	12.35	2.74	74.89	6.00	6.00	6936
4	9.18	0.00	18.52	4.10	112.34	7.22	7.22	6936
5	8.85	0.00	24.70	5.47	149.79	8.45	8.45	6936
6	8.43	0.00	32.77	7.26	198.76	10.06	10.06	6936
7	8.00	0.00	40.85	9.05	247.72	11.68	11.68	6936
8	7.66	0.00	47.26	10.47	286.61	12.96	12.96	6936
9	7.33	0.00	53.67	11.89	325.50	14.24	14.24	6936
10	6.99	0.00	60.09	13.31	364.38	15.50	15.50	6936
11	6.65	0.00	66.50	14.74	403.27	16.76	16.76	6936
		0.00	66.50	23.43	227.48	43.08	43.08	512
12	6.33	0.00	72.02	25.37	246.38	47.97	47.97	512
13	6.00	0.00	77.55	27.32	265.28	53.45	53.45	512
14	5.58	0.00	84.77	29.87	289.99	60.63	60.63	512
15	5.15	0.00	92.00	32.41	314.71	67.80	67.80	512
		Total> 92.00	25.00m	702.96	28.50	28.50		42359
16	4.68	Total> 101.97	27.37m	770.98	29.34	29.34		46383
17	4.20	Total> 111.95	29.75m	838.99	31.30	31.30		50407
18	3.60	Total> 124.55	32.75m	924.91	33.73	33.73		55490
19	3.25	Total> 131.90	34.50m	975.03	36.92	36.92		58455
20	2.90	Total> 139.25	36.25m	1025.14	46.10	46.10		61421
21	2.40	Total> 149.75	38.75m	1096.74	57.32	57.32		65657
22	1.90	Total> 160.25	41.25m	1168.33	65.19	65.19		111450
23	1.55	Total> 167.60	43.00m	1218.45	71.53	71.53		116179
24	1.20	Total> 174.95	44.75m	1268.57	77.51	77.51		120907
25	0.60	Total> 187.55	47.75m	1354.48	87.29	87.29		129012
26	0.00	Total> 200.15	50.75m	1440.40	108.93	108.93		137118

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7147
8	7.66	0.00	6.41	1.42	6.21b	5.93	5.93	7147
		0.00	6.41	1.42	6.04b	5.76	5.76	7147
9	7.33	0.00	12.83	2.84	12.08b	11.76	11.76	7147
		0.00	12.83	2.84	12.02b	11.70	11.70	7147

(continued)

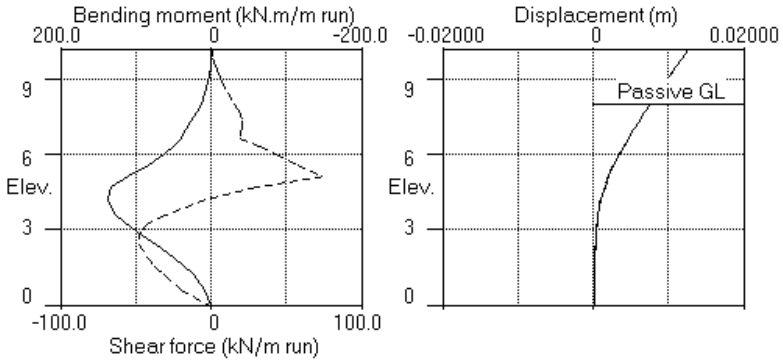
Stage No.12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
10	6.99	0.00	19.24	4.26	18.03b	17.67	17.67	7147
		0.00	19.24	4.26	17.98b	17.63	17.63	7147
11	6.65	0.00	25.65	5.68	23.98b	20.03	20.03	7147
		0.00	25.65	2.82	2.83b	2.82	2.82a	528
12	6.33	0.00	31.18	3.43	3.44b	3.43	3.43a	528
		0.00	31.18	10.98	19.22b	17.96	17.96	528
13	6.00	0.00	36.70	12.93	22.63b	21.14	21.14	528
		0.00	36.70	12.93	22.92b	21.14	21.14	528
14	5.58	0.00	43.93	15.47	27.44b	25.31	25.31	528
		0.00	43.93	15.47	27.72b	25.31	25.31	528
15	5.15	0.00	51.15	18.02	32.28b	29.49	29.49	528
		Total>	51.15	14.25m	662.11	136.98	136.98	43472
16	4.68	Total>	61.13	16.63m	730.13	110.74	110.74	47602
17	4.20	Total>	71.10	19.00m	798.15	88.07	88.07	51732
18	3.60	Total>	83.71	22.00m	884.06	67.28	67.28	56949
19	3.25	Total>	91.06	23.75m	934.18	59.51	59.51	59992
20	2.90	Total>	98.41	25.50m	984.30	54.70	54.70	63035
21	2.40	Total>	108.91	28.00m	1055.90	51.52	51.52	67382
22	1.90	Total>	119.41	30.50m	1127.50	51.97	51.97	111450
23	1.55	Total>	126.77	32.25m	1177.62	55.62	55.62	116179
24	1.20	Total>	134.12	34.00m	1227.74	59.62	59.62	120907
25	0.60	Total>	146.72	37.00m	1313.66	66.90	66.90	129012
26	0.00	Total>	159.33	40.00m	1399.58	62.36	62.36	137118

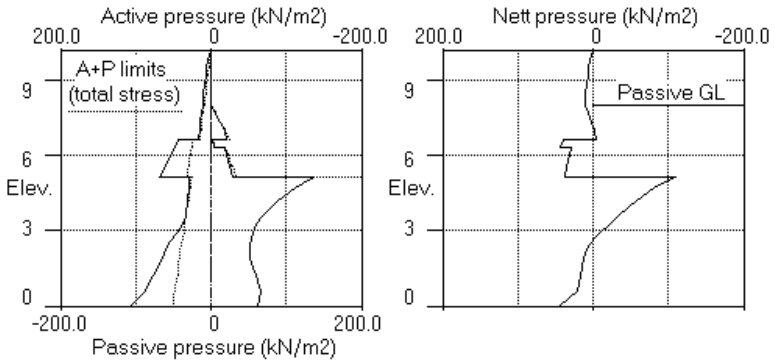
Note: 3.43a Soil pressure at active limit
123.45p Soil pressure at passive limit
32.28b Passive limit reduced because of berm

Units: kN,m

Stage No.12 Change soil type 3 to soil type 4



Stage No.12 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State
All loads and soil strengths are unfactored

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	8.85	8.85		Wall tending to move from right to left			
2	8.85	8.85		No analysis at this stage			
3	8.85	8.85	Cant.	Conditions not suitable for FoS calc.			
4	8.85	8.00	Cant.	9.957	0.63	4.92	3.08
5	8.85	8.00		No analysis at this stage			
6	8.85	8.00		No analysis at this stage			
7	10.15	8.00	Cant.	6.852	1.00	4.22	3.78
8	10.15	8.00	Cant.	5.703	1.13	4.05	3.95
9	10.15	8.00	Cant.	11.969	1.12	9.04	-1.04
10	10.15	8.00		Wall tending to move from right to left			
11	10.15	8.00	Cant.	6.852	1.00	4.22	3.78
12	10.15	8.00	Cant.	7.180	0.97	4.50	3.50
13	10.15	8.00		No analysis at this stage			
14	10.15	8.00	Cant.	5.703	1.13	4.05	3.95
15	10.15	8.00	Cant.	11.969	1.12	9.04	-1.04

Note: To obtain a Factor of Safety for the case of wall failing from right to left you should reverse the data (Ctrl+K) and re-analyse.

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	10.15	0.014	-0.000	0	-0	0	-0	0	0	0	0
2	9.82	0.013	-0.000	1	-0	1	-0	5	0	7	0
3	9.50	0.012	-0.000	3	-0	5	-0	9	0	13	0
4	9.18	0.011	-0.000	7	-0	10	-0	13	0	18	0
5	8.85	0.011	-0.000	12	-0	16	-0	16	0	21	0
6	8.43	0.009	-0.000	19	-0	26	-0	19	-1	26	-1
7	8.00	0.008	-0.000	28	-1	37	-1	21	-3	29	-4
8	7.66	0.008	-0.000	34	-2	46	-3	22	-4	29	-5
9	7.33	0.007	-0.000	41	-3	55	-5	21	-5	28	-7
10	6.99	0.006	-0.000	48	-5	65	-7	21	-6	28	-8
11	6.65	0.005	-0.000	54	-7	72	-10	20	-6	27	-8
12	6.33	0.005	-0.000	59	-9	80	-12	34	-3	45	-4
13	6.00	0.004	-0.000	67	-9	91	-12	46	0	62	0
14	5.58	0.003	-0.000	83	-7	112	-10	67	0	91	0
15	5.15	0.002	-0.000	115	-3	155	-5	92	0	124	0
16	4.68	0.002	-0.000	143	0	193	0	37	0	50	0
17	4.20	0.001	-0.000	149	0	202	0	18	-4	25	-6
18	3.60	0.001	-0.000	138	0	186	0	3	-35	4	-47
19	3.25	0.001	-0.000	123	0	167	0	1	-46	1	-62
20	2.90	0.000	-0.000	106	0	143	0	0	-52	0	-70
21	2.40	0.000	0.000	79	0	106	0	0	-52	0	-71
22	1.90	0.000	0.000	53	0	72	0	0	-46	0	-63
23	1.55	0.000	0.000	38	0	51	0	0	-40	0	-55
24	1.20	0.000	0.000	25	0	34	0	0	-34	0	-45
25	0.60	0.000	0.000	10	0	13	0	0	-21	0	-28
26	0.00	0.000	-0.000	0	-0	0	-0	0	0	0	0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
no.	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	0	1.55	-0	9.50	0	-0	0	10.15	0	10.15	0	0
2	No calculation at this stage											
3	8	3.25	-9	6.00	11	-12	13	5.15	-6	6.65	17	-8
4	67	3.60	-0	9.18	90	-0	44	5.15	-26	1.55	60	-35
5	No calculation at this stage											
6	No calculation at this stage											
7	112	4.20	0	10.15	151	0	71	5.15	-39	2.40	96	-52
8	145	4.20	0	10.15	196	0	89	5.15	-50	2.40	120	-68
9	118	4.20	0	10.15	160	0	51	5.15	-40	2.40	69	-54
10	111	4.20	0	10.15	150	0	43	5.15	-38	2.40	57	-51
11	138	4.20	0	10.15	186	0	79	5.15	-48	2.40	107	-65
12	137	4.20	0	10.15	185	0	74	5.15	-47	2.40	99	-64
13	No calculation at this stage											
14	149	4.20	0	10.15	202	0	92	5.15	-52	2.40	124	-71
15	123	4.20	0	10.15	166	0	54	5.15	-42	2.40	73	-57

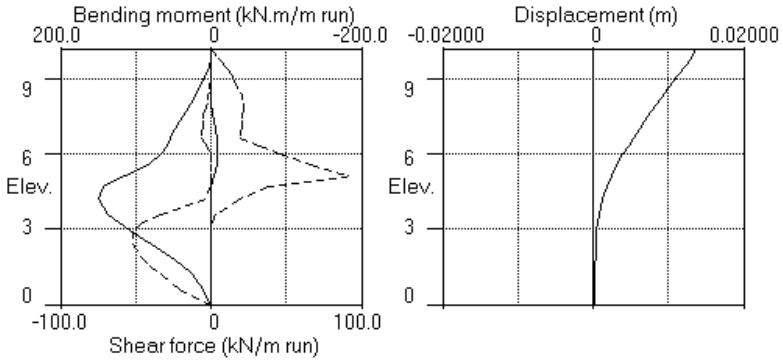
Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	0.00	-0.000	10.15	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.001	10.15	0.000	10.15	Apply surcharge no.2 at elev. 8.85
4	0.002	10.15	0.000	10.15	Excav. to elev. 8.00 on PASSIVE side
5	No calculation at this stage				Change EI of wall to 141654kN.m2/m run
6	No calculation at this stage				Remove surcharge no.2 at elev. 8.85
7	0.009	10.15	0.000	10.15	Fill to elev. 10.15 on ACTIVE side
8	0.013	10.15	0.000	10.15	Apply surcharge no.1 at elev. 10.15
9	0.011	10.15	0.000	10.15	Apply water pressure profile no.2
10	0.010	10.15	-0.000	0.00	Remove surcharge no.1 at elev. 10.15
11	0.013	10.15	0.000	10.15	Apply water pressure profile no.1
12	0.013	10.15	0.000	10.15	Change soil type 3 to soil type 4
13	No calculation at this stage				Change soil type 4 to soil type 3
14	0.014	10.15	0.000	10.15	Apply surcharge no.1 at elev. 10.15
15	0.012	10.15	-0.000	0.00	Apply water pressure profile no.2

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	8.85	1 Fill (D)	7 Fill (P)
2	6.65	3 Silt (U)	3 Silt (U)
3	5.15	5 WRock	5 WRock

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Fill (D)	19.00	30000	0.426	OC (0.250)	0.222 (0.000)	6.064 (0.000)	
2	Not defined							
3	Silt (U)	17.00	3000	0.577	NC (0.490)	1.000 (2.443)	1.000 (2.444)	10.00u
4	Silt (D)	17.00	2400	0.577	NC (0.150)	0.352 (1.389)	3.421 (5.191)	0.0d
5	WRock (5.15)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	Not defined							
7	Fill (P)	19.00	30000	0.426	OC (0.250)	0.222 (0.000)	6.064 (0.000)	

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Fill (D)	35.00	0.816	0.00	33.00	0.820	0.00
2	Not defined						
3	Silt (U)	0.00	0.600	0.00	0.00	0.600	0.00
4	Silt (D)	25.00	0.650	0.00	25.00	0.650	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	Not defined						
7	Fill (P)	35.00	0.816	0.00	33.00	0.820	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	1.90	1.90

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Point no.	Active side Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	2.90	2.90	0.0	1	1.90	1.90	0.0	MC+WC
2	1	2.90	2.90	0.0	1	10.15	10.15	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall =  0.00
             Maximum finite element length =  0.60 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 8.4820E-03 m4/m run
                                       E.I = 198309 kN.m2/m run
                    Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.15	0.00(A)	7.50	100.00	10.00	=	N/A	1.00 P/U
2	8.85	1.20(A)	100.00	100.00	24.70	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined Allow wall to relax with new modulus value
2	Apply water pressure profile no.1 (Mod. Conserv.) No analysis at this stage
3	Apply surcharge no.2 at elevation 8.85
4	Excavate to elevation 8.00 on PASSIVE side Toe of berm at elevation 0.60 Width of top of berm = 0.01 Width of toe of berm = 10.60
5	Change EI of wall to 141654 kN.m2/m run Yield moment not defined No adjustments to wall displacements
6	Remove surcharge no.2 at elevation 8.85 No analysis at this stage
7	Fill to elevation 10.15 on ACTIVE side with soil type 1
8	Apply surcharge no.1 at elevation 10.15
9	Apply water pressure profile no.2 (Mod. Conserv.)
10	Remove surcharge no.1 at elevation 10.15
11	Apply water pressure profile no.1 (Mod. Conserv.)
12	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
13	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
14	Apply surcharge no.1 at elevation 10.15
15	Apply water pressure profile no.2 (Mod. Conserv.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: ULS DA1 Combination 1
  Water pressures : Moderately Conservative
  Partial factor on   C'         = 1.000
  Partial factor on Phi'         = 1.000
  Partial factor on   Cu         = 1.000
  Partial factor on Soil Modulus = 1.000
  Partial factor on Permanent Unfavourable loads = 1.000
  Partial factor on Permanent Favourable loads   = 1.000
  Partial factor on Variable Unfavourable loads  = 1.100
  Design factor on calculated Bending Moments    = 1.350


 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
  Non-linear Modulus Parameter (L) = 10.00 m
```

Boundary conditions:
 Length of wall (normal to plane of analysis) = 1000.00 m

 Width of excavation on active side of wall = 48.00 m
 Width of excavation on passive side of wall = 48.00 m

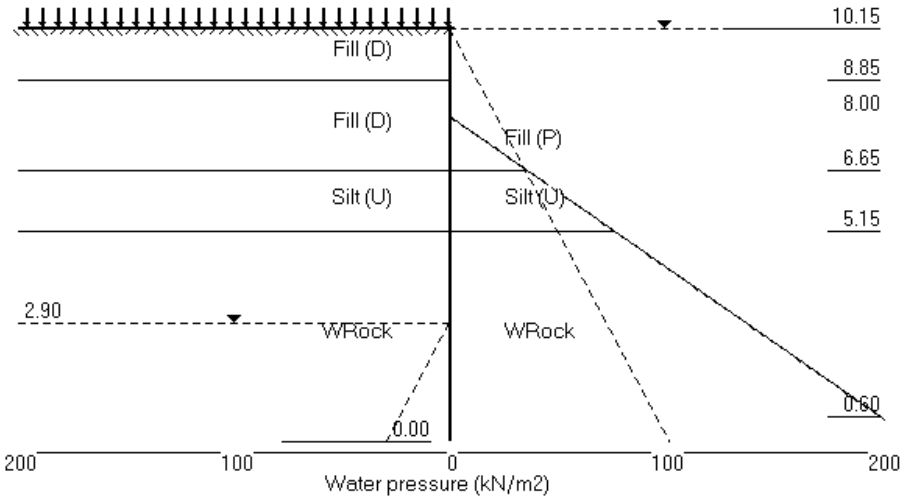
 Distance to rigid boundary on active side = 48.00 m
 Distance to rigid boundary on passive side = 48.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Apply surcharge no.2 at elev. 8.85	No	No	No
4	Excav. to elev. 8.00 on PASSIVE side	No	No	No
5	Change EI of wall to 141654kN.m2/m run	No	No	No
6	Remove surcharge no.2 at elev. 8.85	No	No	No
7	Fill to elev. 10.15 on ACTIVE side	No	No	No
8	Apply surcharge no.1 at elev. 10.15	No	No	No
9	Apply water pressure profile no.2	No	No	No
10	Remove surcharge no.1 at elev. 10.15	No	No	No
11	Apply water pressure profile no.1	No	No	No
12	Change soil type 3 to soil type 4	No	No	No
13	Change soil type 4 to soil type 3	No	No	No
14	Apply surcharge no.1 at elev. 10.15	No	No	No
15	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.15 Apply water pressure profile no.2 (Mod. Conserv.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
2	9.82	0.00	-0.000	-4.08E-18	0.0	-0.0		3521239
3	9.50	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
4	9.18	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
5	8.85	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
6	8.43	0.00	-0.000	-4.08E-18	0.0	0.0		3521239
7	8.00	0.00	-0.000	-4.09E-18	0.0	0.0		3521239
8	7.66	0.00	-0.000	-4.10E-18	0.0	0.0		3521239
9	7.33	0.00	-0.000	-4.13E-18	0.0	0.0		3521239
10	6.99	0.00	-0.000	-4.17E-18	0.0	0.0		3521239
11	6.65	0.00	-0.000	-4.24E-18	0.0	0.0		3521239
12	6.33	0.00	-0.000	-4.33E-18	0.0	0.0		3521239
13	6.00	0.00	-0.000	-4.44E-18	0.0	0.0		3521239
14	5.58	0.00	-0.000	-4.63E-18	0.0	0.0		3521239
15	5.15	0.00	-0.000	-4.85E-18	0.0	0.0		3521239
16	4.68	0.00	-0.000	-5.17E-18	0.0	0.0		3521239
17	4.20	0.00	-0.000	-5.59E-18	0.0	0.0		3521239
18	3.60	0.00	-0.000	-6.32E-18	0.0	0.0		3521239
19	3.25	0.00	-0.000	-6.87E-18	0.0	0.0		3521239
20	2.90	0.00	-0.000	-7.53E-18	0.0	0.0		3521239
21	2.40	0.00	0.000	-8.69E-18	0.0	0.0		3521239
22	1.90	0.00	0.000	-1.00E-17	0.0	0.0		3521239
23	1.55	0.00	0.000	-1.12E-17	0.0	0.0		3521239
24	1.20	0.00	0.000	-1.23E-17	0.0	0.0		3521239
25	0.60	0.00	0.000	-1.34E-17	0.0	0.0		3521239
26	0.00	0.00	0.000	-1.35E-17	0.0	-0.0		---

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7176
6	8.43	0.00	8.08	1.79	48.97	3.44	3.44	7176

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
7	8.00	0.00	16.15	3.58	97.94	6.88	6.88	7176
8	7.66	0.00	22.56	5.00	136.82	9.61	9.61	7176
9	7.33	0.00	28.98	6.42	175.71	12.34	12.34	7176
10	6.99	0.00	35.39	7.84	214.60	15.08	15.08	7176
11	6.65	0.00	41.80	9.26	253.48	17.81	17.81	7176
		Total>	41.80	17.36	66.25	24.12	24.12	1047
12	6.33	Total>	47.33	22.88	71.77	27.31	27.31	1047
13	6.00	Total>	52.85	28.41	77.30	30.49	30.49	1047
14	5.58	Total>	60.08	35.63	84.53	35.63	35.63a	1047
15	5.15	Total>	67.30	42.85	91.75	42.85	42.85a	1047
		Total>	67.30	18.50m	678.28	26.92	26.92	43630
16	4.68	Total>	77.28	20.88m	746.30	30.91	30.91	47775
17	4.20	Total>	87.25	23.25m	814.31	34.90	34.90	51920
18	3.60	Total>	99.85	26.25m	900.23	39.94	39.94	57156
19	3.25	Total>	107.20	28.00m	950.35	42.88	42.88	60210
20	2.90	Total>	114.55	29.75m	1000.47	45.82	45.82	63264
21	2.40	Total>	125.05	32.25m	1072.07	50.02	50.02	137677
22	1.90	Total>	135.55	34.75m	1143.67	54.22	54.22	146559
23	1.55	Total>	142.90	36.50m	1193.79	59.26	59.26	152777
24	1.20	Total>	150.25	38.25m	1243.90	64.30	64.30	158995
25	0.60	Total>	162.85	41.25m	1329.82	72.94	72.94	169654
26	0.00	Total>	175.45	44.25m	1415.74	81.58	81.58	180313

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7176
6	8.43	0.00	8.08	1.79	48.97	3.44	3.44	7176
7	8.00	0.00	16.15	3.58	97.94	6.88	6.88	7176
8	7.66	0.00	22.56	5.00	136.82	9.61	9.61	7176
9	7.33	0.00	28.98	6.42	175.71	12.34	12.34	7176
10	6.99	0.00	35.39	7.84	214.60	15.08	15.08	7176
11	6.65	0.00	41.80	9.26	253.48	17.81	17.81	7176
		Total>	41.80	17.36	66.25	24.12	24.12	1047
12	6.33	Total>	47.33	22.88	71.77	27.31	27.31	1047
13	6.00	Total>	52.85	28.41	77.30	30.49	30.49	1047
14	5.58	Total>	60.08	35.63	84.53	35.63	35.63a	1047
15	5.15	Total>	67.30	42.85	91.75	42.85	42.85a	1047
		Total>	67.30	18.50m	678.28	26.92	26.92	43630
16	4.68	Total>	77.28	20.88m	746.30	30.91	30.91	47775
17	4.20	Total>	87.25	23.25m	814.31	34.90	34.90	51920
18	3.60	Total>	99.85	26.25m	900.23	39.94	39.94	57156
19	3.25	Total>	107.20	28.00m	950.35	42.88	42.88	60210
20	2.90	Total>	114.55	29.75m	1000.47	45.82	45.82	63264
21	2.40	Total>	125.05	32.25m	1072.07	50.02	50.02	137677

(continued)

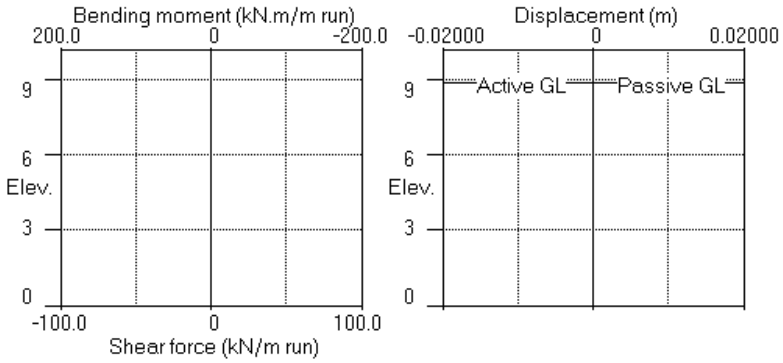
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
22	1.90	Total>	135.55	34.75m	1143.67	54.22	54.22	146559
23	1.55	Total>	142.90	36.50m	1193.79	59.26	59.26	152777
24	1.20	Total>	150.25	38.25m	1243.90	64.30	64.30	158995
25	0.60	Total>	162.85	41.25m	1329.82	72.94	72.94	169654
26	0.00	Total>	175.45	44.25m	1415.74	81.58	81.58	180313

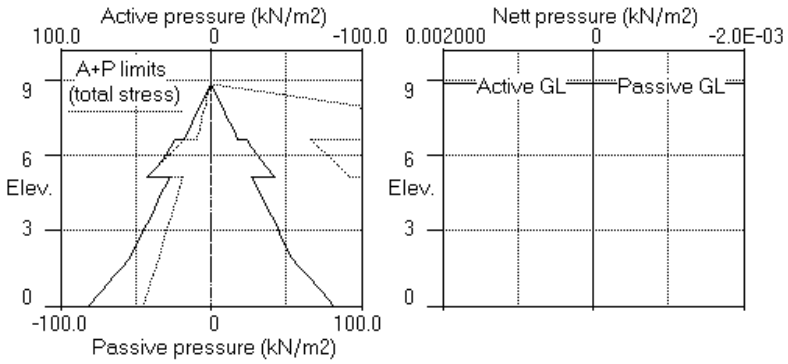
Note: 42.85a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.002	1.78E-04	0.0	0.0		3521239
2	9.82	0.00	0.002	1.78E-04	0.0	-0.0		3521239
3	9.50	0.00	0.002	1.78E-04	0.0	0.0		3521239
4	9.18	0.00	0.002	1.78E-04	0.0	0.0		3521239
5	8.85	0.00	0.001	1.78E-04	0.0	0.0		3521239
6	8.43	1.88	0.001	1.78E-04	0.4	0.1		3521239
7	8.00	4.08	0.001	1.78E-04	1.7	0.6		3521239
8	7.66	-0.23	0.001	1.78E-04	2.3	1.3		3521239
		-0.07	0.001	1.78E-04	2.3	1.3		
9	7.33	-4.21	0.001	1.78E-04	1.6	2.0		3521239
		-4.14	0.001	1.78E-04	1.6	2.0		
10	6.99	-7.49	0.001	1.78E-04	-0.4	2.5		3521239
11	6.65	-6.05	0.001	1.78E-04	-2.7	1.9		3521239
		24.21	0.001	1.78E-04	-2.7	1.9		
12	6.33	25.72	0.001	1.77E-04	5.5	2.4		3521239
13	6.00	27.37	0.001	1.77E-04	14.1	5.5		3521239
		28.84	0.001	1.77E-04	14.1	5.5		
14	5.58	34.61	0.001	1.76E-04	27.6	14.3		3521239
		36.13	0.001	1.76E-04	27.6	14.3		
15	5.15	42.97	0.001	1.73E-04	44.4	29.4		3521239
		-26.51	0.001	1.73E-04	44.4	29.4		
16	4.68	-27.40	0.001	1.68E-04	31.6	47.5		3521239
17	4.20	-27.76	0.001	1.61E-04	18.5	59.3		3521239
18	3.60	-25.20	0.001	1.50E-04	2.6	66.5		3521239
19	3.25	-21.76	0.000	1.43E-04	-5.6	65.9		3521239
20	2.90	-18.03	0.000	1.37E-04	-12.6	62.6		3521239
21	2.40	-12.24	0.000	1.29E-04	-20.2	54.0		3521239
22	1.90	-5.92	0.000	1.22E-04	-24.7	42.4		3521239
23	1.55	-1.16	0.000	1.18E-04	-25.9	33.4		3521239
24	1.20	3.90	0.000	1.15E-04	-25.5	24.3		3521239
25	0.60	13.37	0.000	1.12E-04	-20.3	9.7		3521239
26	0.00	54.21	0.000	1.12E-04	0.0	0.0		---

(continued)

Stage No.4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7387
6	8.43	0.00	8.48	1.88	51.42	1.88	1.88a	7387
7	8.00	0.00	18.42	4.08	111.73	4.08	4.08a	7387
8	7.66	0.00	26.97	5.98	163.54	5.98	5.98a	7387
9	7.33	0.00	35.55	7.88	215.58	7.88	7.88a	7387
10	6.99	0.00	43.93	9.73	266.39	10.24	10.24	7387
11	6.65	0.00	52.04	11.53	315.56	13.96	13.96	7387
		Total>	52.04	27.59	76.49	33.29	33.29	1074
12	6.33	Total>	58.95	34.51	83.40	37.93	37.93	1074
13	6.00	Total>	65.66	41.21	90.11	42.36	42.36	1074
14	5.58	Total>	74.17	49.72	98.63	49.72	49.72a	1074
15	5.15	Total>	82.45	58.00	106.91	58.00	58.00a	1074
		Total>	82.45	18.50m	693.43	18.50	18.50a	44748
16	4.68	Total>	93.39	20.88m	762.42	20.88	20.88a	48999
17	4.20	Total>	104.17	23.25m	831.23	23.25	23.25a	53250
18	3.60	Total>	117.59	26.25m	917.98	28.63	28.63	58619
19	3.25	Total>	125.34	28.00m	968.50	33.46	33.46	61752
20	2.90	Total>	133.06	29.75m	1018.98	38.40	38.40	64884
21	2.40	Total>	144.01	32.25m	1091.03	45.66	45.66	69359
22	1.90	Total>	154.90	34.75m	1163.02	53.15	53.15	73834
23	1.55	Total>	162.49	36.50m	1213.38	60.64	60.64	76966
24	1.20	Total>	170.06	38.25m	1263.71	68.27	68.27	80098
25	0.60	Total>	182.99	41.25m	1349.97	81.72	81.72	85468
26	0.00	Total>	195.88	44.25m	1436.17	110.84	110.84	1362369

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7864
8	7.66	0.00	6.41	1.42	6.21b	6.21	6.21p	7864
		0.00	6.41	1.42	6.04b	6.04	6.04p	7864
9	7.33	0.00	12.83	2.84	12.08b	12.08	12.08p	7864
		0.00	12.83	2.84	12.02b	12.02	12.02p	7864
10	6.99	0.00	19.24	4.26	18.03b	17.73	17.73	7864
		0.00	19.24	4.26	17.98b	17.73	17.73	7864
11	6.65	0.00	25.65	5.68	23.98b	20.01	20.01	7864
		Total>	25.65	6.75m	22.78b	9.08	9.08	1135

(continued)

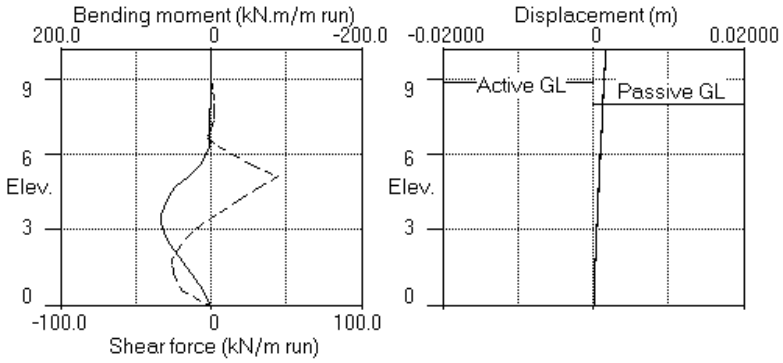
Stage No.4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

Node no.	Y coord	PASSIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
12	6.33	Total>	31.18	8.37m	25.30b	12.20	12.20	1135
		Total>	31.18	8.37m	13.63b	12.20	12.20	1135
13	6.00	Total>	36.70	12.26	14.99b	14.99	14.99p	1135
		Total>	36.70	12.26	13.51b	13.51	13.51p	1135
14	5.58	Total>	43.93	15.10	15.11b	15.11	15.11p	1135
		Total>	43.93	13.58	13.59b	13.59	13.59p	1135
15	5.15	Total>	51.15	15.02	15.03b	15.03	15.03p	1135
		Total>	51.15	14.25m	662.12	45.01	45.01	47298
16	4.68	Total>	61.13	16.63m	730.14	48.27	48.27	51792
17	4.20	Total>	71.10	19.00m	798.16	51.01	51.01	56285
18	3.60	Total>	83.71	22.00m	884.08	53.84	53.84	61961
19	3.25	Total>	91.06	23.75m	934.20	55.22	55.22	65272
20	2.90	Total>	98.41	25.50m	984.32	56.44	56.44	68583
21	2.40	Total>	108.91	28.00m	1055.93	57.90	57.90	73312
22	1.90	Total>	119.41	30.50m	1127.53	59.07	59.07	78042
23	1.55	Total>	126.77	32.25m	1177.65	61.80	61.80	81353
24	1.20	Total>	134.12	34.00m	1227.77	64.37	64.37	84664
25	0.60	Total>	146.72	37.00m	1313.69	68.34	68.34	90340
26	0.00	Total>	159.33	40.00m	1399.61	56.63	56.63	1362369

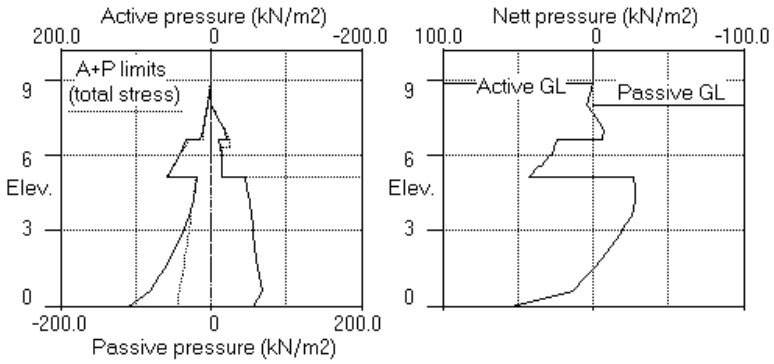
Note: 23.25a Soil pressure at active limit
15.03p Soil pressure at passive limit
15.03b Passive limit reduced because of berm

Units: kN,m

Stage No.4 Excav. to elev. 8.00 on PASSIVE side



Stage No.4 Excav. to elev. 8.00 on PASSIVE side



Units: kN,m

Stage No. 7 Fill to elevation 10.15 on ACTIVE side with soil type 1

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.009	1.51E-03	0.0	0.0		141654
2	9.82	1.37	0.008	1.51E-03	0.2	0.0		141654
3	9.50	2.74	0.008	1.51E-03	0.9	0.2		141654
4	9.18	4.10	0.007	1.51E-03	2.0	0.7		141654
5	8.85	5.47	0.007	1.51E-03	3.6	1.5		141654
6	8.43	7.26	0.006	1.50E-03	6.3	3.7		141654
7	8.00	9.05	0.006	1.48E-03	9.7	7.1		141654
8	7.66	4.27	0.005	1.46E-03	12.0	10.8		141654
		4.43	0.005	1.46E-03	12.0	10.8		
9	7.33	-0.19	0.005	1.44E-03	12.7	15.0		141654
		-0.12	0.005	1.44E-03	12.7	15.0		
10	6.99	-4.71	0.004	1.40E-03	11.9	19.4		141654
		-4.67	0.004	1.40E-03	11.9	19.4		
11	6.65	-9.24	0.004	1.36E-03	9.5	23.1		141654
		31.46	0.004	1.36E-03	9.5	23.1		
12	6.33	32.66	0.003	1.30E-03	19.9	27.8		141654
		34.68	0.003	1.30E-03	19.9	27.8		
13	6.00	38.11	0.003	1.24E-03	31.8	36.1		141654
		39.59	0.003	1.24E-03	31.8	36.1		
14	5.58	45.21	0.002	1.13E-03	49.8	53.4		141654
		46.73	0.002	1.13E-03	49.8	53.4		
15	5.15	52.52	0.002	1.00E-03	70.9	78.9		141654
		-85.57	0.002	1.00E-03	70.9	78.9		
16	4.68	-66.83	0.001	8.19E-04	34.7	102.9		141654
17	4.20	-49.94	0.001	6.31E-04	7.0	111.8		141654
18	3.60	-33.29	0.001	4.22E-04	-18.0	107.9		141654
19	3.25	-25.16	0.001	3.23E-04	-28.2	99.6		141654
20	2.90	-13.79	0.000	2.43E-04	-35.1	88.2		141654
21	2.40	-1.48	0.000	1.63E-04	-38.9	68.9		141654
22	1.90	6.31	0.000	1.18E-04	-37.7	49.3		141654
23	1.55	10.15	0.000	1.02E-04	-34.8	36.5		141654
24	1.20	13.49	0.000	9.49E-05	-30.6	24.9		141654
25	0.60	19.37	0.000	9.22E-05	-20.8	9.0		141654
26	0.00	49.93	0.000	9.29E-05	0.0	0.0		---

(continued)

Stage No.7 Fill to elevation 10.15 on ACTIVE side with soil type 1

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	8752
2	9.82	0.00	6.17	1.37	37.45	1.37	1.37a	8752
3	9.50	0.00	12.35	2.74	74.89	2.74	2.74a	8752
4	9.18	0.00	18.52	4.10	112.34	4.10	4.10a	8752
5	8.85	0.00	24.70	5.47	149.79	5.47	5.47a	8752
6	8.43	0.00	32.77	7.26	198.76	7.26	7.26a	8752
7	8.00	0.00	40.85	9.05	247.72	9.05	9.05a	8752
8	7.66	0.00	47.26	10.47	286.61	10.47	10.47a	8752
9	7.33	0.00	53.67	11.89	325.50	11.89	11.89a	8752
10	6.99	0.00	60.09	13.31	364.38	13.31	13.31a	8752
11	6.65	0.00	66.50	14.73	403.27	14.73	14.73a	8752
		Total> 66.50	42.05	90.95	44.60	44.60		1250
12	6.33	Total> 72.02	47.58	96.48	48.32	48.32		1250
13	6.00	Total> 77.55	53.10	102.01	53.10	53.10a		1250
14	5.58	Total> 84.77	60.32	109.23	60.32	60.32a		1250
15	5.15	Total> 92.00	67.55	116.46	67.55	67.55a		1250
		Total> 92.00	25.00m	702.98	25.00	25.00a		52068
16	4.68	Total> 101.97	27.37m	771.00	27.37	27.37a		57015
17	4.20	Total> 111.95	29.75m	839.02	29.75	29.75a		61961
18	3.60	Total> 124.55	32.75m	924.94	32.75	32.75a		68210
19	3.25	Total> 131.90	34.50m	975.06	35.66	35.66		71854
20	2.90	Total> 139.25	36.25m	1025.18	43.74	43.74		75499
21	2.40	Total> 149.75	38.75m	1096.77	53.91	53.91		113521
22	1.90	Total> 160.25	41.25m	1168.37	61.94	61.94		120845
23	1.55	Total> 167.60	43.00m	1218.49	68.85	68.85		125971
24	1.20	Total> 174.95	44.75m	1268.61	75.51	75.51		131098
25	0.60	Total> 187.55	47.75m	1354.52	86.99	86.99		139887
26	0.00	Total> 200.15	50.75m	1440.44	110.84	110.84		642381

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	11520
8	7.66	0.00	6.41	1.42	6.21b	6.21	6.21p	11520
		0.00	6.41	1.42	6.04b	6.04	6.04p	11520
9	7.33	0.00	12.83	2.84	12.08b	12.08	12.08p	11520
		0.00	12.83	2.84	12.02b	12.02	12.02p	11520
10	6.99	0.00	19.24	4.26	18.03b	18.03	18.03p	11520
		0.00	19.24	4.26	17.98b	17.98	17.98p	11520
11	6.65	0.00	25.65	5.68	23.98b	23.98	23.98p	11520
		Total> 25.65	6.75m	22.78b	13.14	13.14		1610
12	6.33	Total> 31.18	8.37m	25.30b	15.66	15.66		1610
		Total> 31.18	8.37m	13.63b	13.63	13.63p		1610
13	6.00	Total> 36.70	12.26	14.99b	14.99	14.99p		1610
		Total> 36.70	12.26	13.51b	13.51	13.51p		1610

(continued)

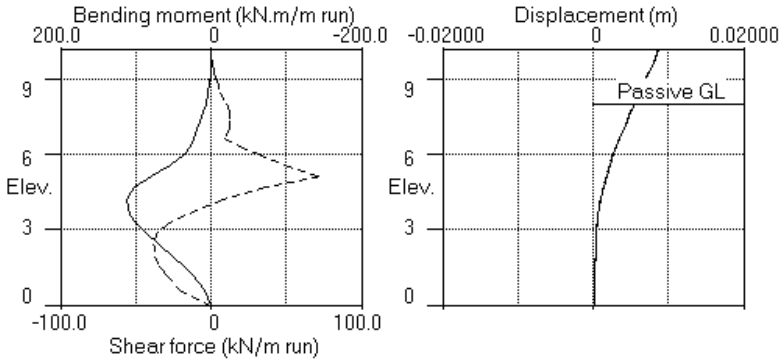
Stage No.7 Fill to elevation 10.15 on ACTIVE side with soil type 1

Node no.	Y coord	PASSIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
14	5.58	Total>	43.93	15.10	15.11b	15.11	15.11p	1610
		Total>	43.93	13.58	13.59b	13.59	13.59p	1610
15	5.15	Total>	51.15	15.02	15.03b	15.03	15.03p	1610
		Total>	51.15	14.25m	662.12	110.57	110.57	67070
16	4.68	Total>	61.13	16.63m	730.14	94.21	94.21	73442
17	4.20	Total>	71.10	19.00m	798.16	79.69	79.69	79813
18	3.60	Total>	83.71	22.00m	884.08	66.04	66.04	87862
19	3.25	Total>	91.06	23.75m	934.20	60.83	60.83	92556
20	2.90	Total>	98.41	25.50m	984.32	57.54	57.54	97251
21	2.40	Total>	108.91	28.00m	1055.93	55.40	55.40	113521
22	1.90	Total>	119.41	30.50m	1127.53	55.63	55.63	120845
23	1.55	Total>	126.77	32.25m	1177.65	58.70	58.70	125971
24	1.20	Total>	134.12	34.00m	1227.77	62.02	62.02	131098
25	0.60	Total>	146.72	37.00m	1313.69	67.62	67.62	139887
26	0.00	Total>	159.33	40.00m	1399.61	60.90	60.90	642381

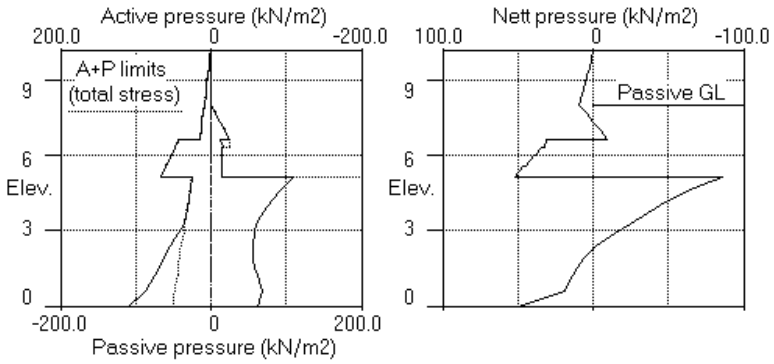
Note: 32.75a Soil pressure at active limit
15.03p Soil pressure at passive limit
15.03b Passive limit reduced because of berm

Units: kN,m

Stage No.7 Fill to elev. 10.15 on ACTIVE side



Stage No.7 Fill to elev. 10.15 on ACTIVE side



Units: kN,m

Stage No. 12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.013	2.30E-03	0.0	0.0		141654
2	9.82	4.78	0.012	2.30E-03	0.8	0.3		141654
3	9.50	6.00	0.011	2.30E-03	2.5	0.8		141654
4	9.18	7.22	0.010	2.30E-03	4.7	1.9		141654
5	8.85	8.45	0.010	2.29E-03	7.2	3.9		141654
6	8.43	10.06	0.009	2.27E-03	11.2	7.8		141654
7	8.00	11.68	0.008	2.24E-03	15.8	13.6		141654
8	7.66	7.03	0.007	2.20E-03	18.9	19.5		141654
		7.20	0.007	2.20E-03	18.9	19.5		
9	7.33	2.47	0.006	2.15E-03	20.6	26.2		141654
		2.54	0.006	2.15E-03	20.6	26.2		
10	6.99	-2.17	0.005	2.09E-03	20.6	33.4		141654
		-2.13	0.005	2.09E-03	20.6	33.4		
11	6.65	-3.27	0.005	2.00E-03	19.7	40.5		141654
		40.26	0.005	2.00E-03	19.7	40.5		
12	6.33	44.52	0.004	1.91E-03	33.5	49.0		141654
		29.99	0.004	1.91E-03	33.5	49.0		
13	6.00	32.29	0.003	1.79E-03	43.6	61.5		141654
14	5.58	35.29	0.003	1.60E-03	58.0	83.0		141654
15	5.15	38.29	0.002	1.37E-03	73.6	110.9		141654
		-108.44	0.002	1.37E-03	73.6	110.9		
16	4.68	-81.37	0.002	1.09E-03	28.5	132.7		141654
17	4.20	-56.75	0.001	8.11E-04	-4.3	137.3		141654
18	3.60	-33.54	0.001	5.08E-04	-31.4	126.2		141654
19	3.25	-22.58	0.001	3.69E-04	-41.2	113.5		141654
20	2.90	-8.59	0.000	2.61E-04	-46.6	97.7		141654
21	2.40	5.80	0.000	1.57E-04	-47.3	73.3		141654
22	1.90	13.22	0.000	1.02E-04	-42.6	50.3		141654
23	1.55	15.90	0.000	8.54E-05	-37.5	36.2		141654
24	1.20	17.88	0.000	7.93E-05	-31.6	24.1		141654
25	0.60	20.38	0.000	7.97E-05	-20.1	8.4		141654
26	0.00	46.56	0.000	8.17E-05	0.0	0.0		---

(continued)

Stage No.12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	100469
2	9.82	0.00	6.17	1.37	37.45	4.78	4.78	6936
3	9.50	0.00	12.35	2.74	74.89	6.00	6.00	6936
4	9.18	0.00	18.52	4.10	112.34	7.22	7.22	6936
5	8.85	0.00	24.70	5.47	149.79	8.45	8.45	6936
6	8.43	0.00	32.77	7.26	198.76	10.06	10.06	6936
7	8.00	0.00	40.85	9.05	247.72	11.68	11.68	6936
8	7.66	0.00	47.26	10.47	286.61	12.96	12.96	6936
9	7.33	0.00	53.67	11.89	325.50	14.24	14.24	6936
10	6.99	0.00	60.09	13.31	364.38	15.50	15.50	6936
11	6.65	0.00	66.50	14.73	403.27	16.76	16.76	6936
		0.00	66.50	23.43	227.48	43.08	43.08	512
12	6.33	0.00	72.02	25.37	246.38	47.95	47.95	512
13	6.00	0.00	77.55	27.32	265.28	53.43	53.43	512
14	5.58	0.00	84.77	29.87	289.99	60.60	60.60	512
15	5.15	0.00	92.00	32.41	314.71	67.77	67.77	512
		Total> 92.00	25.00m	702.98	28.50	28.50		42358
16	4.68	Total> 101.97	27.37m	771.00	29.34	29.34		46382
17	4.20	Total> 111.95	29.75m	839.02	31.30	31.30		50406
18	3.60	Total> 124.55	32.75m	924.94	33.73	33.73		55489
19	3.25	Total> 131.90	34.50m	975.06	36.92	36.92		58454
20	2.90	Total> 139.25	36.25m	1025.18	46.11	46.11		61419
21	2.40	Total> 149.75	38.75m	1096.77	57.32	57.32		65655
22	1.90	Total> 160.25	41.25m	1168.37	65.19	65.19		111448
23	1.55	Total> 167.60	43.00m	1218.49	71.53	71.53		116177
24	1.20	Total> 174.95	44.75m	1268.61	77.50	77.50		120905
25	0.60	Total> 187.55	47.75m	1354.52	87.29	87.29		129010
26	0.00	Total> 200.15	50.75m	1440.44	108.93	108.93		137115

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7147
8	7.66	0.00	6.41	1.42	6.21b	5.93	5.93	7147
		0.00	6.41	1.42	6.04b	5.76	5.76	7147
9	7.33	0.00	12.83	2.84	12.08b	11.76	11.76	7147
		0.00	12.83	2.84	12.02b	11.70	11.70	7147
10	6.99	0.00	19.24	4.26	18.03b	17.67	17.67	7147
		0.00	19.24	4.26	17.98b	17.63	17.63	7147
11	6.65	0.00	25.65	5.68	23.98b	20.03	20.03	7147
		0.00	25.65	2.82	2.83b	2.82	2.82a	528
12	6.33	0.00	31.18	3.43	3.44b	3.43	3.43a	528
		0.00	31.18	10.98	19.22b	17.96	17.96	528
13	6.00	0.00	36.70	12.93	22.63b	21.14	21.14	528
		0.00	36.70	12.93	22.92b	21.14	21.14	528

(continued)

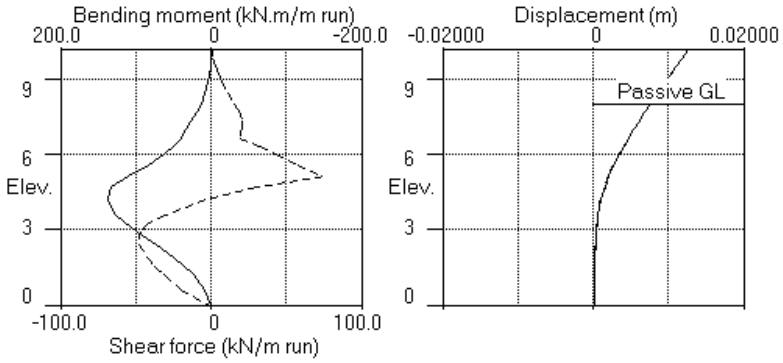
Stage No.12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
14	5.58	0.00	43.93	15.47	27.44b	25.31	25.31	528
		0.00	43.93	15.47	27.72b	25.31	25.31	528
15	5.15	0.00	51.15	18.02	32.28b	29.49	29.49	528
		Total>	51.15	14.25m	662.12	136.94	136.94	43473
16	4.68	Total>	61.13	16.63m	730.14	110.71	110.71	47603
17	4.20	Total>	71.10	19.00m	798.16	88.06	88.06	51733
18	3.60	Total>	83.71	22.00m	884.08	67.27	67.27	56949
19	3.25	Total>	91.06	23.75m	934.20	59.50	59.50	59993
20	2.90	Total>	98.41	25.50m	984.32	54.70	54.70	63036
21	2.40	Total>	108.91	28.00m	1055.93	51.52	51.52	67383
22	1.90	Total>	119.41	30.50m	1127.53	51.97	51.97	111448
23	1.55	Total>	126.77	32.25m	1177.65	55.62	55.62	116177
24	1.20	Total>	134.12	34.00m	1227.77	59.62	59.62	120905
25	0.60	Total>	146.72	37.00m	1313.69	66.90	66.90	129010
26	0.00	Total>	159.33	40.00m	1399.61	62.37	62.37	137115

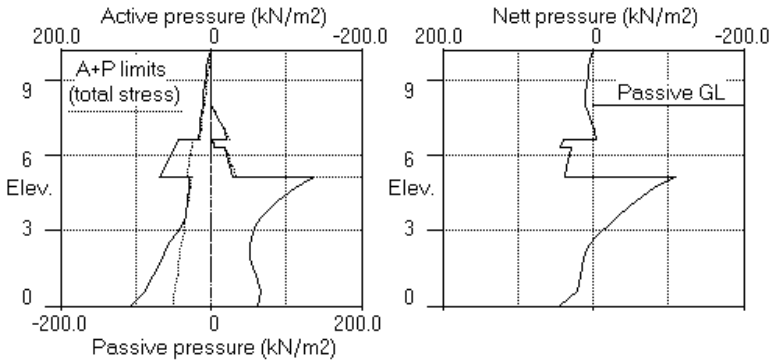
Note: 3.43a Soil pressure at active limit
123.45p Soil pressure at passive limit
32.28b Passive limit reduced because of berm

Units: kN,m

Stage No.12 Change soil type 3 to soil type 4



Stage No.12 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	10.15	0.014	-0.000	0	-0	0	-0	0	0	0	0
2	9.82	0.013	-0.000	1	-0	1	-0	5	0	7	0
3	9.50	0.012	-0.000	3	-0	5	-0	9	0	13	0
4	9.18	0.011	-0.000	7	-0	10	-0	13	0	18	0
5	8.85	0.011	-0.000	12	-0	16	-0	16	0	21	0
6	8.43	0.009	-0.000	19	-0	26	-0	19	-1	26	-1
7	8.00	0.008	-0.000	28	-1	37	-1	21	-3	29	-4
8	7.66	0.008	-0.000	34	-2	46	-3	22	-4	29	-5
9	7.33	0.007	-0.000	41	-3	55	-5	21	-5	28	-7
10	6.99	0.006	-0.000	48	-5	65	-7	21	-6	28	-8
11	6.65	0.005	-0.000	54	-7	72	-10	20	-6	27	-8
12	6.33	0.005	-0.000	59	-9	80	-12	33	-3	45	-4
13	6.00	0.004	-0.000	67	-9	91	-12	46	0	62	0
14	5.58	0.003	-0.000	83	-7	112	-10	67	0	91	0
15	5.15	0.002	-0.000	115	-3	155	-5	92	0	124	0
16	4.68	0.002	-0.000	143	0	192	0	37	0	50	0
17	4.20	0.001	-0.000	149	0	202	0	18	-4	25	-6
18	3.60	0.001	-0.000	138	0	186	0	3	-35	3	-47
19	3.25	0.001	-0.000	123	0	167	0	1	-46	1	-62
20	2.90	0.000	-0.000	106	0	143	0	0	-52	0	-70
21	2.40	0.000	0.000	79	0	106	0	0	-52	0	-71
22	1.90	0.000	0.000	53	0	72	0	0	-46	0	-63
23	1.55	0.000	0.000	38	0	51	0	0	-40	0	-55
24	1.20	0.000	0.000	25	0	34	0	0	-34	0	-45
25	0.60	0.000	0.000	10	0	13	0	0	-21	0	-28
26	0.00	0.000	-0.000	0	-0	0	-0	0	0	0	0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
no.	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	0	1.55	-0	9.50	0	-0	0	10.15	0	10.15	0	0
2	No calculation at this stage											
3	8	3.25	-9	6.00	11	-12	13	5.15	-6	6.65	17	-8
4	66	3.60	-0	9.50	90	-0	44	5.15	-26	1.55	60	-35
5	No calculation at this stage											
6	No calculation at this stage											
7	112	4.20	0	10.15	151	0	71	5.15	-39	2.40	96	-52
8	145	4.20	0	10.15	196	0	89	5.15	-50	2.40	120	-68
9	118	4.20	0	10.15	160	0	51	5.15	-40	2.40	69	-54
10	111	4.20	0	10.15	150	0	43	5.15	-38	2.40	57	-51
11	138	4.20	0	10.15	186	0	79	5.15	-48	2.40	107	-65
12	137	4.20	0	10.15	185	0	74	5.15	-47	2.40	99	-64
13	No calculation at this stage											
14	149	4.20	0	10.15	202	0	92	5.15	-52	2.40	124	-71
15	123	4.20	0	10.15	166	0	54	5.15	-42	2.40	73	-57

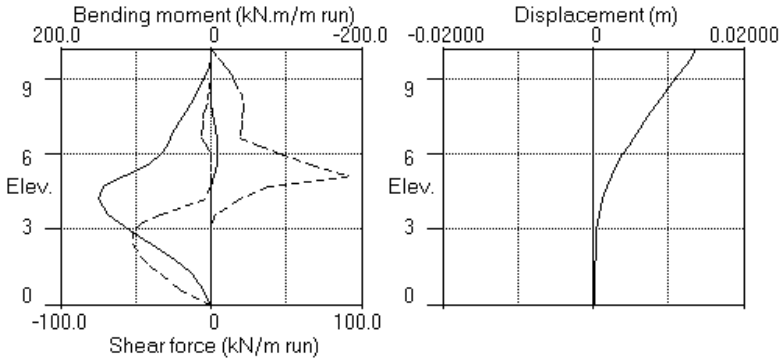
Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	0.00	-0.000	10.15	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.001	10.15	0.000	10.15	Apply surcharge no.2 at elev. 8.85
4	0.002	10.15	0.000	10.15	Excav. to elev. 8.00 on PASSIVE side
5	No calculation at this stage				Change EI of wall to 141654kN.m2/m run
6	No calculation at this stage				Remove surcharge no.2 at elev. 8.85
7	0.009	10.15	0.000	10.15	Fill to elev. 10.15 on ACTIVE side
8	0.013	10.15	0.000	10.15	Apply surcharge no.1 at elev. 10.15
9	0.011	10.15	0.000	10.15	Apply water pressure profile no.2
10	0.010	10.15	-0.000	0.00	Remove surcharge no.1 at elev. 10.15
11	0.013	10.15	0.000	10.15	Apply water pressure profile no.1
12	0.013	10.15	0.000	10.15	Change soil type 3 to soil type 4
13	No calculation at this stage				Change soil type 4 to soil type 3
14	0.014	10.15	0.000	10.15	Apply surcharge no.1 at elev. 10.15
15	0.012	10.15	-0.000	0.00	Apply water pressure profile no.2

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	8.85	1 Fill (D)	7 Fill (P)
2	6.65	3 Silt (U)	3 Silt (U)
3	5.15	5 WRock	5 WRock

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Fill (D)	19.00	30000	0.426	OC (0.250)	0.222 (0.000)	6.064 (0.000)	
2	Not defined							
3	Silt (U)	17.00	3000	0.577	NC (0.490)	1.000 (2.443)	1.000 (2.444)	10.00u
4	Silt (D)	17.00	2400	0.577	NC (0.150)	0.352 (1.389)	3.421 (5.191)	0.0d
5	WRock (5.15)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	Not defined							
7	Fill (P)	19.00	30000	0.426	OC (0.250)	0.222 (0.000)	6.064 (0.000)	

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Fill (D)	35.00	0.816	0.00	33.00	0.820	0.00
2	Not defined						
3	Silt (U)	0.00	0.600	0.00	0.00	0.600	0.00
4	Silt (D)	25.00	0.650	0.00	25.00	0.650	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	Not defined						
7	Fill (P)	35.00	0.816	0.00	33.00	0.820	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	1.90	1.90

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	2.90	2.90	0.0	1	1.90	1.90	0.0	MC+WC
2	1	2.90	2.90	0.0	1	10.15	10.15	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall =  0.00
             Maximum finite element length =  0.60 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 8.4820E-03 m4/m run
                                       E.I = 198309 kN.m2/m run
                    Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.15	0.00(A)	7.50	100.00	10.00	=	N/A	1.00 P/U
2	8.85	1.20(A)	100.00	100.00	24.70	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined Allow wall to relax with new modulus value
2	Apply water pressure profile no.1 (Worst Cred.) No analysis at this stage
3	Apply surcharge no.2 at elevation 8.85
4	Excavate to elevation 8.00 on PASSIVE side Toe of berm at elevation 0.60 Width of top of berm = 0.01 Width of toe of berm = 10.60
5	Change EI of wall to 141654 kN.m2/m run Yield moment not defined No adjustments to wall displacements
6	Remove surcharge no.2 at elevation 8.85 No analysis at this stage
7	Fill to elevation 10.15 on ACTIVE side with soil type 1
8	Apply surcharge no.1 at elevation 10.15
9	Apply water pressure profile no.2 (Worst Cred.)
10	Remove surcharge no.1 at elevation 10.15
11	Apply water pressure profile no.1 (Worst Cred.)
12	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
13	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
14	Apply surcharge no.1 at elevation 10.15
15	Apply water pressure profile no.2 (Worst Cred.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: ULS DA1 Combination 2
  Water pressures : Worst Credible
  Partial factor on   C'         = 1.250
  Partial factor on Phi'         = 1.250
  Partial factor on   Cu         = 1.400
  Partial factor on Soil Modulus = 1.000
  Partial factor on Permanent Unfavourable loads = 1.000
  Partial factor on Permanent Favourable loads   = 1.000
  Partial factor on Variable Unfavourable loads  = 1.300

 Stability analysis:
  Method of analysis  -  Strength Factor method
  Overall factor on soil strength for calculating wall depth = 1.00

 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
```

Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 48.00 m
Width of excavation on passive side of wall = 48.00 m

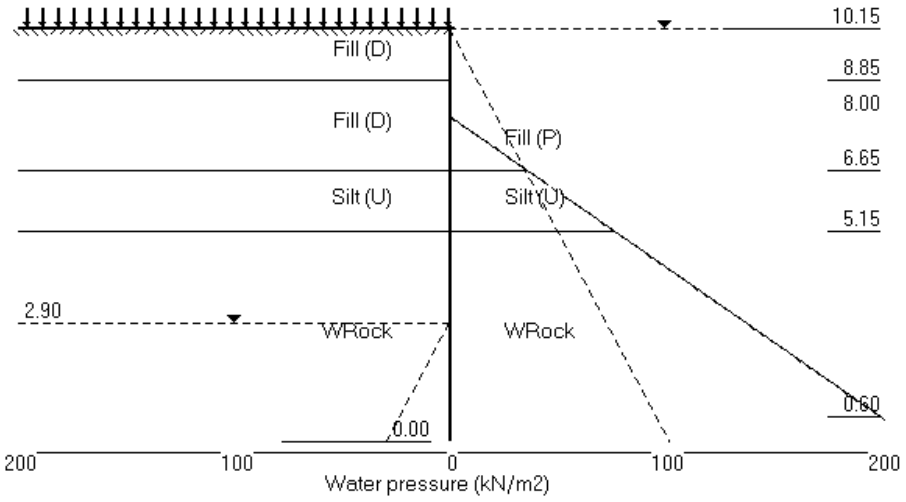
Distance to rigid boundary on active side = 48.00 m
Distance to rigid boundary on passive side = 48.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Apply surcharge no.2 at elev. 8.85	No	No	No
4	Excav. to elev. 8.00 on PASSIVE side	No	No	No
5	Change EI of wall to 141654kN.m2/m run	No	No	No
6	Remove surcharge no.2 at elev. 8.85	No	No	No
7	Fill to elev. 10.15 on ACTIVE side	No	No	No
8	Apply surcharge no.1 at elev. 10.15	No	No	No
9	Apply water pressure profile no.2	No	No	No
10	Remove surcharge no.1 at elev. 10.15	No	No	No
11	Apply water pressure profile no.1	No	No	No
12	Change soil type 3 to soil type 4	No	No	No
13	Change soil type 4 to soil type 3	No	No	No
14	Apply surcharge no.1 at elev. 10.15	No	No	No
15	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.15 Apply water pressure profile no.2 (Worst Cred.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	8.85	8.85	Cant.	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
2	9.82	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
3	9.50	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
4	9.18	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
5	8.85	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
6	8.43	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
7	8.00	0.00	-0.000	-4.15E-18	0.0	0.0		3521239
8	7.66	0.00	-0.000	-4.17E-18	0.0	0.0		3521239
9	7.33	0.00	-0.000	-4.20E-18	0.0	0.0		3521239
10	6.99	0.00	-0.000	-4.24E-18	0.0	0.0		3521239
11	6.65	0.00	-0.000	-4.31E-18	0.0	0.0		3521239
12	6.33	0.00	-0.000	-4.40E-18	0.0	0.0		3521239
13	6.00	0.00	-0.000	-4.51E-18	0.0	0.0		3521239
14	5.58	0.00	-0.000	-4.70E-18	0.0	0.0		3521239
15	5.15	0.00	-0.000	-4.92E-18	0.0	0.0		3521239
16	4.68	0.00	-0.000	-5.24E-18	0.0	0.0		3521239
17	4.20	0.00	-0.000	-5.65E-18	0.0	0.0		3521239
18	3.60	0.00	-0.000	-6.37E-18	0.0	0.0		3521239
19	3.25	0.00	-0.000	-6.92E-18	0.0	0.0		3521239
20	2.90	0.00	-0.000	-7.58E-18	0.0	0.0		3521239
21	2.40	0.00	0.000	-8.73E-18	0.0	0.0		3521239
22	1.90	0.00	0.000	-1.01E-17	0.0	0.0		3521239
23	1.55	0.00	0.000	-1.12E-17	0.0	0.0		3521239
24	1.20	0.00	0.000	-1.23E-17	0.0	0.0		3521239
25	0.60	0.00	0.000	-1.34E-17	0.0	0.0		3521239
26	0.00	0.00	0.000	-1.36E-17	0.0	0.0		---

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7182
6	8.43	0.00	8.08	2.32	33.50	3.44	3.44	7182
7	8.00	0.00	16.15	4.63	67.00	6.88	6.88	7182
8	7.66	0.00	22.56	6.47	93.60	9.61	9.61	7182
9	7.33	0.00	28.98	8.31	120.21	12.34	12.34	7182
10	6.99	0.00	35.39	10.15	146.81	15.08	15.08	7182
11	6.65	0.00	41.80	11.98	173.41	17.81	17.81	7182
		Total>	41.80	24.34	59.27	24.34	24.34a	1048
12	6.33	Total>	47.33	29.86	64.79	29.86	29.86a	1048
13	6.00	Total>	52.85	35.39	70.32	35.39	35.39a	1048
14	5.58	Total>	60.08	42.61	77.55	42.61	42.61a	1048
15	5.15	Total>	67.30	49.83	84.77	49.83	49.83a	1048
		Total>	67.30	18.50m	503.72	26.92	26.92	43663
16	4.68	Total>	77.28	20.88m	555.15	30.91	30.91	47811
17	4.20	Total>	87.25	23.25m	606.59	34.90	34.90	51959
18	3.60	Total>	99.85	26.25m	671.56	39.94	39.94	57198
19	3.25	Total>	107.20	28.00m	709.46	42.88	42.88	60255
20	2.90	Total>	114.55	29.75m	747.36	45.82	45.82	63311
21	2.40	Total>	125.05	32.25m	801.50	50.02	50.02	137776
22	1.90	Total>	135.55	34.75m	855.64	54.22	54.22	146665
23	1.55	Total>	142.90	36.50m	893.54	59.26	59.26	152887
24	1.20	Total>	150.25	38.25m	931.44	64.30	64.30	159109
25	0.60	Total>	162.85	41.25m	996.41	72.94	72.94	169776
26	0.00	Total>	175.45	44.25m	1061.38	81.58	81.58	180442

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7182
6	8.43	0.00	8.08	2.32	33.50	3.44	3.44	7182
7	8.00	0.00	16.15	4.63	67.00	6.88	6.88	7182
8	7.66	0.00	22.56	6.47	93.60	9.61	9.61	7182
9	7.33	0.00	28.98	8.31	120.21	12.34	12.34	7182
10	6.99	0.00	35.39	10.15	146.81	15.08	15.08	7182
11	6.65	0.00	41.80	11.98	173.41	17.81	17.81	7182
		Total>	41.80	24.34	59.27	24.34	24.34a	1048
12	6.33	Total>	47.33	29.86	64.79	29.86	29.86a	1048
13	6.00	Total>	52.85	35.39	70.32	35.39	35.39a	1048
14	5.58	Total>	60.08	42.61	77.55	42.61	42.61a	1048
15	5.15	Total>	67.30	49.83	84.77	49.83	49.83a	1048
		Total>	67.30	18.50m	503.72	26.92	26.92	43663

(continued)

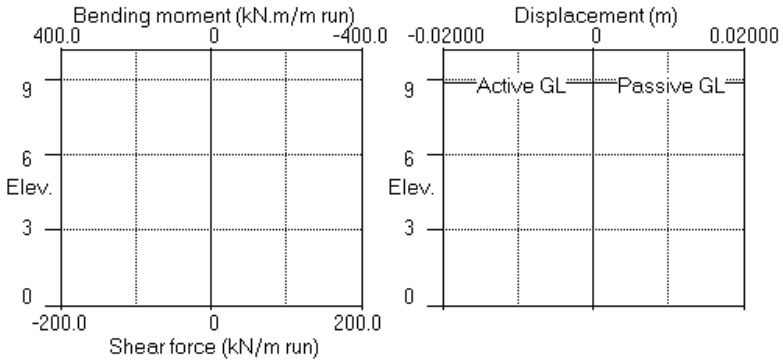
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
16	4.68	Total>	77.28	20.88m	555.15	30.91	30.91	47811
17	4.20	Total>	87.25	23.25m	606.59	34.90	34.90	51959
18	3.60	Total>	99.85	26.25m	671.56	39.94	39.94	57198
19	3.25	Total>	107.20	28.00m	709.46	42.88	42.88	60255
20	2.90	Total>	114.55	29.75m	747.36	45.82	45.82	63311
21	2.40	Total>	125.05	32.25m	801.50	50.02	50.02	137776
22	1.90	Total>	135.55	34.75m	855.64	54.22	54.22	146665
23	1.55	Total>	142.90	36.50m	893.54	59.26	59.26	152887
24	1.20	Total>	150.25	38.25m	931.44	64.30	64.30	159109
25	0.60	Total>	162.85	41.25m	996.41	72.94	72.94	169776
26	0.00	Total>	175.45	44.25m	1061.38	81.58	81.58	180442

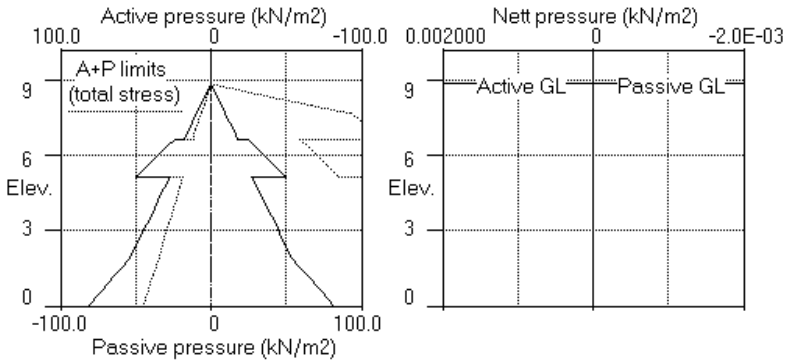
Note: 49.83a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
4	8.85	8.00	Cant.	7.139	0.62	4.24	3.76

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.002	2.56E-04	0.0	0.0		3521239
2	9.82	0.00	0.002	2.56E-04	0.0	-0.0		3521239
3	9.50	0.00	0.002	2.56E-04	0.0	-0.0		3521239
4	9.18	0.00	0.002	2.56E-04	0.0	-0.0		3521239
5	8.85	0.00	0.002	2.56E-04	0.0	-0.0		3521239
6	8.43	2.43	0.002	2.56E-04	0.5	0.2		3521239
7	8.00	5.28	0.002	2.56E-04	2.2	0.7		3521239
8	7.66	2.77	0.002	2.56E-04	3.5	1.7		3521239
		2.90	0.002	2.56E-04	3.5	1.7		
9	7.33	0.52	0.002	2.56E-04	4.1	3.0		3521239
		0.58	0.002	2.56E-04	4.1	3.0		
10	6.99	-1.83	0.001	2.56E-04	3.9	4.4		3521239
		-1.79	0.001	2.56E-04	3.9	4.4		
11	6.65	-4.26	0.001	2.55E-04	2.9	5.5		3521239
		24.87	0.001	2.55E-04	2.9	5.5		
12	6.33	27.82	0.001	2.55E-04	11.4	7.8		3521239
		31.81	0.001	2.55E-04	11.4	7.8		
13	6.00	37.42	0.001	2.54E-04	22.7	13.3		3521239
		38.61	0.001	2.54E-04	22.7	13.3		
14	5.58	45.84	0.001	2.51E-04	40.6	26.6		3521239
		47.05	0.001	2.51E-04	40.6	26.6		
15	5.15	54.19	0.001	2.47E-04	62.1	48.4		3521239
		-37.53	0.001	2.47E-04	62.1	48.4		
16	4.68	-37.58	0.001	2.38E-04	44.3	73.6		3521239
17	4.20	-36.88	0.001	2.27E-04	26.6	90.3		3521239
18	3.60	-35.12	0.001	2.11E-04	5.0	99.5		3521239
19	3.25	-33.71	0.001	2.01E-04	-7.0	99.1		3521239
20	2.90	-28.45	0.001	1.92E-04	-17.9	95.0		3521239

(continued)

Stage No.4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
21	2.40	-19.44	0.000	1.79E-04	-29.9	82.5		3521239
22	1.90	-9.70	0.000	1.69E-04	-37.2	65.1		3521239
23	1.55	-2.44	0.000	1.63E-04	-39.3	51.5		3521239
24	1.20	5.24	0.000	1.58E-04	-38.8	37.6		3521239
25	0.60	19.50	0.000	1.54E-04	-31.4	15.3		3521239
26	0.00	85.15	0.000	1.53E-04	0.0	0.0		---

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7534
6	8.43	0.00	8.48	2.43	35.18	2.43	2.43a	7534
7	8.00	0.00	18.42	5.28	76.43	5.28	5.28a	7534
8	7.66	0.00	26.97	7.73	111.88	7.73	7.73a	7534
9	7.33	0.00	35.55	10.19	147.48	10.19	10.19a	7534
10	6.99	0.00	43.93	12.59	182.24	12.59	12.59a	7534
11	6.65	0.00	52.04	14.92	215.88	14.92	14.92a	7534
		Total> 52.04	34.57	69.51	34.57	34.57a	1093	
12	6.33	Total> 58.95	41.49	76.42	41.49	41.49a	1093	
13	6.00	Total> 65.66	48.19	83.13	48.19	48.19a	1093	
14	5.58	Total> 74.17	56.70	91.64	56.70	56.70a	1093	
15	5.15	Total> 82.45	64.98	99.93	64.98	64.98a	1093	
		Total> 82.45	18.50m	518.87	18.50	18.50a	45533	
16	4.68	Total> 93.39	20.88m	571.27	20.88	20.88a	49859	
17	4.20	Total> 104.17	23.25m	623.51	23.25	23.25a	54185	
18	3.60	Total> 117.59	26.25m	689.30	26.25	26.25a	59649	
19	3.25	Total> 125.34	28.00m	727.61	28.00	28.00a	62836	
20	2.90	Total> 133.06	29.75m	765.87	33.38	33.38	66023	
21	2.40	Total> 144.01	32.25m	820.46	42.20	42.20	70577	
22	1.90	Total> 154.90	34.75m	874.99	51.34	51.34	75130	
23	1.55	Total> 162.49	36.50m	913.13	60.04	60.04	78317	
24	1.20	Total> 170.06	38.25m	951.25	68.93	68.93	81505	
25	0.60	Total> 182.99	41.25m	1016.56	84.70	84.70	86969	
26	0.00	Total> 195.88	44.25m	1081.81	126.31	126.31	452614	

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0

(continued)

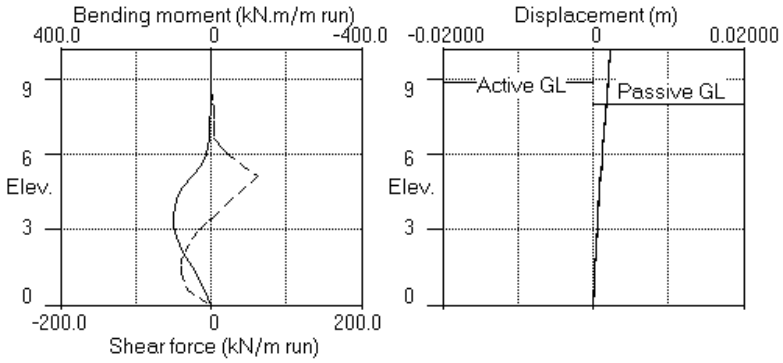
Stage No.4 Excavate to elevation 8.00 on PASSIVE side
Toe of berm at elevation 0.60
Width of top of berm = 0.01
Width of toe of berm = 10.60

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	8055
8	7.66	0.00	6.41	1.84	4.97b	4.97	4.97p	8055
		0.00	6.41	1.84	4.83b	4.83	4.83p	8055
9	7.33	0.00	12.83	3.68	9.67b	9.67	9.67p	8055
		0.00	12.83	3.68	9.61b	9.61	9.61p	8055
10	6.99	0.00	19.24	5.52	14.42b	14.42	14.42p	8055
		0.00	19.24	5.52	14.39b	14.39	14.39p	8055
11	6.65	0.00	25.65	7.35	19.18b	19.18	19.18p	8055
		Total>	25.65	8.19	12.11b	9.70	9.70	1160
12	6.33	Total>	31.18	13.65	13.66b	13.66	13.66p	1160
		Total>	31.18	9.66	9.67b	9.67	9.67p	1160
13	6.00	Total>	36.70	10.76	10.77b	10.77	10.77p	1160
		Total>	36.70	9.57	9.58b	9.58	9.58p	1160
14	5.58	Total>	43.93	10.85	10.86b	10.86	10.86p	1160
		Total>	43.93	9.64	9.65b	9.65	9.65p	1160
15	5.15	Total>	51.15	10.78	10.79b	10.79	10.79p	1160
		Total>	51.15	14.25m	487.56	56.03	56.03	48323
16	4.68	Total>	61.13	16.63m	539.00	58.46	58.46	52913
17	4.20	Total>	71.10	19.00m	590.44	60.13	60.13	57504
18	3.60	Total>	83.71	22.00m	655.41	61.37	61.37	63303
19	3.25	Total>	91.06	23.75m	693.31	61.71	61.71	66685
20	2.90	Total>	98.41	25.50m	731.21	61.83	61.83	70068
21	2.40	Total>	108.91	28.00m	785.36	61.64	61.64	74900
22	1.90	Total>	119.41	30.50m	839.50	61.04	61.04	79732
23	1.55	Total>	126.77	32.25m	877.40	62.48	62.48	83115
24	1.20	Total>	134.12	34.00m	915.31	63.70	63.70	86497
25	0.60	Total>	146.72	37.00m	980.28	65.20	65.20	92296
26	0.00	Total>	159.33	40.00m	1045.26	41.16	41.16	452614

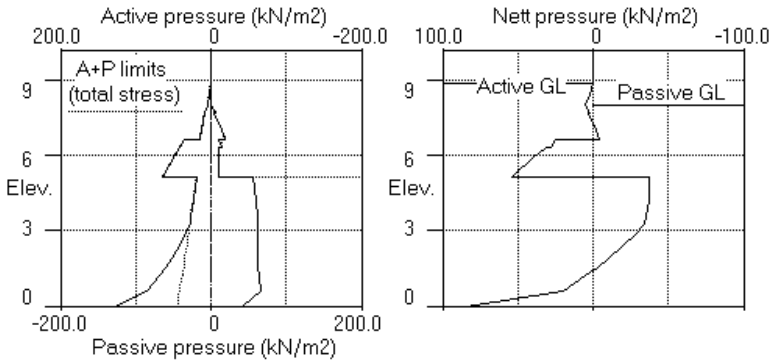
Note: 28.00a Soil pressure at active limit
10.79p Soil pressure at passive limit
10.79b Passive limit reduced because of berm

Units: kN,m

Stage No.4 Excav. to elev. 8.00 on PASSIVE side



Stage No.4 Excav. to elev. 8.00 on PASSIVE side



Units: kN,m

Stage No. 7 Fill to elevation 10.15 on ACTIVE side with soil type 1

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
7	10.15	8.00	Cant.	4.965	0.99	3.70	4.30

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.012	2.04E-03	0.0	0.0		141654
2	9.82	1.77	0.011	2.04E-03	0.3	0.0		141654
3	9.50	3.54	0.010	2.04E-03	1.2	0.2		141654
4	9.18	5.31	0.010	2.03E-03	2.6	0.8		141654
5	8.85	7.08	0.009	2.03E-03	4.6	2.0		141654
6	8.43	9.40	0.008	2.02E-03	8.1	4.7		141654
7	8.00	11.71	0.007	2.00E-03	12.6	9.1		141654
8	7.66	8.58	0.007	1.98E-03	16.0	14.0		141654
		8.72	0.007	1.98E-03	16.0	14.0		
9	7.33	5.72	0.006	1.94E-03	18.5	19.8		141654
		5.77	0.006	1.94E-03	18.5	19.8		
10	6.99	2.81	0.005	1.90E-03	19.9	26.3		141654
		2.84	0.005	1.90E-03	19.9	26.3		
11	6.65	-0.12	0.005	1.84E-03	20.4	33.2		141654
		36.92	0.005	1.84E-03	20.4	33.2		
12	6.33	40.90	0.004	1.76E-03	33.0	41.8		141654
		44.88	0.004	1.76E-03	33.0	41.8		
13	6.00	49.31	0.004	1.68E-03	48.3	54.9		141654
		50.50	0.004	1.68E-03	48.3	54.9		
14	5.58	56.44	0.003	1.53E-03	71.0	80.2		141654
		57.65	0.003	1.53E-03	71.0	80.2		
15	5.15	63.74	0.002	1.35E-03	96.8	115.8		141654
		-117.30	0.002	1.35E-03	96.8	115.8		
16	4.68	-91.05	0.002	1.10E-03	47.3	148.5		141654
17	4.20	-67.37	0.001	8.48E-04	9.7	160.7		141654
18	3.60	-43.80	0.001	5.67E-04	-23.6	154.2		141654
19	3.25	-33.70	0.001	4.35E-04	-37.2	143.3		141654
20	2.90	-23.23	0.001	3.29E-04	-47.2	128.6		141654
21	2.40	-5.45	0.000	2.23E-04	-54.3	102.1		141654
22	1.90	6.20	0.000	1.61E-04	-54.1	74.3		141654
23	1.55	12.27	0.000	1.39E-04	-50.9	55.7		141654

(continued)

Stage No.7 Fill to elevation 10.15 on ACTIVE side with soil type 1

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
24	1.20	17.68	0.000	1.28E-04	-45.7	38.7		141654
25	0.60	27.09	0.000	1.23E-04	-32.2	14.5		141654
26	0.00	80.33	0.000	1.24E-04	0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	8760
2	9.82	0.00	6.17	1.77	25.62	1.77	1.77a	8760
3	9.50	0.00	12.35	3.54	51.24	3.54	3.54a	8760
4	9.18	0.00	18.52	5.31	76.85	5.31	5.31a	8760
5	8.85	0.00	24.70	7.08	102.47	7.08	7.08a	8760
6	8.43	0.00	32.77	9.40	135.97	9.40	9.40a	8760
7	8.00	0.00	40.85	11.71	169.47	11.71	11.71a	8760
8	7.66	0.00	47.26	13.55	196.07	13.55	13.55a	8760
9	7.33	0.00	53.67	15.39	222.68	15.39	15.39a	8760
10	6.99	0.00	60.09	17.23	249.28	17.23	17.23a	8760
11	6.65	0.00	66.50	19.07	275.88	19.07	19.07a	8760
		Total> 66.50		49.03	83.97	49.03	49.03a	1251
12	6.33	Total> 72.02		54.56	89.50	54.56	54.56a	1251
13	6.00	Total> 77.55		60.08	95.02	60.08	60.08a	1251
14	5.58	Total> 84.77		67.30	102.25	67.30	67.30a	1251
15	5.15	Total> 92.00		74.53	109.48	74.53	74.53a	1251
		Total> 92.00		25.00m	528.42	25.00	25.00a	52110
16	4.68	Total> 101.97		27.37m	579.86	27.37	27.37a	57061
17	4.20	Total> 111.95		29.75m	631.29	29.75	29.75a	62011
18	3.60	Total> 124.55		32.75m	696.26	32.75	32.75a	68265
19	3.25	Total> 131.90		34.50m	734.16	34.50	34.50a	71912
20	2.90	Total> 139.25		36.25m	772.06	39.15	39.15	75560
21	2.40	Total> 149.75		38.75m	826.21	52.06	52.06	109465
22	1.90	Total> 160.25		41.25m	880.35	61.96	61.96	116527
23	1.55	Total> 167.60		43.00m	918.25	69.95	69.95	121470
24	1.20	Total> 174.95		44.75m	956.15	77.60	77.60	126414
25	0.60	Total> 187.55		47.75m	1021.11	90.77	90.77	134889
26	0.00	Total> 200.15		50.75m	1086.08	126.12	126.12	702852

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	11557
8	7.66	0.00	6.41	1.84	4.97b	4.97	4.97p	11557
		0.00	6.41	1.84	4.83b	4.83	4.83p	11557
9	7.33	0.00	12.83	3.68	9.67b	9.67	9.67p	11557
		0.00	12.83	3.68	9.61b	9.61	9.61p	11557
10	6.99	0.00	19.24	5.52	14.42b	14.42	14.42p	11557
		0.00	19.24	5.52	14.39b	14.39	14.39p	11557

(continued)

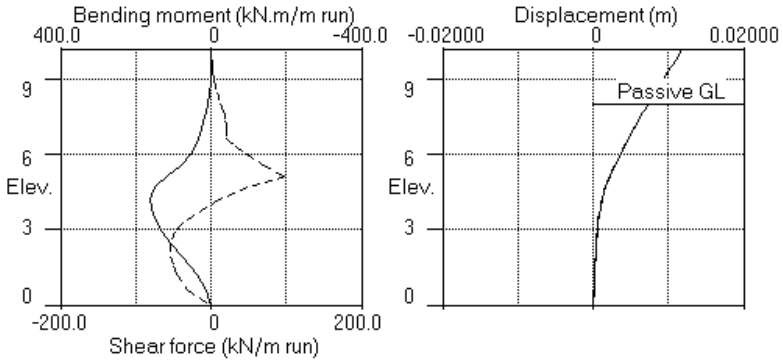
Stage No.7 Fill to elevation 10.15 on ACTIVE side with soil type 1

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
11	6.65	0.00	25.65	7.35	19.18b	19.18	19.18p	11557
		Total>	25.65	8.19	12.11b	12.11	12.11p	1614
12	6.33	Total>	31.18	13.65	13.66b	13.66	13.66p	1614
		Total>	31.18	9.66	9.67b	9.67	9.67p	1614
13	6.00	Total>	36.70	10.76	10.77b	10.77	10.77p	1614
		Total>	36.70	9.57	9.58b	9.58	9.58p	1614
14	5.58	Total>	43.93	10.85	10.86b	10.86	10.86p	1614
		Total>	43.93	9.64	9.65b	9.65	9.65p	1614
15	5.15	Total>	51.15	10.78	10.79b	10.79	10.79p	1614
		Total>	51.15	14.25m	487.56	142.30	142.30	67268
16	4.68	Total>	61.13	16.63m	539.00	118.43	118.43	73658
17	4.20	Total>	71.10	19.00m	590.44	97.12	97.12	80049
18	3.60	Total>	83.71	22.00m	655.41	76.55	76.55	88121
19	3.25	Total>	91.06	23.75m	693.31	68.20	68.20	92830
20	2.90	Total>	98.41	25.50m	731.21	62.37	62.37	97538
21	2.40	Total>	108.91	28.00m	785.36	57.51	57.51	109465
22	1.90	Total>	119.41	30.50m	839.50	55.77	55.77	116527
23	1.55	Total>	126.77	32.25m	877.40	57.68	57.68	121470
24	1.20	Total>	134.12	34.00m	915.31	59.92	59.92	126414
25	0.60	Total>	146.72	37.00m	980.28	63.68	63.68	134889
26	0.00	Total>	159.33	40.00m	1045.26	45.79	45.79	729333

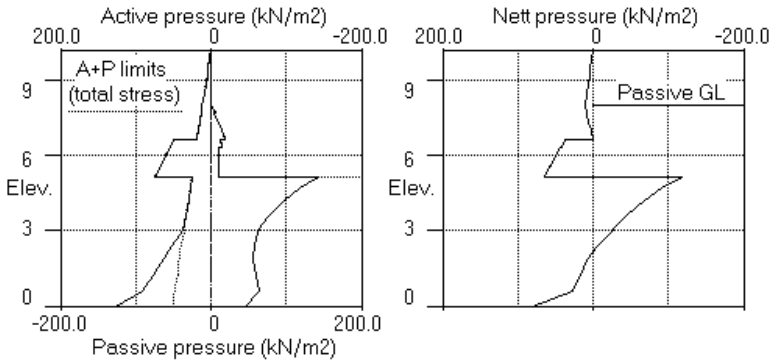
Note: 34.50a Soil pressure at active limit
10.79p Soil pressure at passive limit
10.79b Passive limit reduced because of berm

Units: kN,m

Stage No.7 Fill to elev. 10.15 on ACTIVE side



Stage No.7 Fill to elev. 10.15 on ACTIVE side



Units: kN,m

Stage No. 12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
12	10.15	8.00	Cant.	5.242	0.96	4.05	3.95

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.15	0.00	0.017	3.06E-03	0.0	0.0		141654
2	9.82	6.15	0.016	3.06E-03	1.0	0.3		141654
3	9.50	7.77	0.015	3.06E-03	3.3	1.0		141654
4	9.18	9.38	0.014	3.05E-03	6.0	2.5		141654
5	8.85	11.00	0.013	3.05E-03	9.4	5.0		141654
6	8.43	13.12	0.011	3.02E-03	14.5	10.1		141654
7	8.00	15.24	0.010	2.98E-03	20.5	17.5		141654
8	7.66	12.43	0.009	2.94E-03	25.2	25.3		141654
		12.56	0.009	2.94E-03	25.2	25.3		
9	7.33	9.44	0.008	2.87E-03	28.9	34.4		141654
		9.49	0.008	2.87E-03	28.9	34.4		
10	6.99	6.38	0.007	2.78E-03	31.6	44.7		141654
		6.41	0.007	2.78E-03	31.6	44.7		
11	6.65	3.28	0.006	2.68E-03	33.2	55.6		141654
		47.21	0.006	2.68E-03	33.2	55.6		
12	6.33	52.21	0.005	2.55E-03	49.4	69.0		141654
		39.62	0.005	2.55E-03	49.4	69.0		
13	6.00	42.38	0.005	2.39E-03	62.7	87.2		141654
		42.14	0.005	2.39E-03	62.7	87.2		
14	5.58	45.70	0.004	2.14E-03	81.4	117.7		141654
		45.47	0.004	2.14E-03	81.4	117.7		
15	5.15	48.98	0.003	1.84E-03	101.4	156.5		141654
		-147.70	0.003	1.84E-03	101.4	156.5		
16	4.68	-110.31	0.002	1.46E-03	40.1	188.0		141654
17	4.20	-76.69	0.001	1.08E-03	-4.3	193.8		141654
18	3.60	-44.48	0.001	6.83E-04	-40.6	178.2		141654
19	3.25	-30.72	0.001	4.99E-04	-53.8	161.5		141654
20	2.90	-16.67	0.000	3.55E-04	-62.1	141.2		141654
21	2.40	3.77	0.000	2.16E-04	-65.3	108.1		141654
22	1.90	14.83	0.000	1.41E-04	-60.6	75.9		141654

(continued)

Stage No.12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
23	1.55	19.49	0.000	1.17E-04	-54.6	55.6		141654
24	1.20	23.25	0.000	1.08E-04	-47.2	37.7		141654
25	0.60	29.31	0.000	1.07E-04	-31.4	13.6		141654
26	0.00	75.31	0.000	1.09E-04	0.0	0.0		---

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	6523
2	9.82	0.00	6.17	1.77	25.62	6.15	6.15	6523
3	9.50	0.00	12.35	3.54	51.24	7.77	7.77	6523
4	9.18	0.00	18.52	5.31	76.85	9.38	9.38	6523
5	8.85	0.00	24.70	7.08	102.47	11.00	11.00	6523
6	8.43	0.00	32.77	9.40	135.97	13.12	13.12	6523
7	8.00	0.00	40.85	11.71	169.47	15.24	15.24	6523
8	7.66	0.00	47.26	13.55	196.07	16.92	16.92	6523
9	7.33	0.00	53.67	15.39	222.68	18.59	18.59	6523
10	6.99	0.00	60.09	17.23	249.28	20.24	20.24	6523
11	6.65	0.00	66.50	19.07	275.88	21.88	21.88	6523
		0.00	66.50	28.34	175.99	49.46	49.46	481
12	6.33	0.00	72.02	30.70	190.61	54.95	54.95	481
13	6.00	0.00	77.55	33.05	205.23	60.43	60.43	481
14	5.58	0.00	84.77	36.13	224.35	67.60	67.60	481
15	5.15	0.00	92.00	39.21	243.47	74.77	74.77	481
		Total> 92.00	25.00m	528.42	29.28	29.28		40184
16	4.68	Total> 101.97	27.37m	579.86	29.90	29.90		44002
17	4.20	Total> 111.95	29.75m	631.29	31.58	31.58		47819
18	3.60	Total> 124.55	32.75m	696.26	33.87	33.87		52642
19	3.25	Total> 131.90	34.50m	734.16	35.92	35.92		55455
20	2.90	Total> 139.25	36.25m	772.06	42.13	42.13		58267
21	2.40	Total> 149.75	38.75m	826.21	56.44	56.44		62286
22	1.90	Total> 160.25	41.25m	880.35	66.08	66.08		107190
23	1.55	Total> 167.60	43.00m	918.25	73.37	73.37		111737
24	1.20	Total> 174.95	44.75m	956.15	80.19	80.19		116285
25	0.60	Total> 187.55	47.75m	1021.11	91.68	91.68		124080
26	0.00	Total> 200.15	50.75m	1086.08	123.39	123.39		131876

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.82	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	9.18	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	8.43	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	7287
8	7.66	0.00	6.41	1.84	4.97b	4.49	4.49	7287
		0.00	6.41	1.84	4.83b	4.36	4.36	7287
9	7.33	0.00	12.83	3.68	9.67b	9.15	9.15	7287
		0.00	12.83	3.68	9.61b	9.10	9.10	7287

(continued)

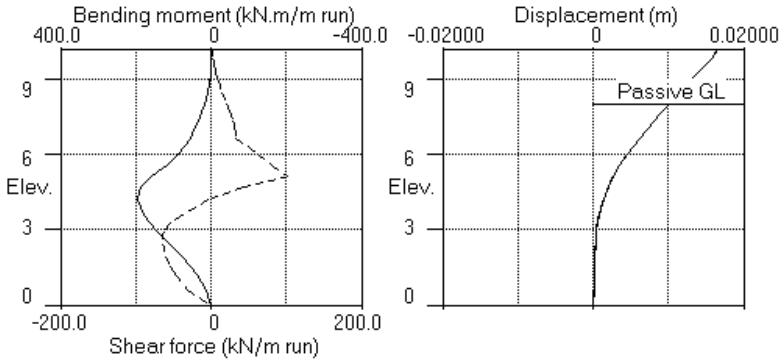
Stage No.12 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
10	6.99	0.00	19.24	5.52	14.42b	13.87	13.87	7287
		0.00	19.24	5.52	14.39b	13.83	13.83	7287
11	6.65	0.00	25.65	7.35	19.18b	18.60	18.60	7287
		0.00	25.65	2.25	2.26b	2.25	2.25a	539
12	6.33	0.00	31.18	2.74	2.75b	2.74	2.74a	539
		0.00	31.18	13.29	15.38b	15.33	15.33	539
13	6.00	0.00	36.70	15.64	18.10b	18.06	18.06	539
		0.00	36.70	15.64	18.34b	18.29	18.29	539
14	5.58	0.00	43.93	18.72	21.95b	21.91	21.91	539
		0.00	43.93	18.72	22.18b	22.13	22.13	539
15	5.15	0.00	51.15	21.80	25.82b	25.79	25.79	539
		Total>	51.15	14.25m	487.56	176.99	176.99	44217
16	4.68	Total>	61.13	16.63m	539.00	140.21	140.21	48418
17	4.20	Total>	71.10	19.00m	590.44	108.27	108.27	52618
18	3.60	Total>	83.71	22.00m	655.41	78.35	78.35	57924
19	3.25	Total>	91.06	23.75m	693.31	66.64	66.64	61019
20	2.90	Total>	98.41	25.50m	731.21	58.80	58.80	64115
21	2.40	Total>	108.91	28.00m	785.36	52.67	52.67	68536
22	1.90	Total>	119.41	30.50m	839.50	51.25	51.25	107190
23	1.55	Total>	126.77	32.25m	877.40	53.87	53.87	111737
24	1.20	Total>	134.12	34.00m	915.31	56.94	56.94	116285
25	0.60	Total>	146.72	37.00m	980.28	62.37	62.37	124080
26	0.00	Total>	159.33	40.00m	1045.26	48.08	48.08	131876

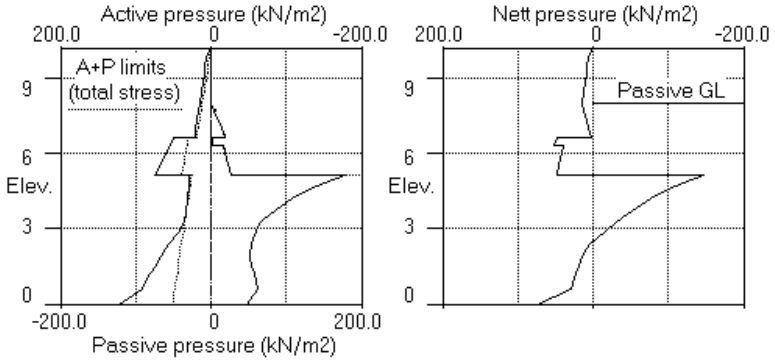
Note: 2.74a Soil pressure at active limit
123.45p Soil pressure at passive limit
25.82b Passive limit reduced because of berm

Units: kN,m

Stage No.12 Change soil type 3 to soil type 4



Stage No.12 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: ULS DA1 Combination 2
Water pressures : Worst Credible
Partial factor on C' = 1.250
Partial factor on Phi' = 1.250
Partial factor on Cu = 1.400
Partial factor on Soil Modulus = 1.000
Partial factor on Permanent Unfavourable loads = 1.000
Partial factor on Permanent Favourable loads = 1.000
Partial factor on Variable Unfavourable loads = 1.300

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 0.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetration
1	8.85	8.85	Cant.	Conditions not suitable for FoS calc.			
2	8.85	8.85		No analysis at this stage			
3	8.85	8.85	Cant.	Conditions not suitable for FoS calc.			
4	8.85	8.00	Cant.	7.139	0.62	4.24	3.76
5	8.85	8.00		No analysis at this stage			
6	8.85	8.00		No analysis at this stage			
7	10.15	8.00	Cant.	4.965	0.99	3.70	4.30
8	10.15	8.00	Cant.	4.156	1.11	3.49	4.51
9	10.15	8.00	Cant.	8.664	1.11	8.30	-0.30
10	10.15	8.00		Wall tending to move from right to left			
11	10.15	8.00	Cant.	4.965	0.99	3.70	4.30
12	10.15	8.00	Cant.	5.242	0.96	4.05	3.95
13	10.15	8.00		No analysis at this stage			
14	10.15	8.00	Cant.	4.156	1.11	3.49	4.51
15	10.15	8.00	Cant.	8.664	1.11	8.30	-0.30

Note: To obtain a Factor of Safety for the case of wall failing from right to left you should reverse the data (Ctrl+K) and re-analyse.

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 48.00 from wall
Passive side 48.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	10.15	0.017	-0.000	0.0	0.0	0.0	0.0
2	9.82	0.016	-0.000	1.1	-0.0	5.7	0.0
3	9.50	0.015	-0.000	3.8	-0.0	10.8	0.0
4	9.18	0.014	-0.000	8.1	-0.0	15.4	0.0
5	8.85	0.013	-0.000	13.8	-0.0	19.4	0.0
6	8.43	0.012	-0.000	23.1	-0.0	24.3	-0.8
7	8.00	0.011	-0.000	34.0	-0.7	28.2	-2.5
8	7.66	0.010	-0.000	43.5	-1.7	30.3	-3.8
9	7.33	0.009	-0.000	53.3	-3.2	31.2	-4.8
10	6.99	0.008	-0.000	63.3	-4.9	31.6	-5.5
11	6.65	0.007	-0.000	73.5	-6.9	33.2	-6.0
12	6.33	0.006	-0.000	84.3	-8.3	49.4	-2.6
13	6.00	0.005	-0.000	97.2	-8.5	63.7	0.0
14	5.58	0.004	-0.000	119.3	-6.8	89.7	0.0
15	5.15	0.003	-0.000	157.3	-2.6	118.6	0.0
16	4.68	0.002	-0.000	194.8	0.0	49.2	0.0
17	4.20	0.002	-0.000	203.4	0.0	26.6	-5.6
18	3.60	0.001	-0.000	187.5	0.0	5.0	-42.7
19	3.25	0.001	-0.000	169.7	0.0	0.5	-57.2
20	2.90	0.001	-0.000	148.1	0.0	0.0	-66.1
21	2.40	0.000	0.000	112.8	0.0	0.0	-69.3
22	1.90	0.000	0.000	78.8	0.0	0.0	-63.9
23	1.55	0.000	0.000	57.4	0.0	0.0	-57.2
24	1.20	0.000	0.000	38.7	0.0	0.0	-49.1
25	0.60	0.000	-0.000	15.3	0.0	0.0	-32.2
26	0.00	0.000	-0.000	0.0	0.0	0.0	0.0

Summary of results (continued)

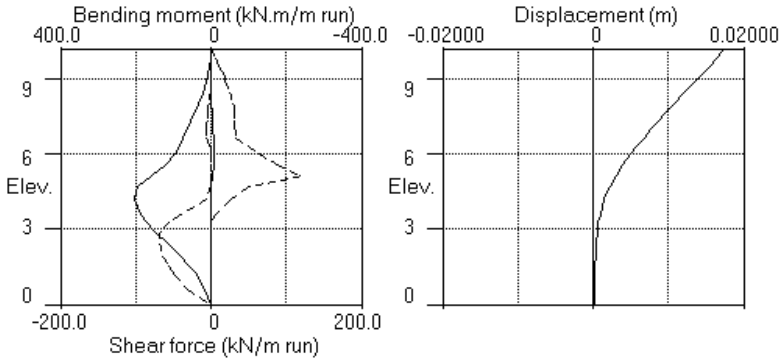
Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment				Shear force			
no.	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	1.55	-0.0	9.18	0.0	10.15	0.0	10.15
2	No calculation at this stage							
3	9.2	3.25	-8.5	6.00	13.0	5.15	-6.0	6.65
4	99.5	3.60	-0.0	9.50	62.1	5.15	-39.3	1.55
5	No calculation at this stage							
6	No calculation at this stage							
7	160.7	4.20	0.0	10.15	96.8	5.15	-54.3	2.40
8	202.8	4.20	0.0	10.15	118.0	5.15	-68.8	2.40
9	170.9	4.20	0.0	10.15	69.7	5.15	-56.4	2.40
10	163.6	4.20	0.0	10.15	60.8	5.15	-53.8	2.40
11	195.1	4.20	0.0	10.15	108.5	5.15	-66.2	2.40
12	193.8	4.20	0.0	10.15	101.4	5.15	-65.3	2.40
13	No calculation at this stage							
14	203.4	4.20	0.0	10.15	118.6	5.15	-69.3	2.40
15	171.4	4.20	0.0	10.15	70.1	5.15	-56.8	2.40

Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	0.00	-0.000	10.15	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.001	10.15	0.000	10.15	Apply surcharge no.2 at elev. 8.85
4	0.002	10.15	0.000	10.15	Excav. to elev. 8.00 on PASSIVE side
5	No calculation at this stage				Change EI of wall to 141654kN.m2/m run
6	No calculation at this stage				Remove surcharge no.2 at elev. 8.85
7	0.012	10.15	0.000	10.15	Fill to elev. 10.15 on ACTIVE side
8	0.017	10.15	0.000	10.15	Apply surcharge no.1 at elev. 10.15
9	0.015	10.15	-0.000	0.00	Apply water pressure profile no.2
10	0.014	10.15	-0.000	0.00	Remove surcharge no.1 at elev. 10.15
11	0.017	10.15	0.000	10.15	Apply water pressure profile no.1
12	0.017	10.15	0.000	10.15	Change soil type 3 to soil type 4
13	No calculation at this stage				Change soil type 4 to soil type 3
14	0.017	10.15	0.000	10.15	Apply surcharge no.1 at elev. 10.15
15	0.015	10.15	-0.000	0.00	Apply water pressure profile no.2

Bending moment, shear force, displacement envelopes



Annex D – WALLAP Results – Netham Road

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	10.25	2 Made ground (U)	7 Made ground (P)
2	8.75	3 Tidal deposits (U)	3 Tidal deposits (U)
3	-0.25	6 RT deposits	6 RT deposits
4	-1.75	5 WRock	5 WRock

SOIL PROPERTIES

No.	Soil type / Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made ground (D)	19.00	4800	0.562	OC (0.150)	0.330 (1.374)	3.793 (5.726)	0.0d
2	Made ground (U)	19.00	6000	0.562	OC (0.490)	1.000 (1.000)	1.000 (1.000)	20.00u
3	Tidal deposits (U)	17.00	3000	0.562	NC (0.490)	1.000 (1.000)	1.000 (1.000)	10.00u
4	Tidal deposits (D)	17.00	2400	0.562	NC (0.150)	1.000 (2.443)	1.000 (2.444)	10.00d
5	WRock (-1.75)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	RT deposits	20.00	6000	0.455	OC (0.300)	0.256 (0.000)	5.303 (0.000)	
7	Made ground (P)	19.00	6000	0.562	OC (0.490)	1.000 (1.000)	1.000 (1.000)	20.00u

Additional soil parameters associated with Ka and Kp

No.	Soil type / Description	Ka: Soil friction angle	Ka: Wall adhesion coeff.	Ka: Back-fill angle	Kp: Soil friction angle	Kp: Wall adhesion coeff.	Kp: Back-fill angle
1	Made ground (D)	26.00	0.833	0.00	26.00	0.833	0.00
2	Made ground (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
3	Tidal deposits (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
4	Tidal deposits (D)	0.00	0.600	0.00	0.00	0.600	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	RT deposits	33.00	0.500	0.00	33.00	0.500	0.00
7	Made ground (P)	0.00	-0.674	0.00	0.00	-0.674	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	3.60	3.60

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	8.75	8.75	0.0	1	3.60	3.60	0.0	MC+WC
2	1	8.75	8.75	0.0	1	10.25	10.25	0.0	MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -10.00
Maximum finite element length = 1.20 m
Youngs modulus of wall E = 2.3380E+07 kN/m2
Moment of inertia of wall I = 0.15061 m4/m run
E.I = 3.5212E+06 kN.m2/m run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.25	0.00(A)	100.00	100.00	10.00	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
2	Apply water pressure profile no.1 (Mod. Conserv.)
3	Excavate to elevation 5.40 on PASSIVE side Toe of berm at elevation 2.90 Width of top of berm = 0.01 Width of toe of berm = 4.00
4	Apply surcharge no.1 at elevation 10.25
5	Change EI of wall to 2.5152E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
6	Apply water pressure profile no.2 (Mod. Conserv.)
7	Apply water pressure profile no.1 (Mod. Conserv.)
8	Remove surcharge no.1 at elevation 10.25
9	Change properties of soil type 2 to soil type 1 Ko pressures will not be reset
10	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
11	Change properties of soil type 1 to soil type 2 No analysis at this stage Ko pressures will not be reset
12	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
13	Apply surcharge no.1 at elevation 10.25
14	Apply water pressure profile no.2 (Mod. Conserv.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 25.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

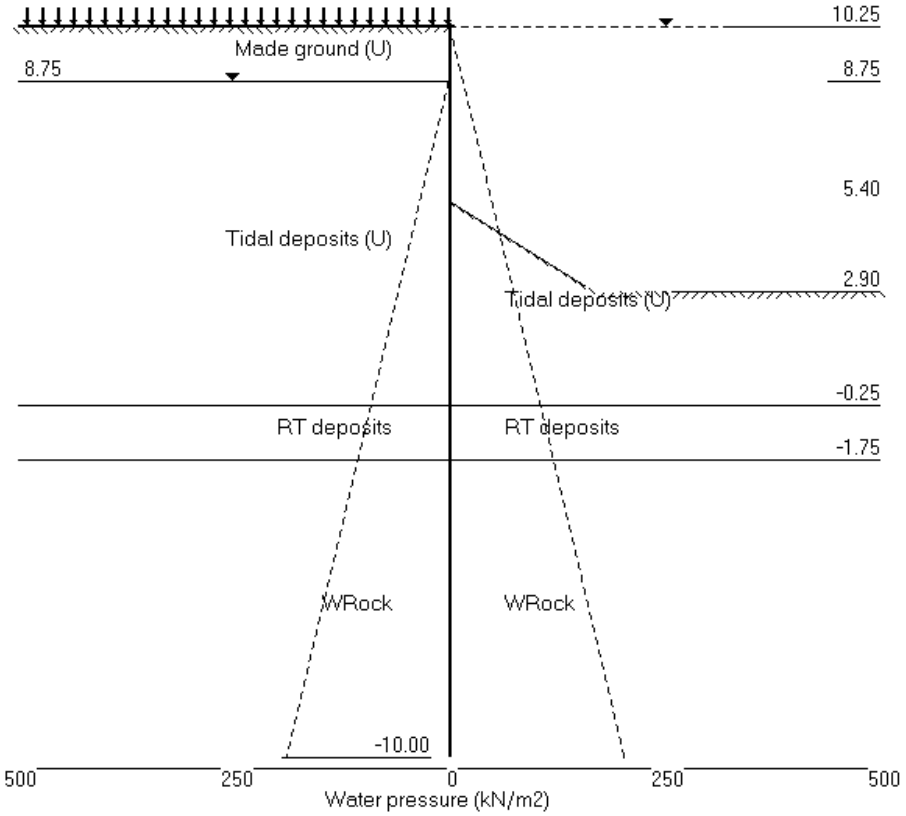
Distance to rigid boundary on active side = 50.00 m
Distance to rigid boundary on passive side = 50.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Excav. to elev. 5.40 on PASSIVE side	No	No	No
4	Apply surcharge no.1 at elev. 10.25	No	No	No
5	Change EI of wall to 2.5152E+06kN.m2/m	No	No	No
6	Apply water pressure profile no.2	No	No	No
7	Apply water pressure profile no.1	No	No	No
8	Remove surcharge no.1 at elev. 10.25	No	No	No
9	Change soil type 2 to soil type 1	No	No	No
10	Change soil type 3 to soil type 4	No	No	No
11	Change soil type 1 to soil type 2	No	No	No
12	Change soil type 4 to soil type 3	No	No	No
13	Apply surcharge no.1 at elev. 10.25	No	No	No
14	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.14 Apply water pressure profile no.2 (Mod. Conserv.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = -10.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.25	10.25	Cant.	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	-0.00	0.000	1.44E-16	0.0	-0.0		3521239
2	9.50	0.00	0.000	1.44E-16	-0.0	-0.0		3521239
3	8.75	0.00	0.000	1.45E-16	-0.0	-0.0		3521239
4	7.98	0.00	0.000	1.47E-16	-0.0	-0.0		3521239
5	7.20	0.00	0.000	1.50E-16	-0.0	-0.0		3521239
6	6.30	0.00	0.000	1.55E-16	-0.0	-0.0		3521239
7	5.40	0.00	0.000	1.62E-16	-0.0	-0.0		3521239
8	4.50	0.00	0.000	1.70E-16	-0.0	-0.0		3521239
9	3.60	0.00	0.000	1.81E-16	-0.0	-0.0		3521239
10	2.90	0.00	0.000	1.90E-16	-0.0	-0.0		3521239
11	2.05	0.00	0.000	2.01E-16	-0.0	-0.0		3521239
12	1.20	0.00	0.000	2.05E-16	-0.0	0.0		3521239
13	0.00	0.00	0.000	2.03E-16	-0.0	0.0		3521239
14	-0.25	0.00	0.000	2.03E-16	-0.0	-0.0		3521239
15	-1.00	0.00	0.000	2.04E-16	-0.0	-0.0		3521239
16	-1.75	0.00	0.000	2.04E-16	-0.0	0.0		3521239
17	-2.68	0.00	0.000	1.99E-16	-0.0	0.0		3521239
18	-3.60	0.00	0.000	1.83E-16	-0.0	0.0		3521239
19	-4.80	0.00	0.000	1.49E-16	-0.0	0.0		3521239
20	-6.00	0.00	0.000	1.16E-16	-0.0	0.0		3521239
21	-7.20	0.00	0.000	1.02E-16	-0.0	0.0		3521239
22	-8.40	0.00	0.000	1.04E-16	-0.0	-0.0		3521239
23	-9.20	0.00	0.000	1.08E-16	-0.0	-0.0		3521239
24	-10.00	0.00	0.000	1.10E-16	-0.0	0.0		---

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	ACTIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	Total>	0.00	0.00	20.00	0.00	0.00a	851
2	9.50	Total>	14.25	3.75m	34.25	8.01	8.01	851
3	8.75	Total>	28.50	8.50	48.50	16.02	16.02	851
		Total>	28.50	18.50	38.50	18.50	18.50a	426
4	7.98	Total>	41.67	31.68	51.67	31.68	31.68a	426
5	7.20	Total>	54.85	44.85	64.85	44.85	44.85a	426
6	6.30	Total>	70.15	60.15	80.15	60.15	60.15a	426
7	5.40	Total>	85.45	75.45	95.45	75.45	75.45a	426
8	4.50	Total>	100.75	90.75	110.75	90.75	90.75a	426
9	3.60	Total>	116.05	106.05	126.05	106.05	106.05a	426
10	2.90	Total>	127.95	117.95	137.95	117.95	117.95a	426
11	2.05	Total>	142.40	132.40	152.40	132.40	132.40a	426
12	1.20	Total>	156.85	146.85	166.85	146.85	146.85a	426
13	0.00	Total>	177.25	167.25	187.25	167.25	167.25a	426
14	-0.25	Total>	181.50	171.50	191.50	171.50	171.50a	426
		38.50	143.00	36.68	758.31	65.06	103.56	609
15	-1.00	46.00	150.50	38.60	798.08	68.48	114.48	609
16	-1.75	53.50	158.00	40.52	837.85	71.89	125.39	609
		Total>	211.50	60.00m	822.46	116.70	116.70	17730
17	-2.68	Total>	230.93	64.63m	954.91	130.02	130.02	21010
18	-3.60	Total>	250.35	69.25m	1087.37	143.34	143.34	24290
19	-4.80	Total>	275.55	75.25m	1259.20	160.62	160.62	28546
20	-6.00	Total>	300.75	81.25m	1431.03	177.90	177.90	32801
21	-7.20	Total>	325.95	87.25m	1602.86	195.18	195.18	37056
22	-8.40	Total>	351.15	93.25m	1774.69	212.46	212.46	41312
23	-9.20	Total>	367.95	97.25m	1889.24	223.98	223.98	44148
24	-10.00	Total>	384.75	101.25m	2003.80	235.50	235.50	226161

Node no.	Y coord	PASSIVE side						
		Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	Total>	0.00	0.00	20.00	0.00	0.00a	851
2	9.50	Total>	14.25	3.75m	34.25	8.01	8.01	851
3	8.75	Total>	28.50	8.50	48.50	16.02	16.02	851
		Total>	28.50	18.50	38.50	18.50	18.50a	426
4	7.98	Total>	41.67	31.68	51.67	31.68	31.68a	426
5	7.20	Total>	54.85	44.85	64.85	44.85	44.85a	426
6	6.30	Total>	70.15	60.15	80.15	60.15	60.15a	426
7	5.40	Total>	85.45	75.45	95.45	75.45	75.45a	426
8	4.50	Total>	100.75	90.75	110.75	90.75	90.75a	426
9	3.60	Total>	116.05	106.05	126.05	106.05	106.05a	426
10	2.90	Total>	127.95	117.95	137.95	117.95	117.95a	426
11	2.05	Total>	142.40	132.40	152.40	132.40	132.40a	426
12	1.20	Total>	156.85	146.85	166.85	146.85	146.85a	426
13	0.00	Total>	177.25	167.25	187.25	167.25	167.25a	426
14	-0.25	Total>	181.50	171.50	191.50	171.50	171.50a	426
		38.50	143.00	36.68	758.31	65.06	103.56	609
15	-1.00	46.00	150.50	38.60	798.08	68.48	114.48	609
16	-1.75	53.50	158.00	40.52	837.85	71.89	125.39	609
		Total>	211.50	60.00m	822.46	116.70	116.70	17730

(continued)

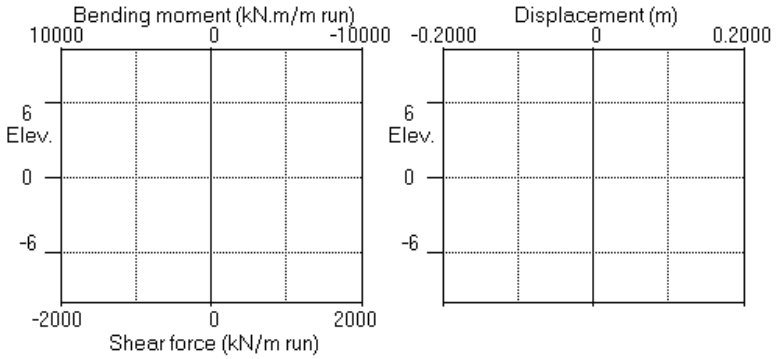
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
17	-2.68	Total>	230.93	64.63m	954.91	130.02	130.02	21010
18	-3.60	Total>	250.35	69.25m	1087.37	143.34	143.34	24290
19	-4.80	Total>	275.55	75.25m	1259.20	160.62	160.62	28546
20	-6.00	Total>	300.75	81.25m	1431.03	177.90	177.90	32801
21	-7.20	Total>	325.95	87.25m	1602.86	195.18	195.18	37056
22	-8.40	Total>	351.15	93.25m	1774.69	212.46	212.46	41312
23	-9.20	Total>	367.95	97.25m	1889.24	223.98	223.98	44148
24	-10.00	Total>	384.75	101.25m	2003.80	235.50	235.50	226161

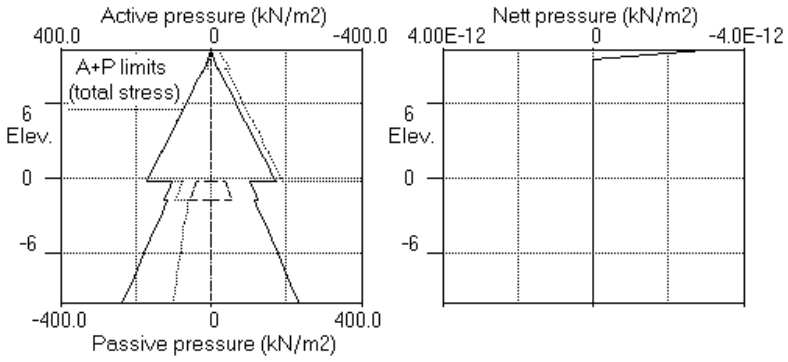
Note: 171.50a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = -10.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
3	10.25	5.40	Cant.	2.084	-7.43	-6.90	12.30

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.131	9.79E-03	0.0	0.0		3521239
2	9.50	3.75	0.124	9.79E-03	1.4	0.4		3521239
3	8.75	8.50	0.116	9.79E-03	6.0	3.0		3521239
		18.50	0.116	9.79E-03	6.0	3.0		
4	7.98	31.68	0.109	9.79E-03	25.4	14.5		3521239
5	7.20	44.85	0.101	9.79E-03	55.1	45.0		3521239
6	6.30	60.15	0.092	9.76E-03	102.3	114.9		3521239
7	5.40	75.45	0.084	9.72E-03	163.4	233.4		3521239
		66.35	0.084	9.72E-03	163.4	233.4		
8	4.50	67.71	0.075	9.64E-03	223.7	407.5		3521239
		78.50	0.075	9.64E-03	223.7	407.5		
9	3.60	86.38	0.066	9.50E-03	297.9	641.7		3521239
		91.01	0.066	9.50E-03	297.9	641.7		
10	2.90	94.07	0.060	9.35E-03	362.7	872.7		3521239
		98.74	0.060	9.35E-03	362.7	872.7		
11	2.05	103.07	0.052	9.10E-03	448.4	1217.2		3521239
		98.87	0.052	9.10E-03	448.4	1217.2		
12	1.20	102.69	0.044	8.76E-03	534.1	1634.5		3521239
		98.20	0.044	8.76E-03	534.1	1634.5		
13	0.00	102.87	0.034	8.08E-03	654.7	2347.2		3521239
		99.88	0.034	8.08E-03	654.7	2347.2		
14	-0.25	100.76	0.032	7.91E-03	679.8	2514.1		3521239
		15.32	0.032	7.91E-03	679.8	2514.1		
15	-1.00	20.20	0.026	7.32E-03	693.1	3030.0		3521239
16	-1.75	29.07	0.021	6.61E-03	711.6	3555.5		3521239
		-539.97	0.021	6.61E-03	711.6	3555.5		
17	-2.68	-473.46	0.015	5.62E-03	242.9	3981.4		3521239

(continued)

Stage No.3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
18	-3.60	-385.77	0.011	4.58E-03	-154.5	4002.1		3521239
19	-4.80	-263.61	0.006	3.29E-03	-544.1	3535.6		3521239
20	-6.00	-151.54	0.003	2.23E-03	-793.2	2689.5		3521239
21	-7.20	25.57	0.001	1.49E-03	-868.8	1650.8		3521239
22	-8.40	281.61	-0.001	1.10E-03	-684.5	642.0		3521239
23	-9.20	425.37	-0.002	1.01E-03	-401.7	184.9		3521239
24	-10.00	578.87	-0.003	9.90E-04	-0.0	0.0		---

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	Total>	0.00	0.00	20.00	0.00	0.00a	1039
2	9.50	Total>	14.25	3.75m	34.25	3.75	3.75a	1039
3	8.75	Total>	28.50	8.50	48.50	8.50	8.50a	1039
		Total>	28.50	18.50	38.50	18.50	18.50a	520
4	7.98	Total>	41.67	31.68	51.67	31.68	31.68a	520
5	7.20	Total>	54.85	44.85	64.85	44.85	44.85a	520
6	6.30	Total>	70.15	60.15	80.15	60.15	60.15a	520
7	5.40	Total>	85.45	75.45	95.45	75.45	75.45a	520
8	4.50	Total>	100.75	90.75	110.75	90.75	90.75a	520
9	3.60	Total>	116.05	106.05	126.05	106.05	106.05a	520
10	2.90	Total>	127.95	117.95	137.95	117.95	117.95a	520
11	2.05	Total>	142.40	132.40	152.40	132.40	132.40a	520
12	1.20	Total>	156.85	146.85	166.85	146.85	146.85a	520
13	0.00	Total>	177.25	167.25	187.25	167.25	167.25a	520
14	-0.25	Total>	181.50	171.50	191.50	171.50	171.50a	520
		90.00	91.50	23.47	485.21	23.47	113.47a	762
15	-1.00	97.50	99.00	25.39	524.98	26.39	123.89	762
16	-1.75	105.00	106.50	27.32	564.76	33.78	138.78	762
		Total>	211.50	60.00m	822.46	60.00	60.00a	21647
17	-2.68	Total>	230.93	64.63m	954.91	64.63	64.63a	25652
18	-3.60	Total>	250.35	69.25m	1087.37	69.25	69.25a	29657
19	-4.80	Total>	275.55	75.25m	1259.20	75.25	75.25a	34852
20	-6.00	Total>	300.75	81.25m	1431.03	81.25	81.25a	40047
21	-7.20	Total>	325.95	87.25m	1602.86	171.08	171.08	45243
22	-8.40	Total>	351.15	93.25m	1774.69	350.61	350.61	139986
23	-9.20	Total>	367.95	97.25m	1889.24	498.37	498.37	149599
24	-10.00	Total>	384.75	101.25m	2003.80	655.87	655.87	159211

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	9.10b	9.10	9.10p	648

(continued)

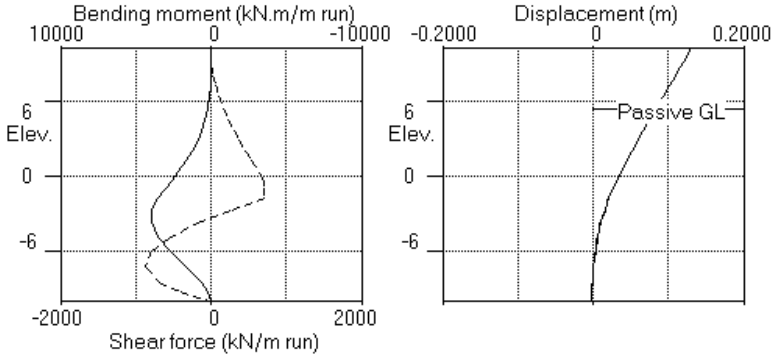
Stage No.3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
8	4.50	Total>	15.30	5.30	23.04b	23.04	23.04p	648
		Total>	15.30	5.30	12.25b	12.25	12.25p	648
9	3.60	Total>	30.63	19.66	19.67b	19.67	19.67p	648
		Total>	30.63	15.03	15.04b	15.04	15.04p	648
10	2.90	Total>	42.57	23.87	23.88b	23.88	23.88p	648
		Total>	42.57	19.20	19.21b	19.21	19.21p	648
11	2.05	Total>	57.11	29.32	29.33b	29.33	29.33p	648
		Total>	57.11	33.52	33.53b	33.53	33.53p	648
12	1.20	Total>	71.72	44.15	44.16b	44.16	44.16p	648
		Total>	71.72	48.64	48.65b	48.65	48.65p	648
13	0.00	Total>	92.46	64.37	64.38b	64.38	64.38p	648
		Total>	92.46	67.36	67.37b	67.37	67.37p	648
14	-0.25	Total>	96.80	70.73	70.74b	70.74	70.74p	648
		38.50	58.30	14.95	299.19b	59.65	98.15	968
15	-1.00	46.00	66.11	16.96	339.28b	57.68	103.68	968
		46.00	66.11	16.96	209.28b	57.68	103.68	968
16	-1.75	53.50	73.98	18.98	234.22b	56.21	109.71	968
		Total>	127.48	35.75m	738.44	599.97	599.97	27014
17	-2.68	Total>	147.46	40.38m	871.45	538.09	538.09	32011
18	-3.60	Total>	167.55	45.00m	1004.56	455.02	455.02	37009
19	-4.80	Total>	193.74	51.00m	1177.38	338.86	338.86	43492
20	-6.00	Total>	220.08	57.00m	1350.36	232.79	232.79	49975
21	-7.20	Total>	246.55	63.00m	1523.46	145.51	145.51	56459
22	-8.40	Total>	273.13	69.00m	1696.67	69.00	69.00a	139986
23	-9.20	Total>	290.90	73.00m	1812.19	73.00	73.00a	149599
24	-10.00	Total>	308.70	77.00m	1927.74	77.00	77.00a	159211

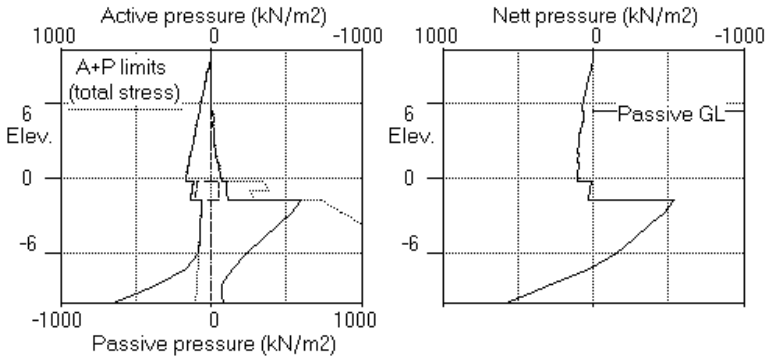
Note: 77.00a Soil pressure at active limit
70.74p Soil pressure at passive limit
234.22b Passive limit reduced because of berm

Units: kN,m

Stage No.3 Excav. to elev. 5.40 on PASSIVE side



Stage No.3 Excav. to elev. 5.40 on PASSIVE side



Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = -10.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
9	10.25	5.40	Cant.	2.076	-7.43	-6.90	12.30

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.142	1.05E-02	0.0	0.0		2515171
2	9.50	10.04	0.134	1.05E-02	3.8	-2.7		2515171
3	8.75	18.30	0.126	1.05E-02	14.4	4.0		2515171
		23.41	0.126	1.05E-02	14.4	4.0		
4	7.98	36.24	0.118	1.05E-02	37.5	23.6		2515171
5	7.20	49.07	0.109	1.05E-02	70.6	65.0		2515171
6	6.30	63.97	0.100	1.05E-02	121.4	150.6		2515171
7	5.40	78.87	0.090	1.04E-02	185.7	288.1		2515171
		74.17	0.090	1.04E-02	185.7	288.1		
8	4.50	74.62	0.081	1.03E-02	252.7	483.5		2515171
		85.41	0.081	1.03E-02	252.7	483.5		
9	3.60	89.02	0.072	1.02E-02	331.2	746.7		2515171
		93.64	0.072	1.02E-02	331.2	746.7		
10	2.90	96.41	0.065	1.00E-02	397.7	1001.8		2515171
		101.07	0.065	1.00E-02	397.7	1001.8		
11	2.05	105.05	0.056	9.79E-03	485.3	1377.0		2515171
		100.85	0.056	9.79E-03	485.3	1377.0		
12	1.20	104.32	0.048	9.42E-03	572.5	1826.5		2515171
		99.83	0.048	9.42E-03	572.5	1826.5		
13	0.00	104.05	0.037	8.68E-03	694.8	2586.9		2515171
		101.07	0.037	8.68E-03	694.8	2586.9		
14	-0.25	101.86	0.035	8.50E-03	720.2	2763.8		2515171
		12.77	0.035	8.50E-03	720.2	2763.8		
15	-1.00	17.04	0.029	7.87E-03	731.3	3309.3		2515171
16	-1.75	25.71	0.023	7.13E-03	747.4	3863.3		2515171
		-565.91	0.023	7.13E-03	747.4	3863.3		
17	-2.68	-501.21	0.017	6.08E-03	253.8	4314.5		2515171
18	-3.60	-413.15	0.012	4.98E-03	-169.1	4337.4		2515171
19	-4.80	-286.84	0.007	3.62E-03	-589.1	3842.2		2515171

(continued)

Stage No.9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
20	-6.00	-166.75	0.003	2.49E-03	-861.2	2932.0		2515171
21	-7.20	22.83	0.001	1.70E-03	-947.6	1806.8		2515171
22	-8.40	303.72	-0.001	1.28E-03	-751.6	705.1		2515171
23	-9.20	466.85	-0.002	1.18E-03	-443.4	203.2		2515171
24	-10.00	641.65	-0.003	1.15E-03	-0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	639
2	9.50	0.00	14.25	4.70	54.04	10.04	10.04	639
3	8.75	0.00	28.50	9.40	108.09	18.30	18.30	639
		Total>	28.50	18.50	38.50	23.41	23.41	607
4	7.98	Total>	41.67	31.68	51.67	36.24	36.24	607
5	7.20	Total>	54.85	44.85	64.85	49.07	49.07	607
6	6.30	Total>	70.15	60.15	80.15	63.97	63.97	607
7	5.40	Total>	85.45	75.45	95.45	78.87	78.87	607
8	4.50	Total>	100.75	90.75	110.75	93.77	93.77	607
9	3.60	Total>	116.05	106.05	126.05	108.67	108.67	607
10	2.90	Total>	127.95	117.95	137.95	120.27	120.27	607
11	2.05	Total>	142.40	132.40	152.40	134.37	134.37	607
12	1.20	Total>	156.85	146.85	166.85	148.48	148.48	607
13	0.00	Total>	177.25	167.25	187.25	168.43	168.43	607
14	-0.25	Total>	181.50	171.50	191.50	172.59	172.59	607
		90.00	91.50	23.47	485.21	23.56	113.56	903
15	-1.00	97.50	99.00	25.39	524.98	25.46	122.96	903
16	-1.75	105.00	106.50	27.32	564.76	32.29	137.29	903
		Total>	211.50	60.00m	822.46	86.14	86.14	25295
17	-2.68	Total>	230.93	64.63m	954.91	84.53	84.53	29975
18	-3.60	Total>	250.35	69.25m	1087.37	82.50	82.50	34655
19	-4.80	Total>	275.55	75.25m	1259.20	80.92	80.92	40726
20	-6.00	Total>	300.75	81.25m	1431.03	81.65	81.65	50293
21	-7.20	Total>	325.95	87.25m	1602.86	169.69	169.69	56817
22	-8.40	Total>	351.15	93.25m	1774.69	377.61	377.61	63342
23	-9.20	Total>	367.95	97.25m	1889.24	544.97	544.97	67691
24	-10.00	Total>	384.75	101.25m	2003.80	723.80	723.80	72041

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	9.10b	4.70	4.70	782
8	4.50	Total>	15.30	5.30	23.04b	19.15	19.15	782
		Total>	15.30	5.30	12.25b	8.36	8.36	782
9	3.60	Total>	30.63	19.66	19.67b	19.66	19.66a	782
		Total>	30.63	15.03	15.04b	15.03	15.03a	782

(continued)

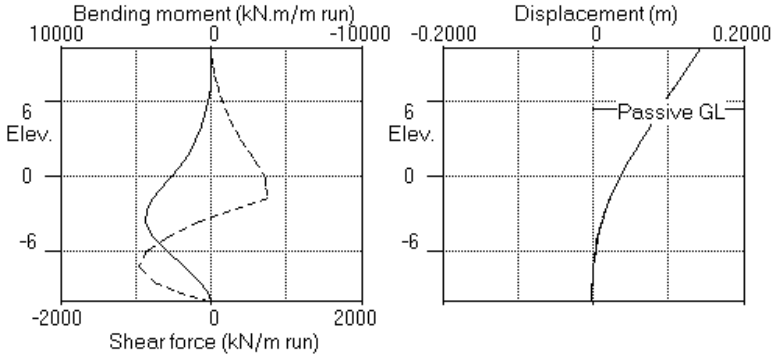
Stage No.9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
10	2.90	Total>	42.57	23.87	23.88b	23.87	23.87a	782
		Total>	42.57	19.20	19.21b	19.20	19.20a	782
11	2.05	Total>	57.11	29.32	29.33b	29.32	29.32a	782
		Total>	57.11	33.52	33.53b	33.52	33.52a	782
12	1.20	Total>	71.72	44.15	44.16b	44.15	44.15a	782
		Total>	71.72	48.64	48.65b	48.64	48.64a	782
13	0.00	Total>	92.46	64.37	64.38b	64.37	64.37a	782
		Total>	92.46	67.36	67.37b	67.36	67.36a	782
14	-0.25	Total>	96.80	70.73	70.74b	70.73	70.73a	782
		38.50	58.30	14.95	299.19b	62.30	100.80	1182
15	-1.00	46.00	66.11	16.96	339.28b	59.92	105.92	1182
		46.00	66.11	16.96	209.28b	59.92	105.92	1182
16	-1.75	53.50	73.98	18.98	234.22b	58.08	111.58	1182
		Total>	127.48	35.75m	738.44	652.05	652.05	32591
17	-2.68	Total>	147.46	40.38m	871.45	585.75	585.75	38620
18	-3.60	Total>	167.55	45.00m	1004.56	495.64	495.64	44650
19	-4.80	Total>	193.74	51.00m	1177.38	367.75	367.75	52472
20	-6.00	Total>	220.08	57.00m	1350.36	248.40	248.40	50293
21	-7.20	Total>	246.55	63.00m	1523.46	146.86	146.86	56817
22	-8.40	Total>	273.13	69.00m	1696.67	73.89	73.89	63342
23	-9.20	Total>	290.90	73.00m	1812.19	78.12	78.12	67691
24	-10.00	Total>	308.70	77.00m	1927.74	82.15	82.15	72041

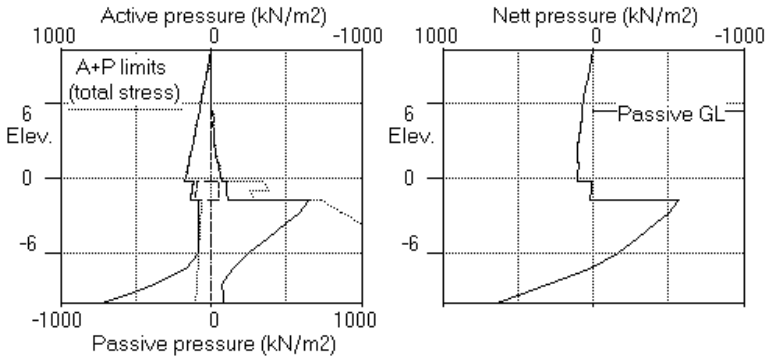
Note: 70.73a Soil pressure at active limit
123.45p Soil pressure at passive limit
234.22b Passive limit reduced because of berm

Units: kN,m

Stage No.9 Change soil type 2 to soil type 1



Stage No.9 Change soil type 2 to soil type 1



Units: kN,m

Stage No. 10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = -10.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	10.25	5.40	Cant.	2.307	-7.46	-6.03	11.43

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.140	1.05E-02	0.0	0.0		2515171
2	9.50	10.61	0.133	1.05E-02	4.0	-2.7		2515171
3	8.75	18.84	0.125	1.05E-02	15.0	4.3		2515171
		23.69	0.125	1.05E-02	15.0	4.3		
4	7.98	36.50	0.117	1.05E-02	38.3	24.5		2515171
5	7.20	49.31	0.108	1.04E-02	71.6	66.6		2515171
6	6.30	64.19	0.099	1.04E-02	122.7	153.2		2515171
7	5.40	79.07	0.090	1.04E-02	187.1	291.9		2515171
		74.64	0.090	1.04E-02	187.1	291.9		
8	4.50	75.05	0.080	1.03E-02	254.5	488.8		2515171
		85.60	0.080	1.03E-02	254.5	488.8		
9	3.60	90.52	0.071	1.01E-02	333.8	753.9		2515171
		93.79	0.071	1.01E-02	333.8	753.9		
10	2.90	96.98	0.064	9.99E-03	400.5	1010.9		2515171
		93.64	0.064	9.99E-03	400.5	1010.9		
11	2.05	95.79	0.056	9.70E-03	481.0	1385.6		2515171
12	1.20	97.92	0.047	9.32E-03	563.4	1829.6		2515171
13	0.00	100.50	0.037	8.59E-03	682.4	2577.3		2515171
14	-0.25	100.32	0.035	8.41E-03	707.5	2751.1		2515171
		13.30	0.035	8.41E-03	707.5	2751.1		
15	-1.00	17.46	0.028	7.79E-03	719.1	3287.3		2515171
16	-1.75	26.04	0.023	7.05E-03	735.4	3832.1		2515171
		-556.67	0.023	7.05E-03	735.4	3832.1		
17	-2.68	-493.80	0.017	6.02E-03	249.5	4276.2		2515171
18	-3.60	-407.85	0.012	4.93E-03	-167.5	4298.3		2515171
19	-4.80	-284.17	0.007	3.59E-03	-582.7	3808.7		2515171
20	-6.00	-166.14	0.003	2.47E-03	-852.9	2908.2		2515171
21	-7.20	21.55	0.001	1.69E-03	-939.6	1793.3		2515171
22	-8.40	301.00	-0.001	1.27E-03	-746.1	700.2		2515171

(continued)

Stage No.10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
23	-9.20	463.40	-0.002	1.17E-03	-440.4	201.9		2515171
24	-10.00	637.49	-0.003	1.15E-03	-0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	504
2	9.50	0.00	14.25	4.70	54.04	10.61	10.61	504
3	8.75	0.00	28.50	9.40	108.09	18.84	18.84	504
		0.00	28.50	4.06	52.95	23.69	23.69	252
4	7.98	7.75	33.92	9.49	58.37	28.75	36.50	252
5	7.20	15.50	39.35	14.91	63.80	33.81	49.31	252
6	6.30	24.50	45.65	21.21	70.10	39.69	64.19	252
7	5.40	33.50	51.95	27.51	76.40	45.57	79.07	252
8	4.50	42.50	58.25	33.80	82.70	51.45	93.95	252
9	3.60	51.50	64.55	40.10	89.00	57.34	108.84	252
10	2.90	58.50	69.45	45.00	93.91	61.93	120.43	252
11	2.05	67.00	75.40	50.95	99.86	67.50	134.50	252
12	1.20	75.50	81.35	56.90	105.81	73.09	148.59	252
13	0.00	87.50	89.75	65.30	114.21	81.01	168.51	252
14	-0.25	90.00	91.50	67.05	115.96	82.67	172.67	252
		90.00	91.50	23.47	485.21	23.79	113.79	718
15	-1.00	97.50	99.00	25.39	524.98	25.65	123.15	718
16	-1.75	105.00	106.50	27.32	564.76	32.43	137.43	718
		Total> 211.50		60.00m	822.46	90.20	90.20	20512
17	-2.68	Total> 230.93		64.63m	954.91	87.80	87.80	24307
18	-3.60	Total> 250.35		69.25m	1087.37	84.82	84.82	28102
19	-4.80	Total> 275.55		75.25m	1259.20	82.09	82.09	33024
20	-6.00	Total> 300.75		81.25m	1431.03	81.92	81.92	37947
21	-7.20	Total> 325.95		87.25m	1602.86	169.05	169.05	81955
22	-8.40	Total> 351.15		93.25m	1774.69	376.24	376.24	91366
23	-9.20	Total> 367.95		97.25m	1889.24	543.25	543.25	97640
24	-10.00	Total> 384.75		101.25m	2003.80	721.72	721.72	103914

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	12.24b	4.43	4.43	331
8	4.50	0.00	15.30	0.00	19.90b	18.90	18.90	331
		0.00	15.30	0.00	13.38b	8.36	8.36	331
9	3.60	0.00	30.63	6.19	18.54b	18.32	18.32	331
		0.00	30.63	6.19	15.27b	15.05	15.05	331
10	2.90	7.00	35.57	11.13	16.65b	16.45	23.45	331
		7.00	35.57	11.13	26.14b	19.79	26.79	331

(continued)

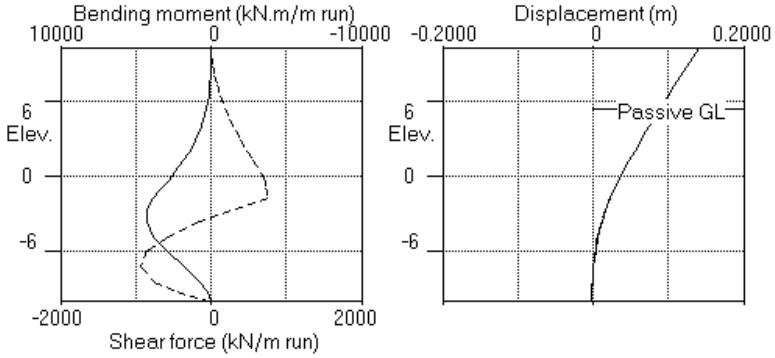
Stage No.10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
11	2.05	15.50	41.61	17.17	28.78b	23.21	38.71	331
		15.50	41.61	17.17	32.06b	23.21	38.71	331
12	1.20	24.00	47.72	23.28	35.02b	26.67	50.67	331
		24.00	47.72	23.28	38.62b	26.67	50.67	331
13	0.00	36.00	56.46	32.01	43.30b	32.01	68.01a	331
		36.00	56.46	32.01	45.73b	32.01	68.01a	331
14	-0.25	38.50	58.30	33.85	46.77b	33.85	72.35a	331
		38.50	58.30	14.95	299.19b	62.00	100.50	935
15	-1.00	46.00	66.11	16.96	339.28b	59.68	105.68	935
		46.00	66.11	16.96	209.28b	59.68	105.68	935
16	-1.75	53.50	73.98	18.98	234.22b	57.89	111.39	935
		Total> 127.48	35.75m	738.44	646.87	646.87		26141
17	-2.68	Total> 147.46	40.38m	871.45	581.59	581.59		30978
18	-3.60	Total> 167.55	45.00m	1004.56	492.68	492.68		35814
19	-4.80	Total> 193.74	51.00m	1177.38	366.26	366.26		42088
20	-6.00	Total> 220.08	57.00m	1350.36	248.06	248.06		48362
21	-7.20	Total> 246.55	63.00m	1523.46	147.50	147.50		81955
22	-8.40	Total> 273.13	69.00m	1696.67	75.25	75.25		91366
23	-9.20	Total> 290.90	73.00m	1812.19	79.85	79.85		97640
24	-10.00	Total> 308.70	77.00m	1927.74	84.23	84.23		103914

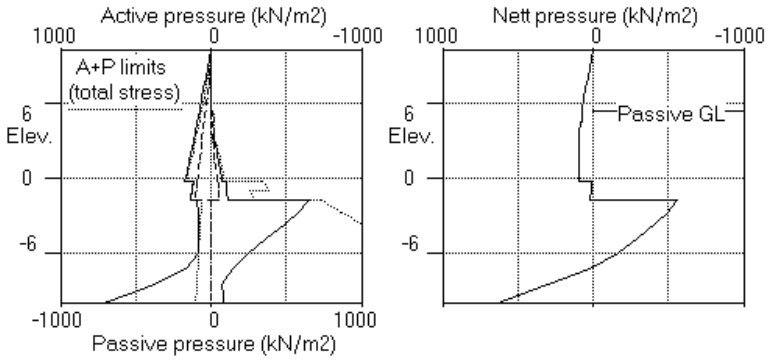
Note: 72.35a Soil pressure at active limit
123.45p Soil pressure at passive limit
234.22b Passive limit reduced because of berm

Units: kN,m

Stage No.10 Change soil type 3 to soil type 4



Stage No.10 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State

All loads and soil strengths are unfactored

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = -10.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.25	10.25	Cant.	Conditions not suitable for FoS calc.			
2	10.25	10.25	Cant.	Conditions not suitable for FoS calc.			
3	10.25	5.40	Cant.	2.084	-7.43	-6.90	12.30
4	10.25	5.40	Cant.	1.814	-7.42	-7.32	12.72
5	10.25	5.40		No analysis at this stage			
6	10.25	5.40	Cant.	4.598	-7.33	-4.81	10.21
7	10.25	5.40	Cant.	1.814	-7.42	-7.32	12.72
8	10.25	5.40	Cant.	2.084	-7.43	-6.90	12.30
9	10.25	5.40	Cant.	2.076	-7.43	-6.90	12.30
10	10.25	5.40	Cant.	2.307	-7.46	-6.03	11.43
11	10.25	5.40		No analysis at this stage			
12	10.25	5.40		No analysis at this stage			
13	10.25	5.40	Cant.	1.814	-7.42	-7.32	12.72
14	10.25	5.40	Cant.	4.598	-7.33	-4.81	10.21

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	10.25	0.154	0.000	0	-0	0	-0	0	0	0	0
2	9.50	0.145	0.000	7	-3	9	-4	25	-1	34	-1
3	8.75	0.136	0.000	35	-1	47	-2	54	-2	73	-3
4	7.98	0.127	0.000	87	-3	118	-4	81	-2	110	-3
5	7.20	0.118	0.000	161	-5	217	-7	111	-3	150	-4
6	6.30	0.108	0.000	278	-8	375	-11	151	-3	203	-4
7	5.40	0.098	0.000	432	-11	584	-14	203	-3	274	-5
8	4.50	0.087	0.000	626	-14	845	-19	272	-4	368	-5
9	3.60	0.077	0.000	868	-17	1172	-23	356	-4	480	-5
10	2.90	0.070	0.000	1090	-20	1472	-27	427	-4	577	-6
11	2.05	0.060	0.000	1483	-24	2002	-32	522	-4	704	-6
12	1.20	0.051	0.000	1966	-28	2654	-38	616	-5	831	-6
13	0.00	0.040	0.000	2785	-34	3759	-45	748	-5	1010	-7
14	-0.25	0.037	0.000	2975	-35	4017	-47	776	-5	1048	-7
15	-1.00	0.031	0.000	3563	-31	4810	-41	787	-0	1063	-0
16	-1.75	0.025	0.000	4159	-10	5615	-13	804	-0	1086	-0
17	-2.68	0.018	0.000	4636	0	6258	0	262	-0	354	-0
18	-3.60	0.012	0.000	4643	0	6268	0	14	-201	20	-272
19	-4.80	0.007	0.000	4086	0	5516	0	2	-648	3	-875
20	-6.00	0.003	0.000	3096	0	4180	0	0	-926	0	-1250
21	-7.20	0.001	0.000	1895	0	2558	0	0	-1004	0	-1355
22	-8.40	0.000	-0.001	736	-0	993	-0	0	-788	0	-1064
23	-9.20	0.000	-0.002	211	-0	285	-0	0	-463	0	-625
24	-10.00	0.000	-0.003	0	0	0	0	0	-0	0	-0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

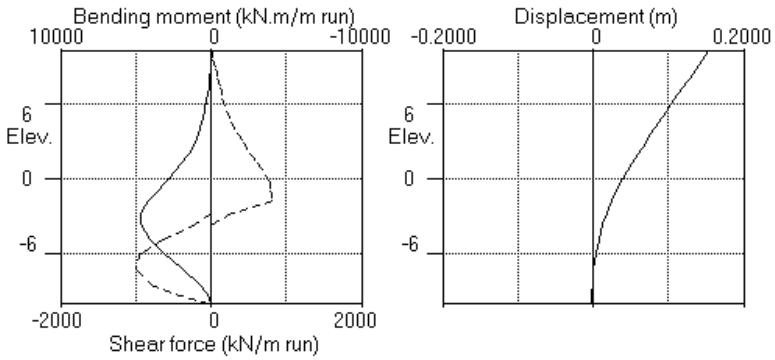
Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
no.	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	0	-4.80	-0	2.90	0	-0	0	10.25	-0	9.50	0	-0
2	47	-4.80	-35	-0.25	63	-47	38	-1.75	-13	-8.40	52	-18
3	4002	-3.60	0	10.25	5403	0	712	-1.75	-869	-7.20	961	-1173
4	4619	-3.60	0	10.25	6236	0	803	-1.75	-995	-7.20	1084	-1344
5	No calculation at this stage											
6	3431	-2.68	0	10.25	4632	0	507	-0.25	-761	-7.20	684	-1027
7	4620	-3.60	-3	9.50	6237	-4	803	-1.75	-1001	-7.20	1084	-1352
8	4354	-3.60	-1	9.50	5878	-1	748	-1.75	-950	-7.20	1010	-1283
9	4337	-3.60	-3	9.50	5856	-4	747	-1.75	-948	-7.20	1009	-1279
10	4298	-3.60	-3	9.50	5803	-4	735	-1.75	-940	-7.20	993	-1269
11	No calculation at this stage											
12	No calculation at this stage											
13	4643	-3.60	-2	9.50	6268	-2	804	-1.75	-1004	-7.20	1086	-1355
14	3444	-2.68	0	10.25	4650	0	508	-0.25	-768	-7.20	686	-1036

Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	10.25	0.000	10.25	Change EI of wall to 3.5212E+06kN.m2/m run
2	0.001	10.25	-0.000	-10.00	Apply water pressure profile no.1
3	0.131	10.25	-0.003	-10.00	Excav. to elev. 5.40 on PASSIVE side
4	0.152	10.25	-0.003	-10.00	Apply surcharge no.1 at elev. 10.25
5	No calculation at this stage				Change EI of wall to 2.5152E+06kN.m2/m run
6	0.110	10.25	-0.003	-10.00	Apply water pressure profile no.2
7	0.152	10.25	-0.003	-10.00	Apply water pressure profile no.1
8	0.142	10.25	-0.003	-10.00	Remove surcharge no.1 at elev. 10.25
9	0.142	10.25	-0.003	-10.00	Change soil type 2 to soil type 1
10	0.140	10.25	-0.003	-10.00	Change soil type 3 to soil type 4
11	No calculation at this stage				Change soil type 1 to soil type 2
12	No calculation at this stage				Change soil type 4 to soil type 3
13	0.154	10.25	-0.003	-10.00	Apply surcharge no.1 at elev. 10.25
14	0.112	10.25	-0.003	-10.00	Apply water pressure profile no.2

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	10.25	2 Made ground (U)	7 Made ground (P)
2	8.75	3 Tidal deposits (U)	3 Tidal deposits (U)
3	-0.25	6 RT deposits	6 RT deposits
4	-1.75	5 WRock	5 WRock

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made ground (D)	19.00	4800	0.562	OC (0.150)	0.330 (1.374)	3.793 (5.726)	0.0d
2	Made ground (U)	19.00	6000	0.562	OC (0.490)	1.000 (1.000)	1.000 (1.000)	20.00u
3	Tidal deposits (U)	17.00	3000	0.562	NC (0.490)	1.000 (1.000)	1.000 (1.000)	10.00u
4	Tidal deposits (D)	17.00	2400	0.562	NC (0.150)	1.000 (2.443)	1.000 (2.444)	10.00d
5	WRock (-1.75)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	RT deposits	20.00	6000	0.455	OC (0.300)	0.256 (0.000)	5.303 (0.000)	
7	Made ground (P)	19.00	6000	0.562	OC (0.490)	1.000 (1.000)	1.000 (1.000)	20.00u

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made ground (D)	26.00	0.833	0.00	26.00	0.833	0.00
2	Made ground (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
3	Tidal deposits (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
4	Tidal deposits (D)	0.00	0.600	0.00	0.00	0.600	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	RT deposits	33.00	0.500	0.00	33.00	0.500	0.00
7	Made ground (P)	0.00	-0.674	0.00	0.00	-0.674	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	3.60	3.60

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	8.75	8.75	0.0	1	3.60	3.60	0.0	MC+WC
2	1	8.75	8.75	0.0	1	10.25	10.25	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall = -9.00
             Maximum finite element length =  1.20 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 0.15061 m4/m run
                                       E.I = 3.5212E+06 kN.m2/m run
                    Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	10.25	0.00(A)	100.00	100.00	10.00	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
2	Apply water pressure profile no.1 (Mod. Conserv.)
3	Excavate to elevation 5.40 on PASSIVE side Toe of berm at elevation 2.90 Width of top of berm = 0.01 Width of toe of berm = 4.00
4	Apply surcharge no.1 at elevation 10.25
5	Change EI of wall to 2.5152E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
6	Apply water pressure profile no.2 (Mod. Conserv.)
7	Apply water pressure profile no.1 (Mod. Conserv.)
8	Remove surcharge no.1 at elevation 10.25
9	Change properties of soil type 2 to soil type 1 Ko pressures will not be reset
10	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
11	Change properties of soil type 1 to soil type 2 No analysis at this stage Ko pressures will not be reset
12	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
13	Apply surcharge no.1 at elevation 10.25
14	Apply water pressure profile no.2 (Mod. Conserv.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: ULS DA1 Combination 1
  Water pressures : Moderately Conservative
  Partial factor on   C'         = 1.000
  Partial factor on Phi'         = 1.000
  Partial factor on   Cu         = 1.000
  Partial factor on Soil Modulus = 1.000
  Partial factor on Permanent Unfavourable loads = 1.000
  Partial factor on Permanent Favourable loads   = 1.000
  Partial factor on Variable Unfavourable loads  = 1.100
  Design factor on calculated Bending Moments    = 1.350


 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
  Open Tension Crack analysis? - No
  Non-linear Modulus Parameter (L) = 25.00 m
```

Boundary conditions:
 Length of wall (normal to plane of analysis) = 1000.00 m

 Width of excavation on active side of wall = 20.00 m
 Width of excavation on passive side of wall = 20.00 m

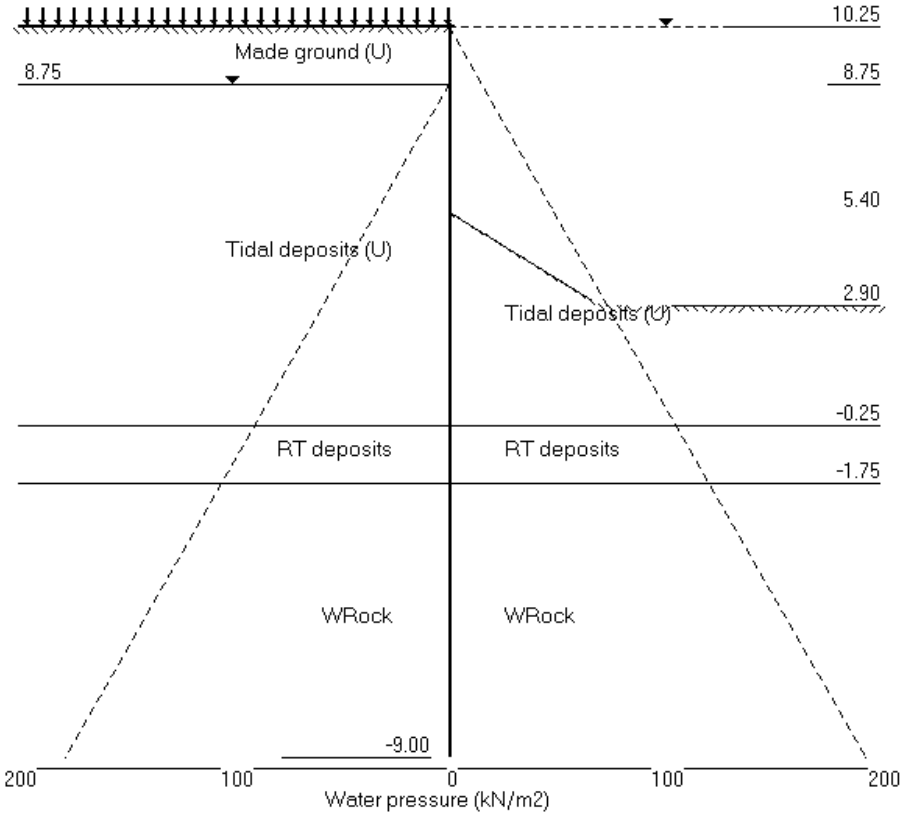
 Distance to rigid boundary on active side = 50.00 m
 Distance to rigid boundary on passive side = 50.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Excav. to elev. 5.40 on PASSIVE side	No	No	No
4	Apply surcharge no.1 at elev. 10.25	No	No	No
5	Change EI of wall to 2.5152E+06kN.m2/m	No	No	No
6	Apply water pressure profile no.2	No	No	No
7	Apply water pressure profile no.1	No	No	No
8	Remove surcharge no.1 at elev. 10.25	No	No	No
9	Change soil type 2 to soil type 1	No	No	No
10	Change soil type 3 to soil type 4	No	No	No
11	Change soil type 1 to soil type 2	No	No	No
12	Change soil type 4 to soil type 3	No	No	No
13	Apply surcharge no.1 at elev. 10.25	No	No	No
14	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.14 Apply water pressure profile no.2 (Mod. Conserv.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	-0.000	-2.43E-16	0.0	0.0		3521239
2	9.50	0.00	-0.000	-2.44E-16	0.0	0.0		3521239
3	8.75	0.00	-0.000	-2.44E-16	0.0	0.0		3521239
4	7.98	0.00	-0.000	-2.46E-16	0.0	0.0		3521239
5	7.20	0.00	-0.000	-2.50E-16	0.0	0.0		3521239
6	6.30	0.00	-0.000	-2.56E-16	0.0	0.0		3521239
7	5.40	0.00	-0.000	-2.65E-16	0.0	0.0		3521239
8	4.50	0.00	-0.000	-2.75E-16	0.0	0.0		3521239
9	3.60	0.00	-0.000	-2.88E-16	0.0	0.0		3521239
10	2.90	0.00	-0.000	-3.00E-16	0.0	0.0		3521239
11	2.05	0.00	-0.000	-3.15E-16	0.0	0.0		3521239
12	1.20	0.00	-0.000	-3.31E-16	0.0	0.0		3521239
13	0.00	0.00	-0.000	-3.34E-16	0.0	-0.0		3521239
14	-0.25	0.00	-0.000	-3.30E-16	0.0	-0.0		3521239
15	-1.00	0.00	-0.000	-3.09E-16	0.0	-0.0		3521239
16	-1.75	0.00	-0.000	-2.76E-16	0.0	-0.0		3521239
17	-2.68	0.00	-0.000	-2.27E-16	0.0	-0.0		3521239
18	-3.60	0.00	0.000	-1.82E-16	0.0	-0.0		3521239
19	-4.80	0.00	0.000	-1.49E-16	0.0	-0.0		3521239
20	-6.00	0.00	0.000	-1.39E-16	0.0	-0.0		3521239
21	-7.20	0.00	0.000	-1.35E-16	0.0	-0.0		3521239
22	-8.10	0.00	0.000	-1.32E-16	0.0	-0.0		3521239
23	-9.00	-0.00	0.000	-1.31E-16	-0.0	-0.0		---

Node no.	Y coord	ACTIVE side						
			Effective stresses			Total	Coeff. of	
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	earth pressure kN/m2	subgrade reaction kN/m3
1	10.25	Total>	0.00	0.00	20.00	0.00	0.00a	1002
2	9.50	Total>	14.25	3.75m	34.25	8.01	8.01	1002
3	8.75	Total>	28.50	8.50	48.50	16.02	16.02	1002
		Total>	28.50	18.50	38.50	18.50	18.50a	501
4	7.98	Total>	41.67	31.67	51.68	31.67	31.67a	501
5	7.20	Total>	54.85	44.84	64.86	44.84	44.84a	501
6	6.30	Total>	70.15	60.14	80.16	60.14	60.14a	501
7	5.40	Total>	85.45	75.44	95.46	75.44	75.44a	501
8	4.50	Total>	100.75	90.74	110.76	90.74	90.74a	501
9	3.60	Total>	116.05	106.04	126.06	106.04	106.04a	501

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

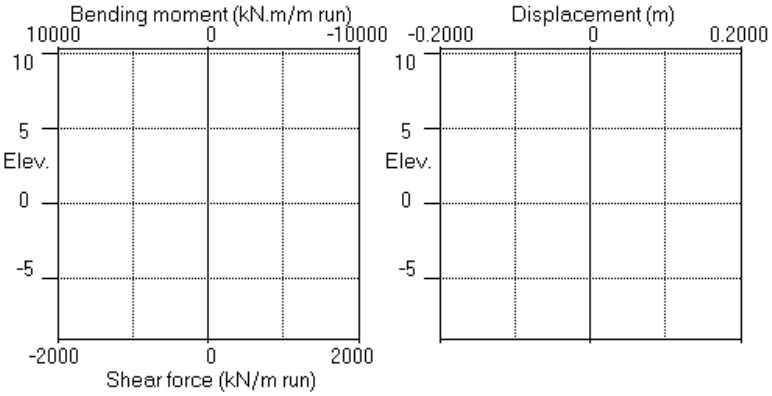
Node no.	Y coord	ACTIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
10	2.90	Total>	127.95	117.94	137.96	117.94	117.94a	501
11	2.05	Total>	142.40	132.39	152.41	132.39	132.39a	501
12	1.20	Total>	156.85	146.84	166.86	146.84	146.84a	501
13	0.00	Total>	177.25	167.24	187.26	167.24	167.24a	501
14	-0.25	Total>	181.50	171.49	191.51	171.49	171.49a	501
		38.50	143.00	36.68	758.32	65.06	103.56	732
15	-1.00	46.00	150.50	38.60	798.09	68.48	114.48	732
16	-1.75	53.50	158.00	40.52	837.86	71.89	125.39	732
		Total>	211.50	60.00m	822.50	116.70	116.70	20872
17	-2.68	Total>	230.93	64.63m	954.95	130.02	130.02	24733
18	-3.60	Total>	250.35	69.25m	1087.41	143.34	143.34	45571
19	-4.80	Total>	275.55	75.25m	1259.24	160.62	160.62	53555
20	-6.00	Total>	300.75	81.25m	1431.08	177.90	177.90	61538
21	-7.20	Total>	325.95	87.25m	1602.91	195.18	195.18	69521
22	-8.10	Total>	344.85	91.75m	1731.79	208.14	208.14	75509
23	-9.00	Total>	363.75	96.25m	1860.66	221.10	221.10	81496

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	10.25	Total>	0.00	0.00	20.00	0.00	0.00a	1002
2	9.50	Total>	14.25	3.75m	34.25	8.01	8.01	1002
3	8.75	Total>	28.50	8.50	48.50	16.02	16.02	1002
		Total>	28.50	18.50	38.50	18.50	18.50a	501
4	7.98	Total>	41.67	31.67	51.68	31.67	31.67a	501
5	7.20	Total>	54.85	44.84	64.86	44.84	44.84a	501
6	6.30	Total>	70.15	60.14	80.16	60.14	60.14a	501
7	5.40	Total>	85.45	75.44	95.46	75.44	75.44a	501
8	4.50	Total>	100.75	90.74	110.76	90.74	90.74a	501
9	3.60	Total>	116.05	106.04	126.06	106.04	106.04a	501
10	2.90	Total>	127.95	117.94	137.96	117.94	117.94a	501
11	2.05	Total>	142.40	132.39	152.41	132.39	132.39a	501
12	1.20	Total>	156.85	146.84	166.86	146.84	146.84a	501
13	0.00	Total>	177.25	167.24	187.26	167.24	167.24a	501
14	-0.25	Total>	181.50	171.49	191.51	171.49	171.49a	501
		38.50	143.00	36.68	758.32	65.06	103.56	732
15	-1.00	46.00	150.50	38.60	798.09	68.48	114.48	732
16	-1.75	53.50	158.00	40.52	837.86	71.89	125.39	732
		Total>	211.50	60.00m	822.50	116.70	116.70	20872
17	-2.68	Total>	230.93	64.63m	954.95	130.02	130.02	24733
18	-3.60	Total>	250.35	69.25m	1087.41	143.34	143.34	45571
19	-4.80	Total>	275.55	75.25m	1259.24	160.62	160.62	53555
20	-6.00	Total>	300.75	81.25m	1431.08	177.90	177.90	61538
21	-7.20	Total>	325.95	87.25m	1602.91	195.18	195.18	69521
22	-8.10	Total>	344.85	91.75m	1731.79	208.14	208.14	75509
23	-9.00	Total>	363.75	96.25m	1860.66	221.10	221.10	81496

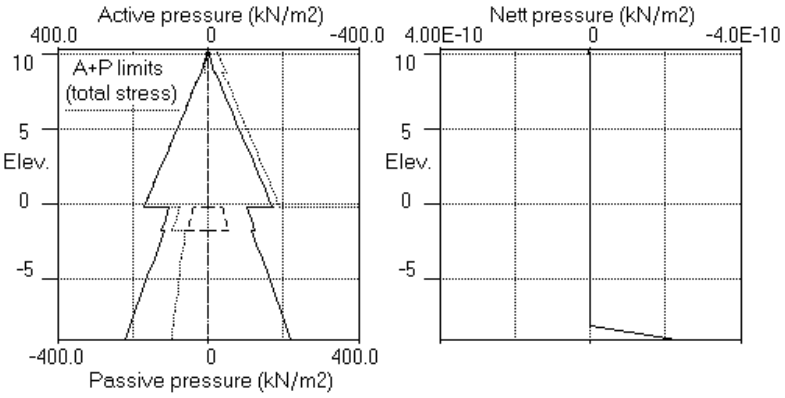
Note: 171.49a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.138	1.02E-02	0.0	-0.0		3521239
2	9.50	3.75	0.130	1.02E-02	1.4	0.4		3521239
3	8.75	8.50	0.123	1.02E-02	6.0	3.0		3521239
		18.50	0.123	1.02E-02	6.0	3.0		
4	7.98	31.67	0.115	1.02E-02	25.4	14.5		3521239
5	7.20	44.85	0.107	1.01E-02	55.1	45.0		3521239
6	6.30	60.15	0.098	1.01E-02	102.3	114.9		3521239
7	5.40	75.44	0.088	1.01E-02	163.4	233.4		3521239
		66.34	0.088	1.01E-02	163.4	233.4		
8	4.50	67.71	0.079	1.00E-02	223.7	407.4		3521239
		78.49	0.079	1.00E-02	223.7	407.4		
9	3.60	86.37	0.070	9.91E-03	297.9	641.6		3521239
		91.00	0.070	9.91E-03	297.9	641.6		
10	2.90	94.07	0.064	9.76E-03	362.6	872.6		3521239
		98.73	0.064	9.76E-03	362.6	872.6		
11	2.05	103.06	0.055	9.51E-03	448.4	1217.1		3521239
		98.86	0.055	9.51E-03	448.4	1217.1		
12	1.20	102.68	0.047	9.17E-03	534.1	1634.4		3521239
		98.19	0.047	9.17E-03	534.1	1634.4		
13	0.00	102.86	0.037	8.49E-03	654.7	2347.1		3521239
		99.87	0.037	8.49E-03	654.7	2347.1		
14	-0.25	100.75	0.035	8.32E-03	679.8	2513.9		3521239
		13.16	0.035	8.32E-03	679.8	2513.9		
15	-1.00	17.30	0.029	7.73E-03	691.2	3027.2		3521239
16	-1.75	26.04	0.023	7.03E-03	707.4	3552.4		3521239
		-586.69	0.023	7.03E-03	707.4	3552.4		
17	-2.68	-518.31	0.017	6.04E-03	196.4	3954.4		3521239
18	-3.60	-424.86	0.012	5.01E-03	-239.8	3912.8		3521239
19	-4.80	-287.94	0.007	3.77E-03	-667.5	3315.8		3521239
20	-6.00	-149.54	0.003	2.82E-03	-930.0	2304.1		3521239
21	-7.20	168.07	-0.000	2.24E-03	-918.9	1102.6		3521239
22	-8.10	502.95	-0.002	2.05E-03	-616.9	351.7		3521239
23	-9.00	868.01	-0.004	2.01E-03	-0.0	0.0		---

(continued)

Stage No.3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	Total>	0.00	0.00	20.00	0.00	0.00a	1034
2	9.50	Total>	14.25	3.75m	34.25	3.75	3.75a	1034
3	8.75	Total>	28.50	8.50	48.50	8.50	8.50a	1034
		Total>	28.50	18.50	38.50	18.50	18.50a	517
4	7.98	Total>	41.67	31.67	51.68	31.67	31.67a	517
5	7.20	Total>	54.85	44.85	64.85	44.85	44.85a	517
6	6.30	Total>	70.15	60.15	80.15	60.15	60.15a	517
7	5.40	Total>	85.45	75.44	95.46	75.44	75.44a	517
8	4.50	Total>	100.75	90.74	110.76	90.74	90.74a	517
9	3.60	Total>	116.05	106.04	126.06	106.04	106.04a	517
10	2.90	Total>	127.95	117.94	137.96	117.94	117.94a	517
11	2.05	Total>	142.40	132.39	152.41	132.39	132.39a	517
12	1.20	Total>	156.85	146.84	166.86	146.84	146.84a	517
13	0.00	Total>	177.25	167.24	187.26	167.24	167.24a	517
14	-0.25	Total>	181.50	171.49	191.51	171.49	171.49a	517
		90.00	91.50	23.47	485.22	23.47	113.47a	758
15	-1.00	97.50	99.00	25.39	524.99	25.39	122.89a	758
16	-1.75	105.00	106.50	27.31	564.76	32.41	137.41	758
		Total>	211.50	60.00m	822.49	60.00	60.00a	21535
17	-2.68	Total>	230.93	64.63m	954.94	64.63	64.63a	25519
18	-3.60	Total>	250.35	69.25m	1087.40	69.25	69.25a	29503
19	-4.80	Total>	275.55	75.25m	1259.23	75.25	75.25a	34672
20	-6.00	Total>	300.75	81.25m	1431.06	81.25	81.25a	39840
21	-7.20	Total>	325.95	87.25m	1602.90	239.51	239.51	152175
22	-8.10	Total>	344.85	91.75m	1731.77	570.45	570.45	165281
23	-9.00	Total>	363.75	96.25m	1860.65	940.01	940.01	178388

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	9.10b	9.10	9.10p	643
8	4.50	Total>	15.30	5.30	23.04b	23.04	23.04p	643
		Total>	15.30	5.30	12.25b	12.25	12.25p	643
9	3.60	Total>	30.63	19.66	19.67b	19.67	19.67p	643
		Total>	30.63	15.03	15.04b	15.04	15.04p	643
10	2.90	Total>	42.57	23.87	23.88b	23.88	23.88p	643
		Total>	42.57	19.20	19.21b	19.21	19.21p	643
11	2.05	Total>	57.11	29.32	29.33b	29.33	29.33p	643
		Total>	57.11	33.52	33.53b	33.53	33.53p	643
12	1.20	Total>	71.72	44.15	44.16b	44.16	44.16p	643
		Total>	71.72	48.64	48.65b	48.65	48.65p	643
13	0.00	Total>	92.46	64.38	64.39b	64.39	64.39p	643
		Total>	92.46	67.36	67.37b	67.37	67.37p	643

(continued)

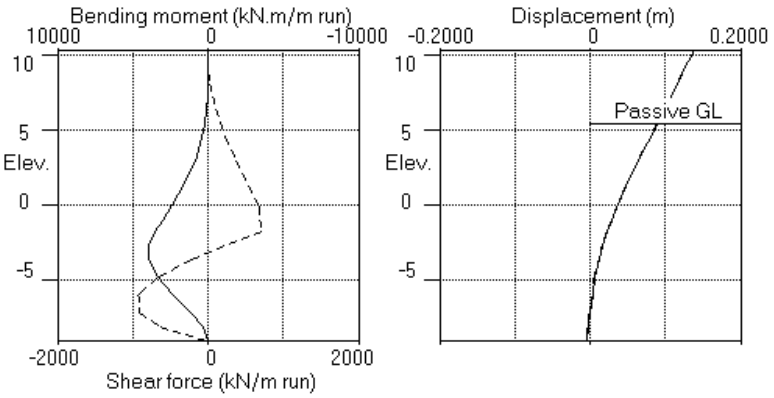
Stage No.3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
14	-0.25	Total>	96.80	70.73	70.74b	70.74	70.74p	643
		38.50	58.30	14.95	299.20b	61.81	100.31	960
15	-1.00	46.00	66.11	16.95	339.29b	59.59	105.59	960
		46.00	66.11	16.95	209.29b	59.59	105.59	960
16	-1.75	53.50	73.98	18.98	234.22b	57.87	111.37	960
		Total>	127.48	35.75m	738.46	646.69	646.69	26781
17	-2.68	Total>	147.46	40.38m	871.47	582.93	582.93	31735
18	-3.60	Total>	167.55	45.00m	1004.58	494.11	494.11	36690
19	-4.80	Total>	193.74	51.00m	1177.41	363.19	363.19	43117
20	-6.00	Total>	220.08	57.00m	1350.39	230.79	230.79	49545
21	-7.20	Total>	246.55	63.00m	1523.49	71.44	71.44	152175
22	-8.10	Total>	266.47	67.50m	1653.39	67.50	67.50a	165281
23	-9.00	Total>	286.45	72.00m	1783.34	72.00	72.00a	178388

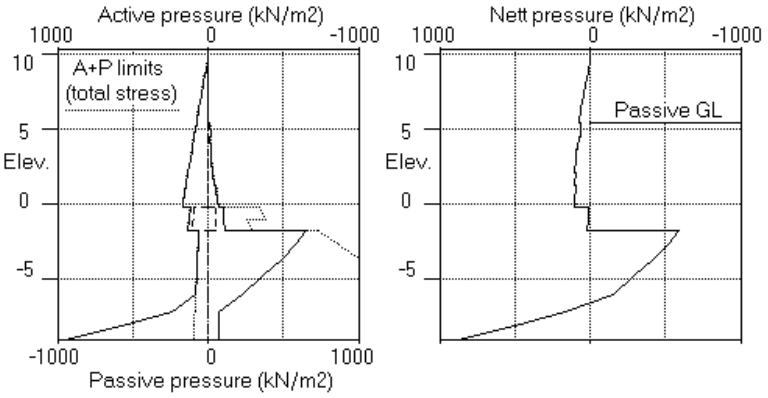
Note: 72.00a Soil pressure at active limit
70.74p Soil pressure at passive limit
234.22b Passive limit reduced because of berm

Units: kN,m

Stage No.3 Excav. to elev. 5.40 on PASSIVE side



Stage No.3 Excav. to elev. 5.40 on PASSIVE side



Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.150	1.11E-02	0.0	-0.0		2515171
2	9.50	10.06	0.142	1.11E-02	3.8	-2.7		2515171
3	8.75	18.32	0.134	1.11E-02	14.4	4.0		2515171
		23.42	0.134	1.11E-02	14.4	4.0		
4	7.98	36.25	0.125	1.11E-02	37.5	23.6		2515171
5	7.20	49.08	0.117	1.11E-02	70.6	65.0		2515171
6	6.30	63.98	0.107	1.10E-02	121.5	150.7		2515171
7	5.40	78.87	0.097	1.10E-02	185.8	288.2		2515171
		74.18	0.097	1.10E-02	185.8	288.2		
8	4.50	74.64	0.087	1.09E-02	252.7	483.6		2515171
		85.43	0.087	1.09E-02	252.7	483.6		
9	3.60	89.02	0.077	1.07E-02	331.2	746.9		2515171
		93.65	0.077	1.07E-02	331.2	746.9		
10	2.90	96.41	0.069	1.06E-02	397.8	1002.1		2515171
		101.08	0.069	1.06E-02	397.8	1002.1		
11	2.05	105.05	0.061	1.03E-02	485.4	1377.3		2515171
		100.85	0.061	1.03E-02	485.4	1377.3		
12	1.20	104.33	0.052	9.95E-03	572.6	1826.9		2515171
		99.84	0.052	9.95E-03	572.6	1826.9		
13	0.00	104.06	0.040	9.22E-03	694.9	2587.4		2515171
		101.07	0.040	9.22E-03	694.9	2587.4		
14	-0.25	101.86	0.038	9.04E-03	720.3	2764.3		2515171
		10.04	0.038	9.04E-03	720.3	2764.3		
15	-1.00	14.63	0.032	8.41E-03	729.5	3307.3		2515171
16	-1.75	21.93	0.025	7.67E-03	743.2	3861.1		2515171
		-617.42	0.025	7.67E-03	743.2	3861.1		
17	-2.68	-555.81	0.019	6.62E-03	200.6	4325.2		2515171
18	-3.60	-459.97	0.013	5.52E-03	-269.2	4275.5		2515171
19	-4.80	-315.39	0.007	4.20E-03	-734.4	3626.5		2515171
20	-6.00	-164.49	0.003	3.18E-03	-1022.3	2521.8		2515171
21	-7.20	181.28	-0.000	2.55E-03	-1012.3	1206.1		2515171
22	-8.10	552.72	-0.003	2.35E-03	-682.0	382.1		2515171
23	-9.00	962.74	-0.005	2.31E-03	-0.0	0.0		---

(continued)

Stage No.9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	638
2	9.50	0.00	14.25	4.70	54.04	10.06	10.06	638
3	8.75	0.00	28.50	9.40	108.09	18.32	18.32	638
		Total>	28.50	18.50	38.50	23.42	23.42	606
4	7.98	Total>	41.67	31.67	51.68	36.25	36.25	606
5	7.20	Total>	54.85	44.85	64.85	49.08	49.08	606
6	6.30	Total>	70.15	60.15	80.15	63.98	63.98	606
7	5.40	Total>	85.45	75.44	95.46	78.87	78.87	606
8	4.50	Total>	100.75	90.74	110.76	93.78	93.78	606
9	3.60	Total>	116.05	106.04	126.06	108.68	108.68	606
10	2.90	Total>	127.95	117.94	137.96	120.28	120.28	606
11	2.05	Total>	142.40	132.39	152.41	134.37	134.37	606
12	1.20	Total>	156.85	146.84	166.86	148.48	148.48	606
13	0.00	Total>	177.25	167.24	187.26	168.43	168.43	606
14	-0.25	Total>	181.50	171.49	191.51	172.59	172.59	606
		90.00	91.50	23.47	485.22	23.56	113.56	901
15	-1.00	97.50	99.00	25.39	524.99	25.46	122.96	901
16	-1.75	105.00	106.50	27.31	564.76	30.58	135.58	901
		Total>	211.50	60.00m	822.49	86.69	86.69	25267
17	-2.68	Total>	230.93	64.63m	954.94	85.15	85.15	29942
18	-3.60	Total>	250.35	69.25m	1087.40	83.14	83.14	34616
19	-4.80	Total>	275.55	75.25m	1259.23	81.48	81.48	40680
20	-6.00	Total>	300.75	81.25m	1431.06	81.80	81.80	62048
21	-7.20	Total>	325.95	87.25m	1602.90	252.46	252.46	70097
22	-8.10	Total>	344.85	91.75m	1731.77	630.85	630.85	76134
23	-9.00	Total>	363.75	96.25m	1860.65	1049.59	1049.59	82171

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	9.10b	4.69	4.69	780
8	4.50	Total>	15.30	5.30	23.04b	19.14	19.14	780
		Total>	15.30	5.30	12.25b	8.35	8.35	780
9	3.60	Total>	30.63	19.66	19.67b	19.66	19.66a	780
		Total>	30.63	15.03	15.04b	15.03	15.03a	780
10	2.90	Total>	42.57	23.87	23.88b	23.87	23.87a	780
		Total>	42.57	19.20	19.21b	19.20	19.20a	780
11	2.05	Total>	57.11	29.32	29.33b	29.32	29.32a	780
		Total>	57.11	33.52	33.53b	33.52	33.52a	780
12	1.20	Total>	71.72	44.15	44.16b	44.15	44.15a	780
		Total>	71.72	48.64	48.65b	48.64	48.64a	780
13	0.00	Total>	92.46	64.38	64.39b	64.38	64.38a	780
		Total>	92.46	67.36	67.37b	67.36	67.36a	780
14	-0.25	Total>	96.80	70.73	70.74b	70.73	70.73a	780
		38.50	58.30	14.95	299.20b	65.03	103.53	1179

(continued)

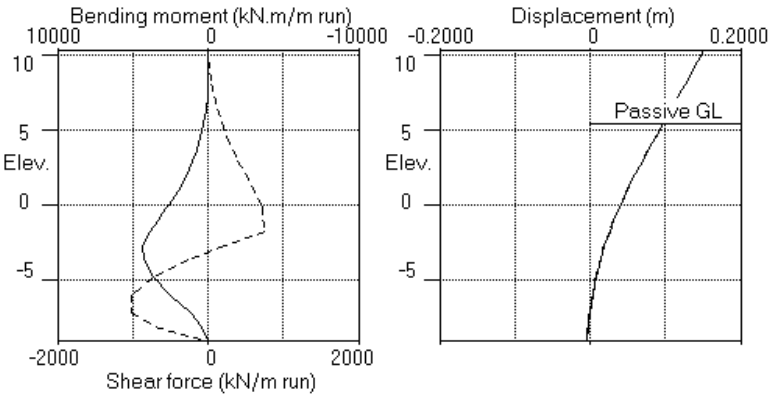
Stage No.9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
15	-1.00	46.00	66.11	16.95	339.29b	62.33	108.33	1179
		46.00	66.11	16.95	209.29b	62.33	108.33	1179
16	-1.75	53.50	73.98	18.98	234.22b	60.15	113.65	1179
		Total> 127.48		35.75m	738.46	704.11	704.11	32517
17	-2.68	Total> 147.46		40.38m	871.47	640.96	640.96	38532
18	-3.60	Total> 167.55		45.00m	1004.58	543.11	543.11	44548
19	-4.80	Total> 193.74		51.00m	1177.41	396.87	396.87	52352
20	-6.00	Total> 220.08		57.00m	1350.39	246.29	246.29	62048
21	-7.20	Total> 246.55		63.00m	1523.49	71.18	71.18	70097
22	-8.10	Total> 266.47		67.50m	1653.39	78.12	78.12	76134
23	-9.00	Total> 286.45		72.00m	1783.34	86.85	86.85	82171

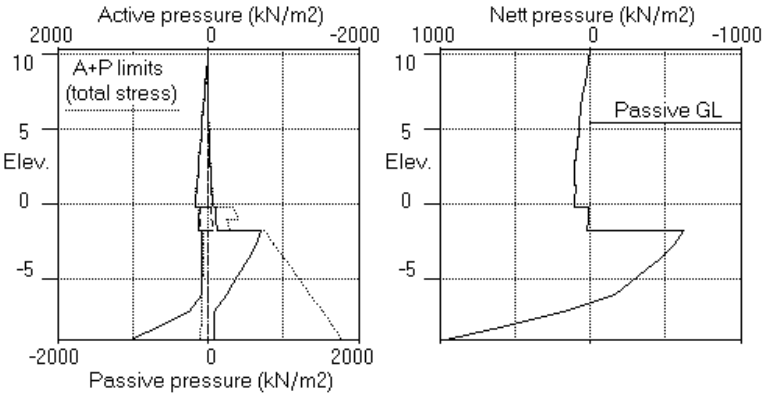
Note: 70.73a Soil pressure at active limit
123.45p Soil pressure at passive limit
234.22b Passive limit reduced because of berm

Units: kN,m

Stage No.9 Change soil type 2 to soil type 1



Stage No.9 Change soil type 2 to soil type 1



Units: kN,m

Stage No. 10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.149	1.10E-02	0.0	-0.0		2515171
2	9.50	10.63	0.141	1.10E-02	4.0	-2.7		2515171
3	8.75	18.86	0.133	1.10E-02	15.0	4.3		2515171
		23.69	0.133	1.10E-02	15.0	4.3		
4	7.98	36.51	0.124	1.10E-02	38.4	24.5		2515171
5	7.20	49.32	0.116	1.10E-02	71.6	66.6		2515171
6	6.30	64.20	0.106	1.10E-02	122.7	153.3		2515171
7	5.40	79.08	0.096	1.09E-02	187.2	292.0		2515171
		74.66	0.096	1.09E-02	187.2	292.0		
8	4.50	75.07	0.086	1.08E-02	254.6	488.9		2515171
		85.61	0.086	1.08E-02	254.6	488.9		
9	3.60	90.53	0.076	1.06E-02	333.8	754.2		2515171
		93.80	0.076	1.06E-02	333.8	754.2		
10	2.90	96.99	0.069	1.05E-02	400.6	1011.2		2515171
		93.65	0.069	1.05E-02	400.6	1011.2		
11	2.05	95.80	0.060	1.02E-02	481.1	1386.0		2515171
12	1.20	97.93	0.051	9.86E-03	563.5	1830.0		2515171
13	0.00	100.51	0.040	9.13E-03	682.5	2577.9		2515171
14	-0.25	100.33	0.038	8.95E-03	707.6	2751.7		2515171
		10.58	0.038	8.95E-03	707.6	2751.7		
15	-1.00	15.07	0.031	8.33E-03	717.2	3285.3		2515171
16	-1.75	22.26	0.025	7.59E-03	731.2	3830.0		2515171
		-607.98	0.025	7.59E-03	731.2	3830.0		
17	-2.68	-548.16	0.019	6.56E-03	196.5	4287.1		2515171
18	-3.60	-454.42	0.013	5.47E-03	-267.2	4236.9		2515171
19	-4.80	-312.47	0.007	4.17E-03	-727.3	3594.3		2515171
20	-6.00	-163.72	0.003	3.16E-03	-1013.0	2500.3		2515171
21	-7.20	179.15	-0.000	2.54E-03	-1003.7	1196.3		2515171
22	-8.10	548.01	-0.003	2.35E-03	-676.5	379.1		2515171
23	-9.00	955.39	-0.005	2.30E-03	-0.0	0.0		---

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	503
2	9.50	0.00	14.25	4.70	54.04	10.63	10.63	503
3	8.75	0.00	28.50	9.40	108.09	18.86	18.86	503
		0.00	28.50	4.06	52.95	23.69	23.69	252

(continued)

Stage No.10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
4	7.98	7.75	33.92	9.49	58.37	28.76	36.51	252
5	7.20	15.50	39.35	14.91	63.80	33.82	49.32	252
6	6.30	24.50	45.65	21.21	70.10	39.70	64.20	252
7	5.40	33.50	51.95	27.51	76.40	45.58	79.08	252
8	4.50	42.50	58.25	33.80	82.70	51.46	93.96	252
9	3.60	51.50	64.55	40.10	89.00	57.35	108.85	252
10	2.90	58.50	69.45	45.00	93.91	61.93	120.43	252
11	2.05	67.00	75.40	50.95	99.86	67.51	134.51	252
12	1.20	75.50	81.35	56.90	105.81	73.10	148.60	252
13	0.00	87.50	89.75	65.30	114.21	81.02	168.52	252
14	-0.25	90.00	91.50	67.05	115.96	82.68	172.68	252
		90.00	91.50	23.47	485.22	23.80	113.80	716
15	-1.00	97.50	99.00	25.39	524.99	25.65	123.15	716
16	-1.75	105.00	106.50	27.31	564.76	30.73	135.73	716
		Total> 211.50		60.00m	822.49	90.85	90.85	20475
17	-2.68	Total> 230.93		64.63m	954.94	88.52	88.52	24263
18	-3.60	Total> 250.35		69.25m	1087.40	85.58	85.58	28051
19	-4.80	Total> 275.55		75.25m	1259.23	82.77	82.77	32965
20	-6.00	Total> 300.75		81.25m	1431.06	82.14	82.14	37879
21	-7.20	Total> 325.95		87.25m	1602.90	251.40	251.40	119744
22	-8.10	Total> 344.85		91.75m	1731.77	628.49	628.49	130057
23	-9.00	Total> 363.75		96.25m	1860.65	1045.91	1045.91	140370

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	12.24b	4.42	4.42	330
8	4.50	0.00	15.30	0.00	19.90b	18.89	18.89	330
		0.00	15.30	0.00	13.38b	8.35	8.35	330
9	3.60	0.00	30.63	6.19	18.54b	18.32	18.32	330
		0.00	30.63	6.19	15.27b	15.05	15.05	330
10	2.90	7.00	35.57	11.13	16.65b	16.44	23.44	330
		7.00	35.57	11.13	26.14b	19.79	26.79	330
11	2.05	15.50	41.61	17.17	28.78b	23.21	38.71	330
		15.50	41.61	17.17	32.06b	23.21	38.71	330
12	1.20	24.00	47.72	23.28	35.02b	26.67	50.67	330
		24.00	47.72	23.28	38.62b	26.67	50.67	330
13	0.00	36.00	56.46	32.01	43.30b	32.01	68.01a	330
		36.00	56.46	32.01	45.73b	32.01	68.01a	330
14	-0.25	38.50	58.30	33.85	46.77b	33.85	72.35a	330
		38.50	58.30	14.95	299.20b	64.72	103.22	932
15	-1.00	46.00	66.11	16.95	339.29b	62.08	108.08	932
		46.00	66.11	16.95	209.29b	62.08	108.08	932
16	-1.75	53.50	73.98	18.98	234.22b	59.96	113.46	932
		Total> 127.48		35.75m	738.46	698.83	698.83	26061

(continued)

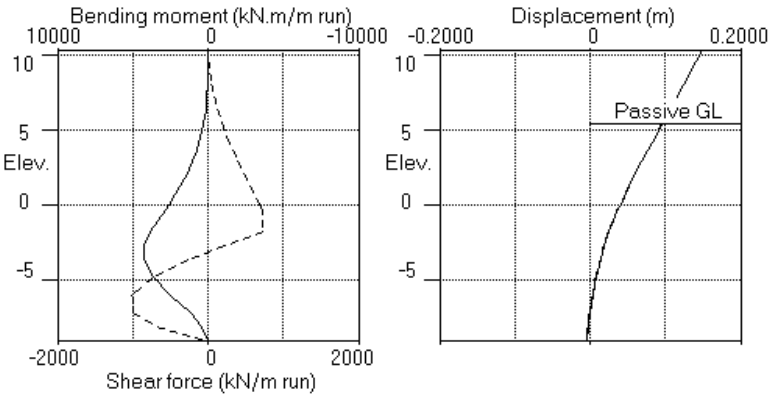
Stage No.10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
17	-2.68	Total>	147.46	40.38m	871.47	636.68	636.68	30883
18	-3.60	Total>	167.55	45.00m	1004.58	540.00	540.00	35704
19	-4.80	Total>	193.74	51.00m	1177.41	395.23	395.23	41959
20	-6.00	Total>	220.08	57.00m	1350.39	245.86	245.86	48214
21	-7.20	Total>	246.55	63.00m	1523.49	72.25	72.25	119744
22	-8.10	Total>	266.47	67.50m	1653.39	80.48	80.48	130057
23	-9.00	Total>	286.45	72.00m	1783.34	90.52	90.52	140370

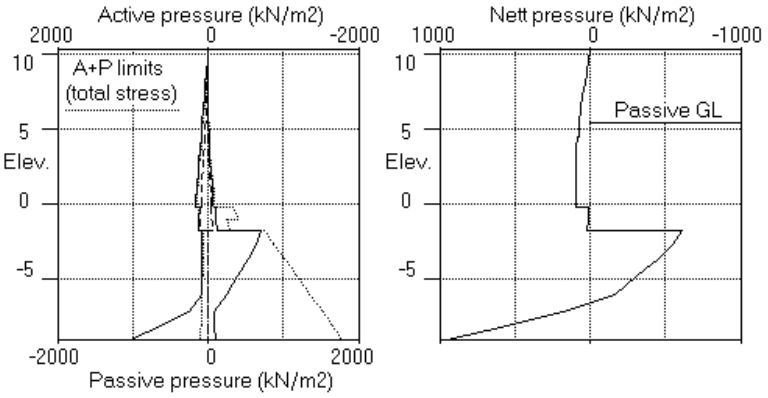
Note: 72.35a Soil pressure at active limit
123.45p Soil pressure at passive limit
234.22b Passive limit reduced because of berm

Units: kN,m

Stage No.10 Change soil type 3 to soil type 4



Stage No.10 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: ULS DA1 Combination 1

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	10.25	0.163	-0.000	0	-0	0	-0	0	0	0	0
2	9.50	0.154	-0.000	7	-3	9	-4	25	-1	34	-1
3	8.75	0.145	-0.000	35	-1	47	-2	54	-2	73	-3
4	7.98	0.135	-0.000	87	-3	118	-4	81	-3	110	-3
5	7.20	0.126	-0.000	162	-5	218	-7	112	-3	151	-4
6	6.30	0.115	-0.000	279	-8	376	-11	151	-3	204	-4
7	5.40	0.104	-0.000	433	-11	585	-15	203	-3	274	-5
8	4.50	0.093	-0.000	627	-14	847	-19	272	-4	368	-5
9	3.60	0.083	-0.000	870	-18	1174	-24	355	-4	480	-6
10	2.90	0.075	-0.000	1092	-21	1474	-28	427	-4	577	-6
11	2.05	0.065	-0.000	1482	-25	2000	-33	521	-5	704	-6
12	1.20	0.056	-0.000	1965	-29	2653	-39	616	-5	831	-6
13	0.00	0.043	-0.000	2783	-35	3757	-47	748	-5	1010	-7
14	-0.25	0.041	-0.000	2974	-36	4014	-48	776	-5	1047	-7
15	-1.00	0.034	-0.000	3558	-32	4804	-43	785	0	1060	0
16	-1.75	0.027	-0.000	4154	-11	5608	-15	800	0	1080	0
17	-2.68	0.020	-0.000	4651	-0	6279	-0	209	0	281	0
18	-3.60	0.014	0.000	4584	-0	6188	-0	13	-304	18	-411
19	-4.80	0.008	0.000	3867	-0	5221	-0	0	-800	1	-1079
20	-6.00	0.003	0.000	2674	-0	3610	-0	0	-1096	0	-1479
21	-7.20	0.000	-0.000	1271	-0	1716	-0	0	-1074	0	-1449
22	-8.10	0.000	-0.003	401	-0	542	-0	0	-720	0	-971
23	-9.00	0.000	-0.005	0	-0	0	-0	0	-0	0	-0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

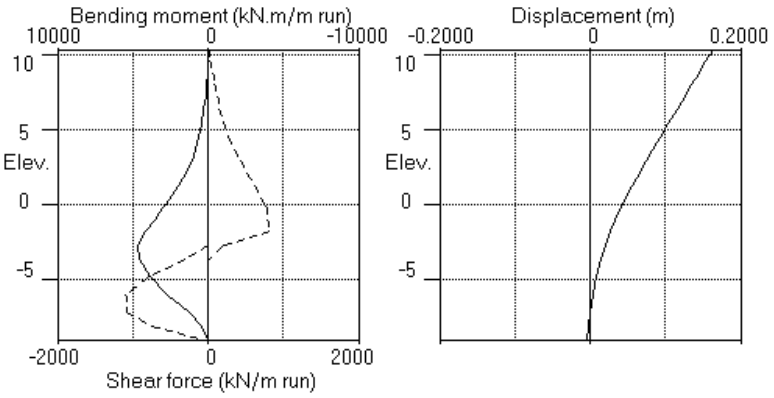
Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
no.	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	0	2.05	-0	-2.68	0	-0	0	9.50	-0	-9.00	0	-0
2	42	-4.80	-36	-0.25	57	-48	38	-1.75	-13	-7.20	51	-18
3	3954	-2.68	-0	10.25	5338	-0	707	-1.75	-930	-6.00	955	-1256
4	4595	-2.68	-0	10.25	6203	-0	799	-1.75	-1078	-6.00	1078	-1455
5	No calculation at this stage											
6	3424	-2.68	-0	10.25	4623	-0	507	-0.25	-807	-6.00	685	-1089
7	4620	-2.68	-3	9.50	6237	-4	798	-1.75	-1091	-6.00	1078	-1472
8	4345	-2.68	-1	9.50	5865	-1	744	-1.75	-1026	-6.00	1004	-1385
9	4325	-2.68	-3	9.50	5839	-4	743	-1.75	-1022	-6.00	1003	-1380
10	4287	-2.68	-3	9.50	5788	-4	731	-1.75	-1013	-6.00	987	-1368
11	No calculation at this stage											
12	No calculation at this stage											
13	4651	-2.68	-2	9.50	6279	-2	800	-1.75	-1096	-6.00	1080	-1479
14	3470	-2.68	-0	10.25	4685	-0	509	-0.25	-823	-6.00	687	-1110

Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	-9.00	-0.000	10.25	Change EI of wall to 3.5212E+06kN.m2/m run
2	0.001	10.25	-0.000	-9.00	Apply water pressure profile no.1
3	0.138	10.25	-0.004	-9.00	Excav. to elev. 5.40 on PASSIVE side
4	0.160	10.25	-0.005	-9.00	Apply surcharge no.1 at elev. 10.25
5	No calculation at this stage				Change EI of wall to 2.5152E+06kN.m2/m run
6	0.118	10.25	-0.004	-9.00	Apply water pressure profile no.2
7	0.161	10.25	-0.005	-9.00	Apply water pressure profile no.1
8	0.151	10.25	-0.005	-9.00	Remove surcharge no.1 at elev. 10.25
9	0.150	10.25	-0.005	-9.00	Change soil type 2 to soil type 1
10	0.149	10.25	-0.005	-9.00	Change soil type 3 to soil type 4
11	No calculation at this stage				Change soil type 1 to soil type 2
12	No calculation at this stage				Change soil type 4 to soil type 3
13	0.163	10.25	-0.005	-9.00	Apply surcharge no.1 at elev. 10.25
14	0.121	10.25	-0.004	-9.00	Apply water pressure profile no.2

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	10.25	2 Made ground (U)	7 Made ground (P)
2	8.75	3 Tidal deposits (U)	3 Tidal deposits (U)
3	-0.25	6 RT deposits	6 RT deposits
4	-1.75	5 WRock	5 WRock

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made ground (D)	19.00	4800	0.562	OC (0.150)	0.330 (1.374)	3.793 (5.726)	0.0d
2	Made ground (U)	19.00	6000	0.562	OC (0.490)	1.000 (1.000)	1.000 (1.000)	20.00u
3	Tidal deposits (U)	17.00	3000	0.562	NC (0.490)	1.000 (1.000)	1.000 (1.000)	10.00u
4	Tidal deposits (D)	17.00	2400	0.562	NC (0.150)	1.000 (2.443)	1.000 (2.444)	10.00d
5	WRock (-1.75)	21.00	125000 (25000)	0.400	NC (0.490)	1.000 (2.443)	1.000 (2.444)	250.0u (50.00)
6	RT deposits	20.00	6000	0.455	OC (0.300)	0.256 (0.000)	5.303 (0.000)	
7	Made ground (P)	19.00	6000	0.562	OC (0.490)	1.000 (1.000)	1.000 (1.000)	20.00u

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made ground (D)	26.00	0.833	0.00	26.00	0.833	0.00
2	Made ground (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
3	Tidal deposits (U)	0.00	-0.674	0.00	0.00	-0.674	0.00
4	Tidal deposits (D)	0.00	0.600	0.00	0.00	0.600	0.00
5	WRock	0.00	0.600	0.00	0.00	0.600	0.00
6	RT deposits	33.00	0.500	0.00	33.00	0.500	0.00
7	Made ground (P)	0.00	-0.674	0.00	0.00	-0.674	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	3.60	3.60

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	8.75	8.75	0.0	1	3.60	3.60	0.0	MC+WC
2	1	8.75	8.75	0.0	1	10.25	10.25	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                  Elevation of toe of wall = -9.00
             Maximum finite element length =  1.20 m
                  Youngs modulus of wall E = 2.3380E+07 kN/m2
               Moment of inertia of wall I = 0.15061 m4/m run
                                       E.I = 3.5212E+06 kN.m2/m run
                    Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	10.25	0.00(A)	100.00	100.00	10.00	=	N/A	1.00 P/U

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 3.5212E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
2	Apply water pressure profile no.1 (Worst Cred.) No analysis at this stage
3	Excavate to elevation 5.40 on PASSIVE side Toe of berm at elevation 2.90 Width of top of berm = 0.01 Width of toe of berm = 4.00
4	Apply surcharge no.1 at elevation 10.25
5	Change EI of wall to 2.5152E+06 kN.m2/m run Yield moment not defined No adjustments to wall displacements
6	Apply water pressure profile no.2 (Worst Cred.)
7	Apply water pressure profile no.1 (Worst Cred.)
8	Remove surcharge no.1 at elevation 10.25
9	Change properties of soil type 2 to soil type 1 Ko pressures will not be reset
10	Change properties of soil type 3 to soil type 4 Ko pressures will be reset
11	Change properties of soil type 1 to soil type 2 No analysis at this stage Ko pressures will not be reset
12	Change properties of soil type 4 to soil type 3 No analysis at this stage Ko pressures will not be reset
13	Apply surcharge no.1 at elevation 10.25
14	Apply water pressure profile no.2 (Worst Cred.)

FACTORS OF SAFETY and ANALYSIS OPTIONS

```
 Limit State options: ULS DA1 Combination 2
  Water pressures : Worst Credible
  Partial factor on   C'         = 1.250
  Partial factor on Phi'         = 1.250
  Partial factor on   Cu         = 1.400
  Partial factor on Soil Modulus = 1.000
  Partial factor on Permanent Unfavourable loads = 1.000
  Partial factor on Permanent Favourable loads   = 1.000
  Partial factor on Variable Unfavourable loads  = 1.300

 Stability analysis:
  Method of analysis  -  Strength Factor method
  Overall factor on soil strength for calculating wall depth = 1.00

 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  Subgrade reaction model using Influence Coefficients
```

Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 25.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

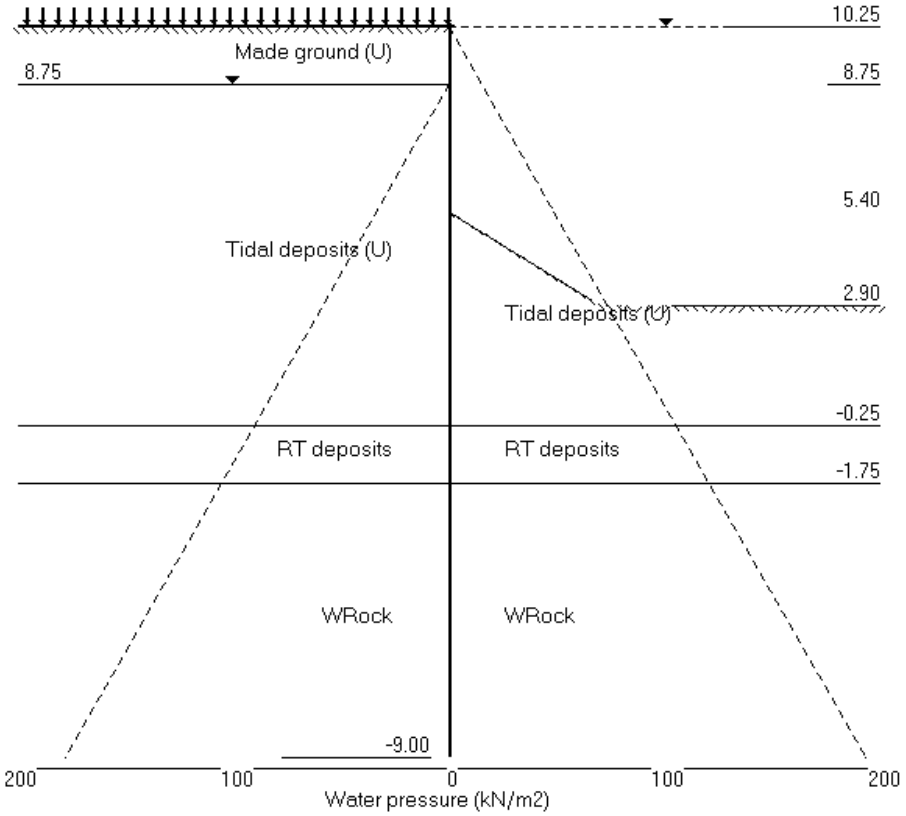
Distance to rigid boundary on active side = 50.00 m
Distance to rigid boundary on passive side = 50.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 3.5212E+06kN.m2/m	Yes	Yes	Yes
2	Apply water pressure profile no.1	No	No	No
3	Excav. to elev. 5.40 on PASSIVE side	No	No	No
4	Apply surcharge no.1 at elev. 10.25	No	No	No
5	Change EI of wall to 2.5152E+06kN.m2/m	No	No	No
6	Apply water pressure profile no.2	No	No	No
7	Apply water pressure profile no.1	No	No	No
8	Remove surcharge no.1 at elev. 10.25	No	No	No
9	Change soil type 2 to soil type 1	No	No	No
10	Change soil type 3 to soil type 4	No	No	No
11	Change soil type 1 to soil type 2	No	No	No
12	Change soil type 4 to soil type 3	No	No	No
13	Apply surcharge no.1 at elev. 10.25	No	No	No
14	Apply water pressure profile no.2	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.14 Apply water pressure profile no.2 (Worst Cred.)



Units: kN,m

Stage No. 1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = -9.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.25	10.25	Cant.	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	-0.00	0.000	4.58E-16	0.0	0.0		3521239
2	9.50	-0.00	0.000	4.59E-16	-0.0	-0.0		3521239
3	8.75	0.00	0.000	4.60E-16	-0.0	-0.0		3521239
4	7.98	0.00	0.000	4.65E-16	-0.0	-0.0		3521239
5	7.20	0.00	0.000	4.74E-16	-0.0	-0.0		3521239
6	6.30	0.00	0.000	4.88E-16	-0.0	-0.0		3521239
7	5.40	0.00	0.000	5.08E-16	-0.0	-0.0		3521239
8	4.50	0.00	0.000	5.32E-16	-0.0	-0.0		3521239
9	3.60	0.00	0.000	5.61E-16	-0.0	-0.0		3521239
10	2.90	0.00	0.000	5.87E-16	-0.0	-0.0		3521239
11	2.05	0.00	0.000	6.21E-16	-0.0	-0.0		3521239
12	1.20	0.00	0.000	6.49E-16	-0.0	-0.0		3521239
13	0.00	0.00	0.000	6.64E-16	-0.0	0.0		3521239
14	-0.25	0.00	0.000	6.64E-16	-0.0	0.0		3521239
15	-1.00	0.00	0.000	6.51E-16	-0.0	0.0		3521239
16	-1.75	0.00	0.000	6.20E-16	-0.0	0.0		3521239
17	-2.68	0.00	0.000	5.58E-16	-0.0	0.0		3521239
18	-3.60	0.00	0.000	4.73E-16	-0.0	0.0		3521239
19	-4.80	0.00	0.000	3.46E-16	-0.0	0.0		3521239
20	-6.00	0.00	0.000	2.34E-16	-0.0	0.0		3521239
21	-7.20	0.00	0.000	1.66E-16	-0.0	0.0		3521239
22	-8.10	0.00	0.000	1.47E-16	-0.0	0.0		3521239
23	-9.00	0.00	0.000	1.43E-16	-0.0	0.0		---

(continued)

Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	ACTIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	10.25	Total> 0.00	0.00	14.29	0.00	0.00a		898
2	9.50	Total> 14.25	3.75m	28.54	8.01	8.01		898
3	8.75	Total> 28.50	14.21	42.79	16.02	16.02		898
		Total> 28.50	21.35	35.65	21.35	21.35a		449
4	7.98	Total> 41.67	34.53	48.82	34.53	34.53a		449
5	7.20	Total> 54.85	47.70	62.00	47.70	47.70a		449
6	6.30	Total> 70.15	63.00	77.30	63.00	63.00a		449
7	5.40	Total> 85.45	78.30	92.60	78.30	78.30a		449
8	4.50	Total> 100.75	93.60	107.90	93.60	93.60a		449
9	3.60	Total> 116.05	108.90	123.20	108.90	108.90a		449
10	2.90	Total> 127.95	120.80	135.10	120.80	120.80a		449
11	2.05	Total> 142.40	135.24	149.56	135.24	135.24a		449
12	1.20	Total> 156.85	149.69	164.01	149.69	149.69a		449
13	0.00	Total> 177.25	170.09	184.41	170.09	170.09a		449
14	-0.25	Total> 181.50	174.34	188.66	174.34	174.34a		449
		38.50	143.00	46.58	535.54	65.06	103.56	647
15	-1.00	46.00	150.50	49.02	563.63	68.48	114.48	647
16	-1.75	53.50	158.00	51.47	591.72	71.89	125.39	647
		Total> 211.50	60.00m	647.94	116.70	116.70		18702
17	-2.68	Total> 230.93	64.63m	748.10	130.02	130.02		22162
18	-3.60	Total> 250.35	69.25m	848.26	143.34	143.34		25622
19	-4.80	Total> 275.55	75.25m	978.20	160.62	160.62		30110
20	-6.00	Total> 300.75	81.25m	1108.14	177.90	177.90		34598
21	-7.20	Total> 325.95	87.25m	1238.08	195.18	195.18		39087
22	-8.10	Total> 344.85	91.75m	1335.53	208.14	208.14		42453
23	-9.00	Total> 363.75	96.25m	1432.99	221.10	221.10		45820

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	10.25	Total> 0.00	0.00	14.29	0.00	0.00a		898
2	9.50	Total> 14.25	3.75m	28.54	8.01	8.01		898
3	8.75	Total> 28.50	14.21	42.79	16.02	16.02		898
		Total> 28.50	21.35	35.65	21.35	21.35a		449
4	7.98	Total> 41.67	34.53	48.82	34.53	34.53a		449
5	7.20	Total> 54.85	47.70	62.00	47.70	47.70a		449
6	6.30	Total> 70.15	63.00	77.30	63.00	63.00a		449
7	5.40	Total> 85.45	78.30	92.60	78.30	78.30a		449
8	4.50	Total> 100.75	93.60	107.90	93.60	93.60a		449
9	3.60	Total> 116.05	108.90	123.20	108.90	108.90a		449
10	2.90	Total> 127.95	120.80	135.10	120.80	120.80a		449
11	2.05	Total> 142.40	135.24	149.56	135.24	135.24a		449
12	1.20	Total> 156.85	149.69	164.01	149.69	149.69a		449
13	0.00	Total> 177.25	170.09	184.41	170.09	170.09a		449
14	-0.25	Total> 181.50	174.34	188.66	174.34	174.34a		449
		38.50	143.00	46.58	535.54	65.06	103.56	647
15	-1.00	46.00	150.50	49.02	563.63	68.48	114.48	647
16	-1.75	53.50	158.00	51.47	591.72	71.89	125.39	647
		Total> 211.50	60.00m	647.94	116.70	116.70		18702
17	-2.68	Total> 230.93	64.63m	748.10	130.02	130.02		22162

(continued)

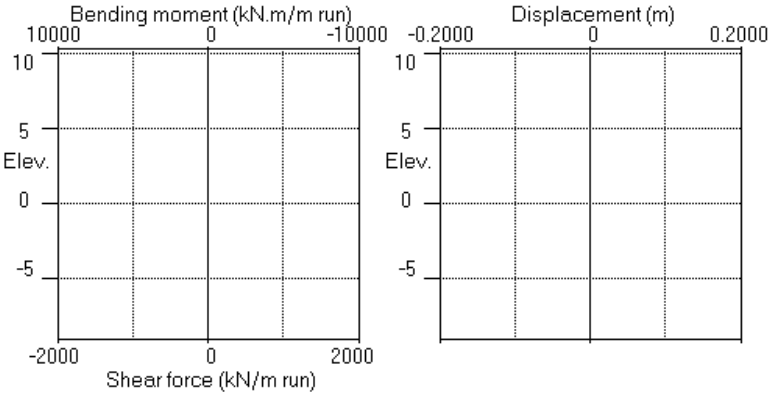
Stage No.1 Change EI of wall to 3.5212E+06 kN.m2/m run
Yield moment not defined
No adjustments to wall displacements

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
18	-3.60	Total>	250.35	69.25m	848.26	143.34	143.34	25622
19	-4.80	Total>	275.55	75.25m	978.20	160.62	160.62	30110
20	-6.00	Total>	300.75	81.25m	1108.14	177.90	177.90	34598
21	-7.20	Total>	325.95	87.25m	1238.08	195.18	195.18	39087
22	-8.10	Total>	344.85	91.75m	1335.53	208.14	208.14	42453
23	-9.00	Total>	363.75	96.25m	1432.99	221.10	221.10	45820

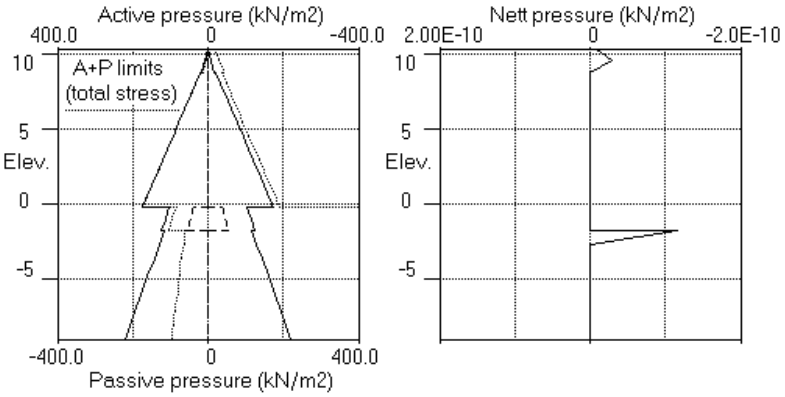
Note: 174.34a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Stage No.1 Change EI of wall to 3.5212E+06kN.m2/m run



Units: kN,m

Stage No. 3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = -9.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
3	10.25	5.40	Cant.	1.217	-6.64	-8.23	13.63

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.154	1.13E-02	0.0	0.0		3521239
2	9.50	3.75	0.146	1.13E-02	1.4	0.4		3521239
3	8.75	14.21	0.137	1.13E-02	8.1	3.4		3521239
		21.35	0.137	1.13E-02	8.1	3.4		
4	7.98	34.53	0.128	1.13E-02	29.8	17.5		3521239
5	7.20	47.70	0.120	1.13E-02	61.7	52.3		3521239
6	6.30	63.00	0.109	1.13E-02	111.5	129.1		3521239
7	5.40	78.30	0.099	1.12E-02	175.1	257.1		3521239
		72.76	0.099	1.12E-02	175.1	257.1		
8	4.50	76.18	0.089	1.11E-02	242.1	444.5		3521239
		86.67	0.089	1.11E-02	242.1	444.5		
9	3.60	97.24	0.079	1.10E-02	324.8	699.0		3521239
		95.66	0.079	1.10E-02	324.8	699.0		
10	2.90	98.83	0.071	1.08E-02	392.9	950.0		3521239
		104.31	0.071	1.08E-02	392.9	950.0		
11	2.05	108.91	0.062	1.06E-02	483.5	1322.3		3521239
		104.47	0.062	1.06E-02	483.5	1322.3		
12	1.20	108.50	0.053	1.02E-02	574.1	1771.5		3521239
		103.78	0.053	1.02E-02	574.1	1771.5		
13	0.00	108.69	0.042	9.49E-03	701.5	2536.3		3521239
		105.56	0.042	9.49E-03	701.5	2536.3		
14	-0.25	106.48	0.039	9.31E-03	728.0	2715.0		3521239
		15.19	0.039	9.31E-03	728.0	2715.0		
15	-1.00	20.52	0.032	8.67E-03	741.4	3265.2		3521239
16	-1.75	25.32	0.026	7.91E-03	758.6	3826.9		3521239
		-503.90	0.026	7.91E-03	758.6	3826.9		
17	-2.68	-593.14	0.019	6.84E-03	251.2	4387.5		3521239
18	-3.60	-486.73	0.014	5.69E-03	-248.2	4364.8		3521239

(continued)

Stage No.3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
19	-4.80	-329.66	0.008	4.31E-03	-738.0	3713.5		3521239
20	-6.00	-169.51	0.003	3.24E-03	-1037.5	2587.6		3521239
21	-7.20	180.66	-0.000	2.58E-03	-1030.8	1243.3		3521239
22	-8.10	563.50	-0.003	2.37E-03	-696.0	397.0		3521239
23	-9.00	983.11	-0.005	2.32E-03	-0.0	0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	Total>	0.00	0.00	14.29	0.00	0.00a	1029
2	9.50	Total>	14.25	3.75m	28.54	3.75	3.75a	1029
3	8.75	Total>	28.50	14.21	42.79	14.21	14.21a	1029
		Total>	28.50	21.35	35.65	21.35	21.35a	515
4	7.98	Total>	41.67	34.53	48.82	34.53	34.53a	515
5	7.20	Total>	54.85	47.70	62.00	47.70	47.70a	515
6	6.30	Total>	70.15	63.00	77.30	63.00	63.00a	515
7	5.40	Total>	85.45	78.30	92.60	78.30	78.30a	515
8	4.50	Total>	100.75	93.60	107.90	93.60	93.60a	515
9	3.60	Total>	116.05	108.90	123.20	108.90	108.90a	515
10	2.90	Total>	127.95	120.80	135.10	120.80	120.80a	515
11	2.05	Total>	142.40	135.25	149.55	135.25	135.25a	515
12	1.20	Total>	156.85	149.70	164.00	149.70	149.70a	515
13	0.00	Total>	177.25	170.10	184.40	170.10	170.10a	515
14	-0.25	Total>	181.50	174.35	188.65	174.35	174.35a	515
		90.00	91.50	29.81	342.67	29.81	119.81a	754
15	-1.00	97.50	99.00	32.25	370.76	32.25	129.75a	754
16	-1.75	105.00	106.50	34.69	398.85	34.69	139.69a	754
		Total>	211.50	60.00m	647.93	60.00	60.00a	21440
17	-2.68	Total>	230.93	64.63m	748.09	64.63	64.63a	25407
18	-3.60	Total>	250.35	69.25m	848.25	69.25	69.25a	29373
19	-4.80	Total>	275.55	75.25m	978.19	75.25	75.25a	34519
20	-6.00	Total>	300.75	81.25m	1108.13	81.25	81.25a	39665
21	-7.20	Total>	325.95	87.25m	1238.07	245.81	245.81	152642
22	-8.10	Total>	344.85	91.75m	1335.52	631.00	631.00	165788
23	-9.00	Total>	363.75	96.25m	1432.98	1055.11	1055.11	178935

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	5.54b	5.54	5.54p	638
8	4.50	Total>	15.30	8.16	17.42b	17.42	17.42p	638
		Total>	15.30	6.92	6.93b	6.93	6.93p	638

(continued)

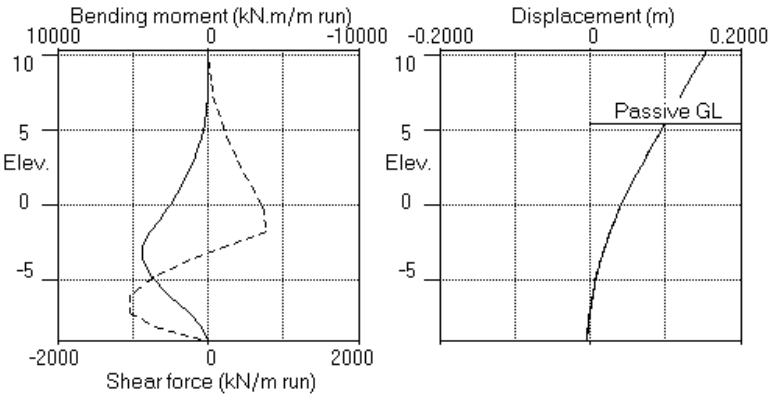
Stage No.3 Excavate to elevation 5.40 on PASSIVE side
Toe of berm at elevation 2.90
Width of top of berm = 0.01
Width of toe of berm = 4.00

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
9	3.60	Total>	30.63	11.65	11.66b	11.66	11.66p	638
		Total>	30.63	13.23	13.24b	13.24	13.24p	638
10	2.90	Total>	42.57	21.96	21.97b	21.97	21.97p	638
		Total>	42.57	16.48	16.49b	16.49	16.49p	638
11	2.05	Total>	57.11	26.33	26.34b	26.34	26.34p	638
		Total>	57.11	30.77	30.78b	30.78	30.78p	638
12	1.20	Total>	71.72	41.19	41.20b	41.20	41.20p	638
		Total>	71.72	45.91	45.92b	45.92	45.92p	638
13	0.00	Total>	92.46	61.40	61.41b	61.41	61.41p	638
		Total>	92.46	64.53	64.54b	64.54	64.54p	638
14	-0.25	Total>	96.80	67.85	67.86b	67.86	67.86p	638
		38.50	58.30	18.99	218.32	66.12	104.62	953
15	-1.00	46.00	66.11	21.53	247.57	63.23	109.23	953
		46.00	66.11	21.53	164.25b	63.23	109.23	953
16	-1.75	53.50	73.98	24.10	183.82b	60.87	114.37	953
		Total>	127.48	35.75m	563.90	563.90	563.90p	26598
17	-2.68	Total>	147.46	40.38m	664.62	657.77	657.77	31518
18	-3.60	Total>	167.55	45.00m	765.44	555.98	555.98	36439
19	-4.80	Total>	193.74	51.00m	896.37	404.91	404.91	42822
20	-6.00	Total>	220.08	57.00m	1027.45	250.76	250.76	49206
21	-7.20	Total>	246.55	63.00m	1158.66	65.15	65.15	152642
22	-8.10	Total>	266.47	67.50m	1257.14	67.50	67.50a	165788
23	-9.00	Total>	286.45	72.00m	1355.67	72.00	72.00a	178935

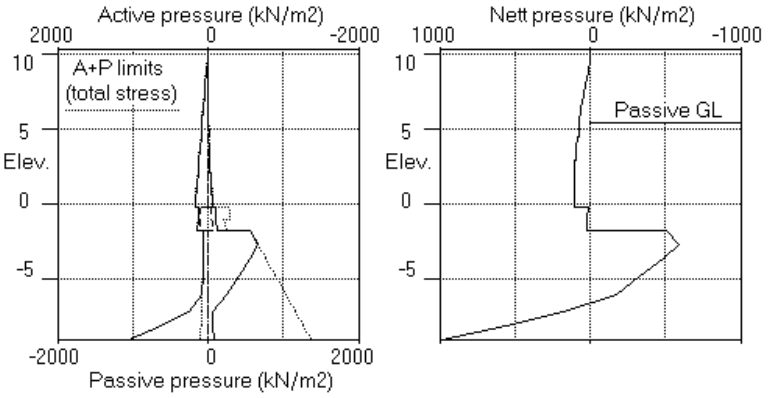
Note: 72.00a Soil pressure at active limit
563.90p Soil pressure at passive limit
183.82b Passive limit reduced because of berm

Units: kN,m

Stage No.3 Excav. to elev. 5.40 on PASSIVE side



Stage No.3 Excav. to elev. 5.40 on PASSIVE side



Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = -9.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
9	10.25	5.40	Cant.	1.215	-6.64	-8.23	13.63

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.178	1.29E-02	0.0	0.0		2515171
2	9.50	11.42	0.168	1.29E-02	4.3	1.1		2515171
3	8.75	24.96	0.158	1.29E-02	17.9	8.8		2515171
		26.77	0.158	1.29E-02	17.9	8.8		
4	7.98	39.56	0.148	1.29E-02	43.6	32.1		2515171
5	7.20	52.34	0.138	1.29E-02	79.2	79.1		2515171
6	6.30	67.20	0.127	1.29E-02	133.0	173.7		2515171
7	5.40	82.05	0.115	1.28E-02	200.2	322.7		2515171
		81.32	0.115	1.28E-02	200.2	322.7		
8	4.50	83.74	0.104	1.27E-02	274.5	536.3		2515171
		89.98	0.104	1.27E-02	274.5	536.3		
9	3.60	100.12	0.092	1.25E-02	360.0	819.3		2515171
		98.54	0.092	1.25E-02	360.0	819.3		
10	2.90	101.38	0.084	1.23E-02	430.0	1095.8		2515171
		106.85	0.084	1.23E-02	430.0	1095.8		
11	2.05	111.07	0.073	1.20E-02	522.6	1500.7		2515171
		106.62	0.073	1.20E-02	522.6	1500.7		
12	1.20	110.28	0.063	1.16E-02	614.8	1984.1		2515171
		105.56	0.063	1.16E-02	614.8	1984.1		
13	0.00	109.98	0.050	1.08E-02	744.1	2799.5		2515171
		106.85	0.050	1.08E-02	744.1	2799.5		
14	-0.25	107.68	0.047	1.06E-02	770.9	2988.9		2515171
		9.19	0.047	1.06E-02	770.9	2988.9		
15	-1.00	14.99	0.039	9.99E-03	780.0	3569.8		2515171
16	-1.75	20.36	0.032	9.19E-03	793.3	4159.2		2515171
		-438.53	0.032	9.19E-03	793.3	4159.2		
17	-2.68	-549.95	0.024	8.05E-03	336.1	4788.5		2515171
18	-3.60	-589.55	0.017	6.81E-03	-190.9	4893.3		2515171
19	-4.80	-410.72	0.010	5.28E-03	-791.1	4247.1		2515171
20	-6.00	-219.21	0.004	4.07E-03	-1169.1	3007.4		2515171

(continued)

Stage No.9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
21	-7.20	164.47	-0.000	3.32E-03	-1201.9	1475.4		2515171
22	-8.10	653.66	-0.003	3.07E-03	-833.7	476.9		2515171
23	-9.00	1199.07	-0.006	3.01E-03	-0.0	-0.0		---

ACTIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	636
2	9.50	0.00	14.25	5.74	40.88	11.42	11.42	636
3	8.75	0.00	28.50	11.48	81.76	24.96	24.96	636
		Total>	28.50	21.35	35.65	26.77	26.77	605
4	7.98	Total>	41.67	34.53	48.82	39.56	39.56	605
5	7.20	Total>	54.85	47.70	62.00	52.34	52.34	605
6	6.30	Total>	70.15	63.00	77.30	67.20	67.20	605
7	5.40	Total>	85.45	78.30	92.60	82.05	82.05	605
8	4.50	Total>	100.75	93.60	107.90	96.91	96.91	605
9	3.60	Total>	116.05	108.90	123.20	111.77	111.77	605
10	2.90	Total>	127.95	120.80	135.10	123.34	123.34	605
11	2.05	Total>	142.40	135.25	149.55	137.40	137.40	605
12	1.20	Total>	156.85	149.70	164.00	151.47	151.47	605
13	0.00	Total>	177.25	170.10	184.40	171.38	171.38	605
14	-0.25	Total>	181.50	174.35	188.65	175.54	175.54	605
		90.00	91.50	29.81	342.67	30.53	120.53	899
15	-1.00	97.50	99.00	32.25	370.76	32.58	130.08	899
16	-1.75	105.00	106.50	34.69	398.85	34.75	139.75	899
		Total>	211.50	60.00m	647.93	88.60	88.60	25202
17	-2.68	Total>	230.93	64.63m	748.09	86.52	86.52	29865
18	-3.60	Total>	250.35	69.25m	848.25	83.95	83.95	34527
19	-4.80	Total>	275.55	75.25m	978.19	81.68	81.68	40576
20	-6.00	Total>	300.75	81.25m	1108.13	81.55	81.55	62281
21	-7.20	Total>	325.95	87.25m	1238.07	237.96	237.96	70360
22	-8.10	Total>	344.85	91.75m	1335.52	732.81	732.81	76420
23	-9.00	Total>	363.75	96.25m	1432.98	1287.09	1287.09	82480

PASSIVE side

Node no.	Y coord	Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	5.54b	0.72	0.72	778
8	4.50	Total>	15.30	8.16	17.42b	13.17	13.17	778
		Total>	15.30	6.92	6.93b	6.92	6.92a	778
9	3.60	Total>	30.63	11.65	11.66b	11.65	11.65a	778
		Total>	30.63	13.23	13.24b	13.23	13.23a	778
10	2.90	Total>	42.57	21.96	21.97b	21.96	21.96a	778
		Total>	42.57	16.48	16.49b	16.48	16.48a	778

(continued)

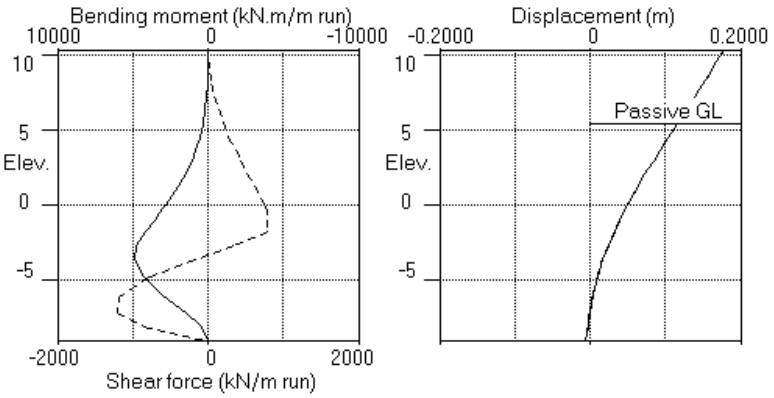
Stage No.9 Change properties of soil type 2 to soil type 1
Ko pressures will not be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		kN/m3
11	2.05	Total>	57.11	26.33	26.34b	26.33	26.33a	778
		Total>	57.11	30.77	30.78b	30.77	30.77a	778
12	1.20	Total>	71.72	41.19	41.20b	41.19	41.19a	778
		Total>	71.72	45.91	45.92b	45.91	45.91a	778
13	0.00	Total>	92.46	61.40	61.41b	61.40	61.40a	778
		Total>	92.46	64.53	64.54b	64.53	64.53a	778
14	-0.25	Total>	96.80	67.85	67.86b	67.85	67.85a	778
		38.50	58.30	18.99	218.32	72.84	111.34	1176
15	-1.00	46.00	66.11	21.53	247.57	69.09	115.09	1176
		46.00	66.11	21.53	164.25b	69.09	115.09	1176
16	-1.75	53.50	73.98	24.10	183.82b	65.89	119.39	1176
		Total>	127.48	35.75m	563.90	527.13	527.13	32434
17	-2.68	Total>	147.46	40.38m	664.62	636.47	636.47	38434
18	-3.60	Total>	167.55	45.00m	765.44	673.50	673.50	44434
19	-4.80	Total>	193.74	51.00m	896.37	492.39	492.39	52218
20	-6.00	Total>	220.08	57.00m	1027.45	300.77	300.77	62281
21	-7.20	Total>	246.55	63.00m	1158.66	73.49	73.49	70360
22	-8.10	Total>	266.47	67.50m	1257.14	79.14	79.14	76420
23	-9.00	Total>	286.45	72.00m	1355.67	88.02	88.02	82480

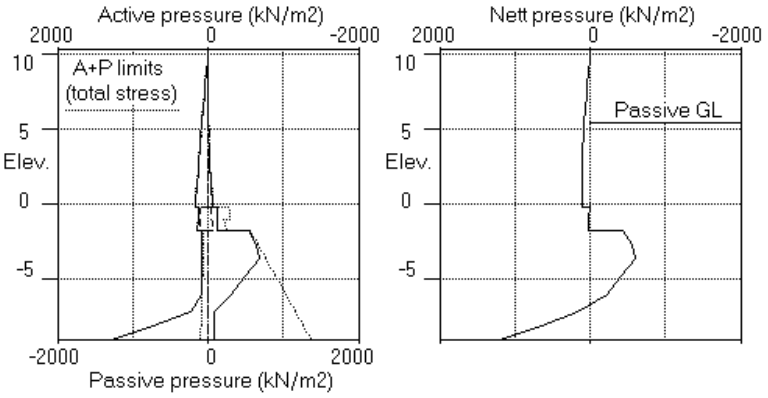
Note: 67.85a Soil pressure at active limit
123.45p Soil pressure at passive limit
183.82b Passive limit reduced because of berm

Units: kN,m

Stage No.9 Change soil type 2 to soil type 1



Stage No.9 Change soil type 2 to soil type 1



Units: kN,m

Stage No. 10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = -9.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	10.25	5.40	Cant.	1.404	-6.67	-7.33	12.73

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall
Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	10.25	0.00	0.176	1.27E-02	0.0	0.0		2515171
2	9.50	12.57	0.166	1.27E-02	4.7	1.1		2515171
3	8.75	26.06	0.156	1.27E-02	19.2	9.5		2515171
		27.32	0.156	1.27E-02	19.2	9.5		
4	7.98	40.07	0.146	1.27E-02	45.3	33.9		2515171
5	7.20	52.83	0.136	1.27E-02	81.3	82.4		2515171
6	6.30	67.64	0.125	1.27E-02	135.5	179.0		2515171
7	5.40	82.46	0.114	1.26E-02	203.1	330.4		2515171
		82.28	0.114	1.26E-02	203.1	330.4		
8	4.50	84.61	0.102	1.25E-02	278.2	547.0		2515171
		89.17	0.102	1.25E-02	278.2	547.0		
9	3.60	98.57	0.091	1.23E-02	362.7	832.9		2515171
		99.25	0.091	1.23E-02	362.7	832.9		
10	2.90	102.05	0.082	1.22E-02	433.1	1111.5		2515171
		97.06	0.082	1.22E-02	433.1	1111.5		
11	2.05	99.14	0.072	1.18E-02	516.5	1515.2		2515171
12	1.20	99.54	0.062	1.14E-02	600.9	1990.4		2515171
13	0.00	98.66	0.049	1.06E-02	719.9	2783.7		2515171
14	-0.25	98.47	0.046	1.04E-02	744.5	2966.7		2515171
		10.29	0.046	1.04E-02	744.5	2966.7		
15	-1.00	15.87	0.039	9.82E-03	754.3	3528.1		2515171
16	-1.75	21.04	0.031	9.04E-03	768.2	4098.4		2515171
		-419.30	0.031	9.04E-03	768.2	4098.4		
17	-2.68	-534.31	0.024	7.92E-03	327.1	4712.7		2515171
18	-3.60	-578.13	0.017	6.71E-03	-187.4	4816.0		2515171
19	-4.80	-404.62	0.010	5.22E-03	-777.1	4182.2		2515171
20	-6.00	-217.50	0.004	4.03E-03	-1150.3	2963.7		2515171
21	-7.20	160.34	-0.000	3.29E-03	-1184.6	1455.4		2515171
22	-8.10	644.10	-0.003	3.05E-03	-822.6	470.8		2515171
23	-9.00	1183.96	-0.006	2.99E-03	-0.0	-0.0		---

(continued)

Stage No.10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	ACTIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	503
2	9.50	0.00	14.25	5.74	40.88	12.57	12.57	503
3	8.75	0.00	28.50	11.48	81.76	26.06	26.06	503
		0.00	28.50	8.95	48.06	27.32	27.32	252
4	7.98	7.75	33.92	14.37	53.48	32.32	40.07	252
5	7.20	15.50	39.35	19.80	58.91	37.33	52.83	252
6	6.30	24.50	45.65	26.09	65.21	43.14	67.64	252
7	5.40	33.50	51.95	32.39	71.51	48.96	82.46	252
8	4.50	42.50	58.25	38.69	77.81	54.78	97.28	252
9	3.60	51.50	64.55	44.99	84.12	60.61	112.11	252
10	2.90	58.50	69.45	49.89	89.02	65.15	123.65	252
11	2.05	67.00	75.40	55.84	94.97	70.67	137.67	252
12	1.20	75.50	81.35	61.78	100.92	76.20	151.70	252
13	0.00	87.50	89.75	70.18	109.32	84.06	171.56	252
14	-0.25	90.00	91.50	71.93	111.07	85.70	175.70	252
		90.00	91.50	29.81	342.67	31.01	121.01	716
15	-1.00	97.50	99.00	32.25	370.76	32.97	130.47	716
16	-1.75	105.00	106.50	34.69	398.85	35.04	140.04	716
		Total> 211.50	60.00m	647.93	97.07	97.07	20470	
17	-2.68	Total> 230.93	64.63m	748.09	93.41	93.41	24257	
18	-3.60	Total> 250.35	69.25m	848.25	88.98	88.98	28043	
19	-4.80	Total> 275.55	75.25m	978.19	84.36	84.36	32956	
20	-6.00	Total> 300.75	81.25m	1108.13	82.31	82.31	37869	
21	-7.20	Total> 325.95	87.25m	1238.07	235.90	235.90	121868	
22	-8.10	Total> 344.85	91.75m	1335.52	728.02	728.02	132364	
23	-9.00	Total> 363.75	96.25m	1432.98	1279.54	1279.54	142860	

Node no.	Y coord	PASSIVE side: Effective stresses: Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	7.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	9.24b	0.18	0.18	329
8	4.50	0.00	15.30	0.00	16.47b	12.67	12.67	329
		0.00	15.30	0.00	9.71b	8.11	8.11	329
9	3.60	0.00	30.63	11.07	13.98b	13.54	13.54	329
		0.00	30.63	11.07	13.30b	12.85	12.85	329
10	2.90	7.00	35.57	14.60	14.61b	14.60	21.60a	329
		7.00	35.57	16.02	21.40b	19.59	26.59	329
11	2.05	15.50	41.61	22.06	23.75b	23.03	38.53	329
		15.50	41.61	22.06	27.29b	23.03	38.53	329
12	1.20	24.00	47.72	28.16	30.01b	28.16	52.16a	329
		24.00	47.72	28.16	33.87b	28.16	52.16a	329
13	0.00	36.00	56.46	36.90	38.27b	36.90	72.90a	329
		36.00	56.46	36.90	40.87b	36.90	72.90a	329
14	-0.25	38.50	58.30	38.74	41.86b	38.74	77.24a	329
		38.50	58.30	18.99	218.32	72.22	110.72	929

(continued)

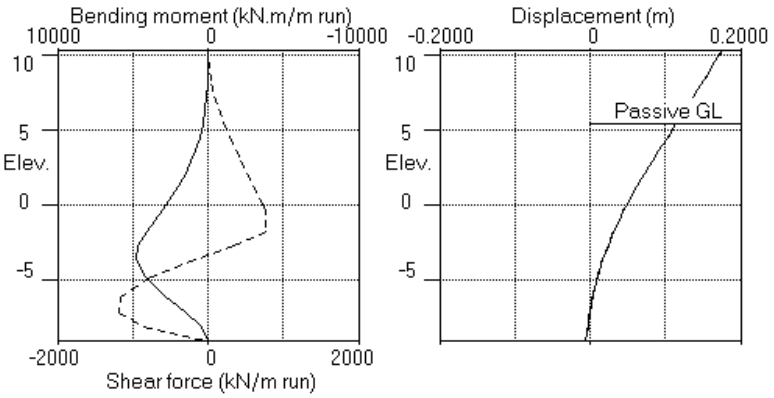
Stage No.10 Change properties of soil type 3 to soil type 4
Ko pressures will be reset

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
15	-1.00	46.00	66.11	21.53	247.57	68.59	114.59	929
		46.00	66.11	21.53	159.93b	68.59	114.59	929
16	-1.75	53.50	73.98	24.10	178.99b	65.50	119.00	929
		Total> 127.48		35.75m	563.90	516.37	516.37	25990
17	-2.68	Total> 147.46		40.38m	664.62	627.72	627.72	30798
18	-3.60	Total> 167.55		45.00m	765.44	667.11	667.11	35606
19	-4.80	Total> 193.74		51.00m	896.37	488.98	488.98	41844
20	-6.00	Total> 220.08		57.00m	1027.45	299.81	299.81	48081
21	-7.20	Total> 246.55		63.00m	1158.66	75.56	75.56	121868
22	-8.10	Total> 266.47		67.50m	1257.14	83.92	83.92	132364
23	-9.00	Total> 286.45		72.00m	1355.67	95.58	95.58	142860

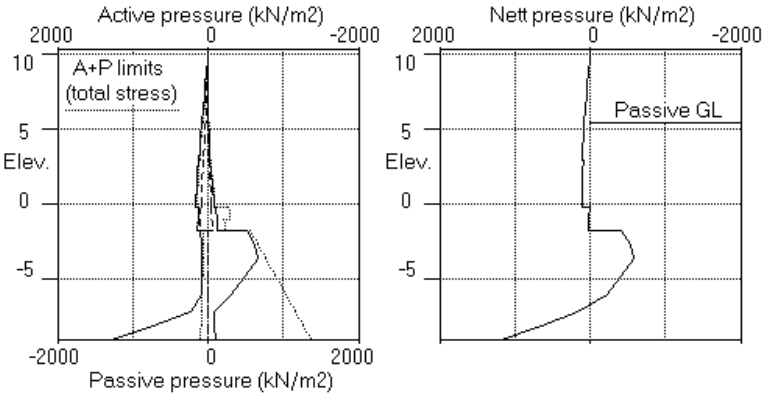
Note: 77.24a Soil pressure at active limit
123.45p Soil pressure at passive limit
178.99b Passive limit reduced because of berm

Units: kN,m

Stage No.10 Change soil type 3 to soil type 4



Stage No.10 Change soil type 3 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: ULS DA1 Combination 2
Water pressures : Worst Credible
Partial factor on C' = 1.250
Partial factor on Phi' = 1.250
Partial factor on Cu = 1.400
Partial factor on Soil Modulus = 1.000
Partial factor on Permanent Unfavourable loads = 1.000
Partial factor on Permanent Favourable loads = 1.000
Partial factor on Variable Unfavourable loads = 1.300

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = -9.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	10.25	10.25	Cant.	Conditions not suitable for FoS calc.			
2	10.25	10.25		No analysis at this stage			
3	10.25	5.40	Cant.	1.217	-6.64	-8.23	13.63
4	10.25	5.40	Cant.	1.069	-6.62	-8.70	14.10
5	10.25	5.40		No analysis at this stage			
6	10.25	5.40	Cant.	2.582	-6.54	-5.81	11.21
7	10.25	5.40	Cant.	1.069	-6.62	-8.70	14.10
8	10.25	5.40	Cant.	1.217	-6.64	-8.23	13.63
9	10.25	5.40	Cant.	1.215	-6.64	-8.23	13.63
10	10.25	5.40	Cant.	1.404	-6.67	-7.33	12.73
11	10.25	5.40		No analysis at this stage			
12	10.25	5.40		No analysis at this stage			
13	10.25	5.40	Cant.	1.069	-6.62	-8.70	14.10
14	10.25	5.40	Cant.	2.582	-6.54	-5.81	11.21

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 50.00 from wall
Passive side 50.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	10.25	0.190	0.000	0.0	0.0	0.0	0.0
2	9.50	0.180	0.000	7.5	-0.0	20.7	-0.0
3	8.75	0.169	0.000	32.4	-0.0	46.6	-0.0
4	7.98	0.159	0.000	78.2	-0.0	72.4	-0.0
5	7.20	0.148	0.000	145.8	-0.0	102.5	-0.0
6	6.30	0.135	0.000	255.7	-0.0	144.4	-0.0
7	5.40	0.123	0.000	404.4	-0.0	217.0	-0.0
8	4.50	0.110	0.000	597.0	-0.0	293.0	-0.0
9	3.60	0.098	0.000	879.3	-0.0	384.7	-0.0
10	2.90	0.089	0.000	1174.7	-0.0	459.8	-0.0
11	2.05	0.078	0.000	1607.4	-0.0	558.9	-0.0
12	1.20	0.067	0.000	2124.3	-0.0	657.9	-0.0
13	0.00	0.052	0.000	2996.8	0.0	797.3	-0.0
14	-0.25	0.049	0.000	3199.8	0.0	826.3	-0.0
15	-1.00	0.041	0.000	3822.2	0.0	836.3	-0.0
16	-1.75	0.033	0.000	4454.0	0.0	850.9	-0.0
17	-2.68	0.025	0.000	5110.1	0.0	342.3	-0.0
18	-3.60	0.018	0.000	5206.0	0.0	0.0	-248.2
19	-4.80	0.010	0.000	4493.7	0.0	0.0	-856.0
20	-6.00	0.004	0.000	3164.3	0.0	0.0	-1243.6
21	-7.20	0.000	-0.000	1543.0	0.0	0.0	-1265.5
22	-8.10	0.000	-0.003	496.8	0.0	0.0	-873.1
23	-9.00	0.000	-0.006	0.0	-0.0	0.0	-0.0

Summary of results (continued)

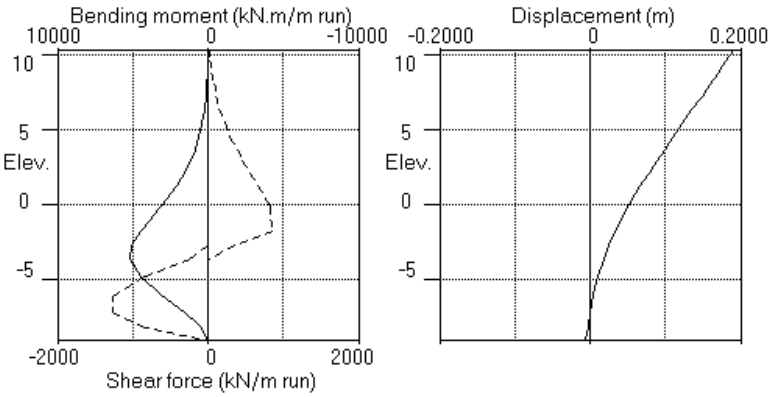
Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment				Shear force			
no.	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	-4.80	-0.0	2.05	0.0	10.25	-0.0	-2.68
2	No calculation at this stage							
3	4387.5	-2.68	0.0	10.25	758.6	-1.75	-1037.5	-6.00
4	5156.8	-3.60	-0.0	-9.00	850.9	-1.75	-1243.3	-7.20
5	No calculation at this stage							
6	3715.5	-3.60	-0.0	-9.00	524.7	-0.25	-938.3	-7.20
7	5193.9	-3.60	-0.0	-9.00	850.3	-1.75	-1261.3	-7.20
8	4912.2	-3.60	-0.0	-9.00	793.9	-1.75	-1204.9	-7.20
9	4893.3	-3.60	-0.0	-9.00	793.3	-1.75	-1201.9	-7.20
10	4816.0	-3.60	-0.0	-9.00	768.2	-1.75	-1184.6	-7.20
11	No calculation at this stage							
12	No calculation at this stage							
13	5206.0	-3.60	-0.0	-9.00	849.8	-1.75	-1265.5	-7.20
14	3764.7	-3.60	-0.0	-9.00	524.7	-0.25	-960.5	-7.20

Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	10.25	0.000	10.25	Change EI of wall to 3.5212E+06kN.m2/m run
2	No calculation at this stage				Apply water pressure profile no.1
3	0.154	10.25	-0.005	-9.00	Excav. to elev. 5.40 on PASSIVE side
4	0.188	10.25	-0.006	-9.00	Apply surcharge no.1 at elev. 10.25
5	No calculation at this stage				Change EI of wall to 2.5152E+06kN.m2/m run
6	0.135	10.25	-0.005	-9.00	Apply water pressure profile no.2
7	0.189	10.25	-0.006	-9.00	Apply water pressure profile no.1
8	0.179	10.25	-0.006	-9.00	Remove surcharge no.1 at elev. 10.25
9	0.178	10.25	-0.006	-9.00	Change soil type 2 to soil type 1
10	0.176	10.25	-0.006	-9.00	Change soil type 3 to soil type 4
11	No calculation at this stage				Change soil type 1 to soil type 2
12	No calculation at this stage				Change soil type 4 to soil type 3
13	0.190	10.25	-0.006	-9.00	Apply surcharge no.1 at elev. 10.25
14	0.137	10.25	-0.005	-9.00	Apply water pressure profile no.2

Bending moment, shear force, displacement envelopes

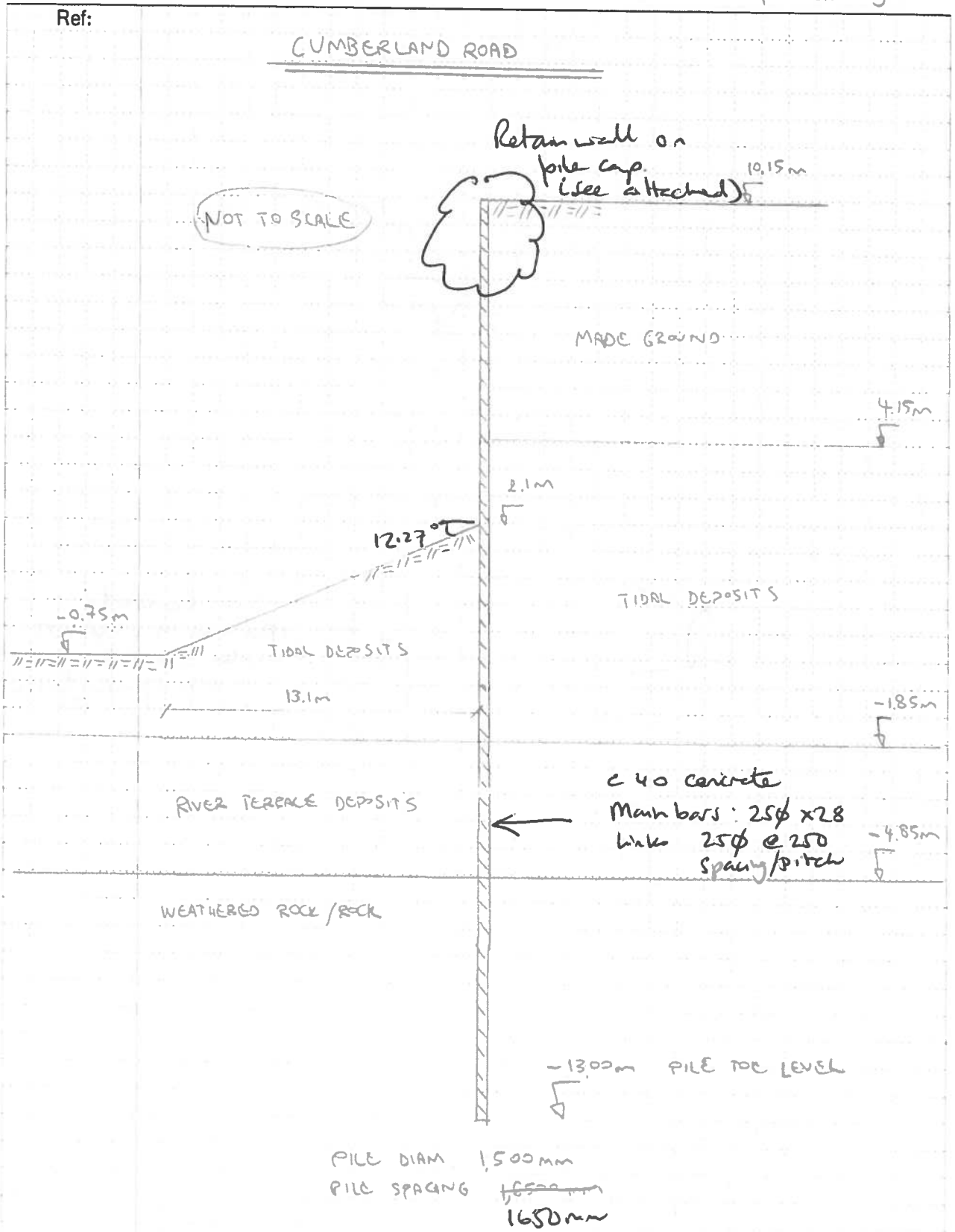


CALCULATION SHEET

AECOM

Project Title:	BRISTOL AVON TIDAL DEFENCE STRATEGY	Job No:	60478613
Subject:	RETAINING WALL CONCEPT DESIGN	Ref:	
		Date:	14/11/2016
Made by:	VST	Checked by:	
		Sheet No:	1 of: 3

Ref:

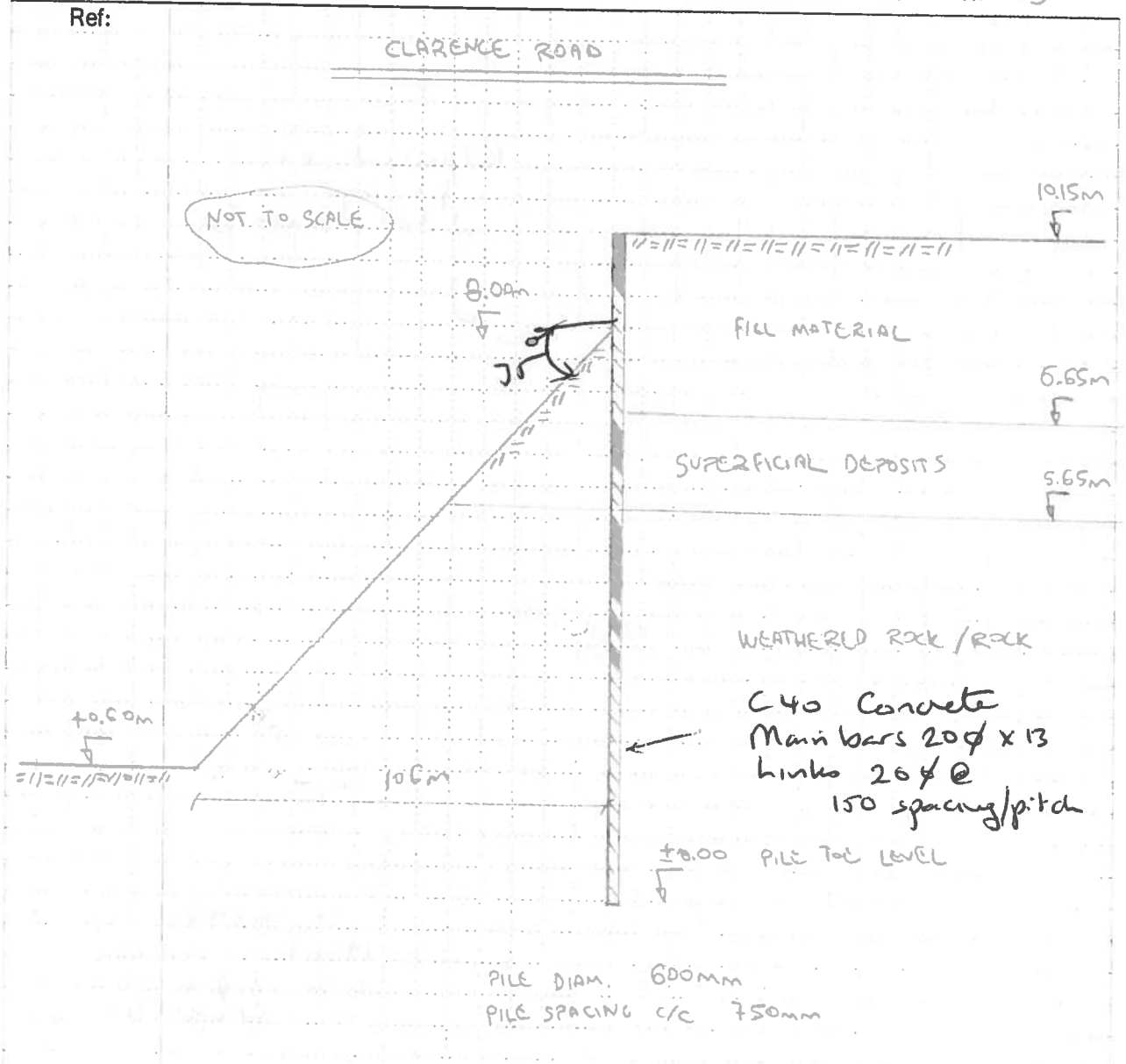


CALCULATION SHEET

AECOM

Project Title:	BRISTOL AVON TIDAL DEFENCE STRATEGY	Job No:	60478613
Subject:	RETAINING WALL CONCEPT DESIGN	Ref:	
		Date:	14/11/2016
Made by:	VST	Checked by:	
		Sheet No:	2 of: 3

Ref:



CALCULATION SHEET

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Project Title:	BRISTOL AVON TIDAL DEFENCE STRATEGY	Job No:	60478613
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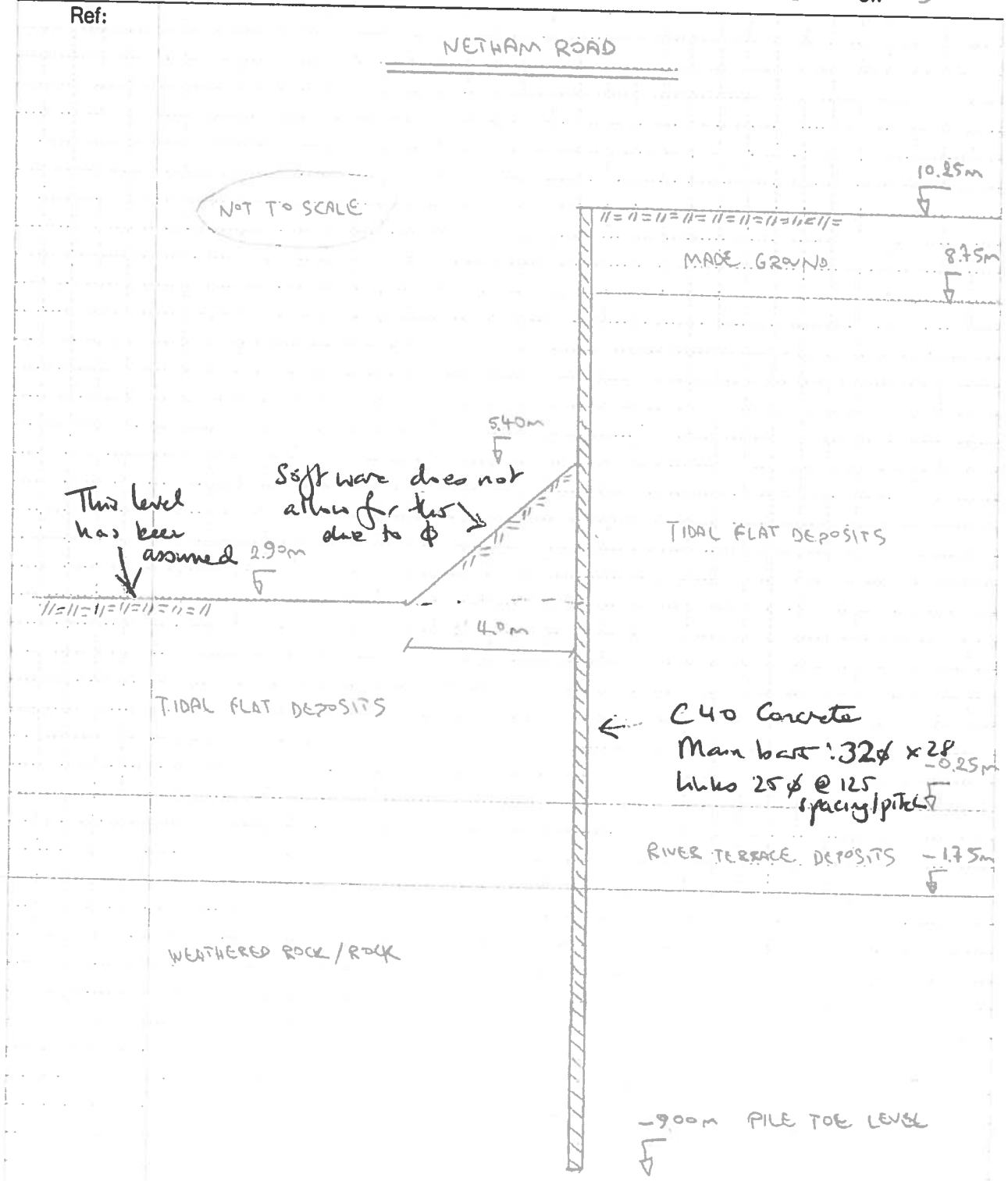
Made by:	VST	Checked by:	
		Sheet No:	3 of: 3

Ref:



APPENDIX E: COSTING TABLES

APPENDIX F: BATHURST DAM DESIGN REVIEW

Technical Note

Project:	**River Avon Tidal Flood Risk Management Strategy**	Job No:	60478613
Subject:	**Bathurst Basin Design Review**		
Prepared by:	**Nancy Collins**	Date:	**20 Oct 2017**
Checked by:	**Jason Drummond**	Date:	**25 Oct 2017**
Approved by:	**David Dales**	Date:	**08 Nov 2017**

Rev 1	Draft	Orig'd by NJC	Ckd by JRD	App'd by
Rev 2	Final with client comments	Orig'd by NJC	Ckd by JRD	App'd by DCD
Rev 3	Memorial comment wrt fencing amended (06/12/17)	Orig'd by JRD	Ckd by NJC	App'd by NS

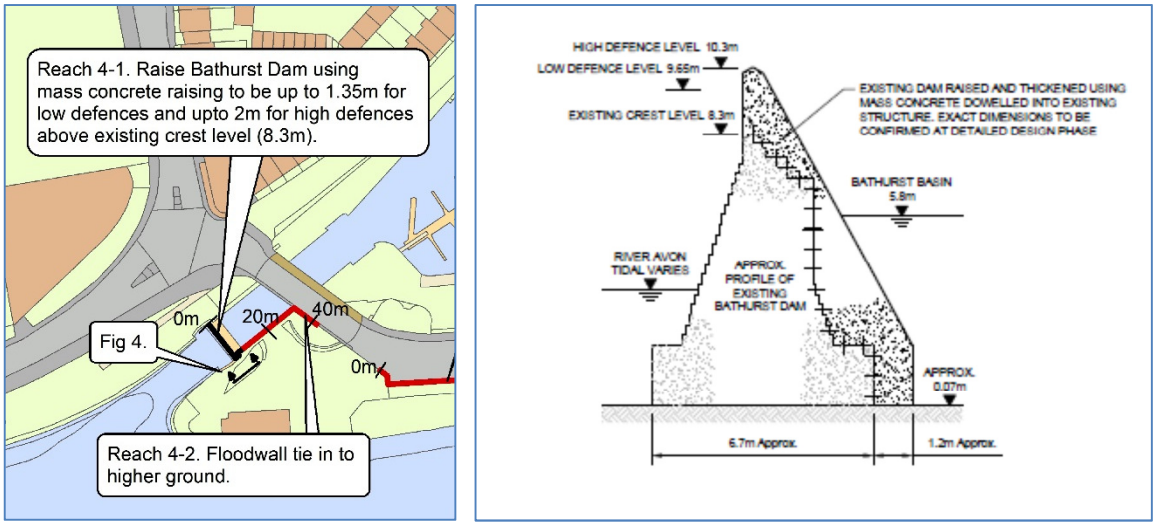
1. Background and Introduction

As part of the River Avon Tidal Flood Risk Management Strategy (TFRMS) concept designs were prepared for flood defence structures to prevent inundation of the city from tidal flooding.

Initial proposals for the Bathurst Basin area comprised the raising of the existing Bathurst Dam with reinforced concrete gravity walls to tie into the high ground of Cumberland Road to the west and into the contiguous piled defences proposed alongside Commercial Road to the east. The original proposals are shown in the plan and section below.

However, the construction of the new Metrobus bridge across the basin and its proximity to the dam mean that these proposals are no longer deemed viable (due to physical constraints and buildability issues) and alternatives have been considered.

This technical note presents the revised preferred option for the defence alignment, considers the construction methodology and assesses the changes in cost.



Figures 1-1 Original Proposals (now superseded)

2. Constraints and assumptions

The following constraints and assumptions were taken into account when considering the options for defence alignment and type. Key constraints are labelled on the plan below:

1) Flood defence design level including freeboard (top of wall level) = 9.65m (low defences and 10.3m (high defences).
2) Bathurst Basin walls, quays and bollards are Grade II listed (Historic England list entry no. 1204010). Visual impacts to be dealt with through appropriate detailing
3) Eastern quayside cannot be disturbed
4) Access to God's Garden to be retained
5) Access to buildings and car parking associated with boatyard to be retained
6) No access required across or through the flood defence line (no steps, ramps or flood gates to be incorporated)
7) Mature willow tree to be removed or canopy reduced. Construction traffic to be allowed within canopy area (not normally allowed to restrict impacts on the root zone)
8) New Metrobus Bridge
9) Underground features associated with the original swing bridge and quay walls

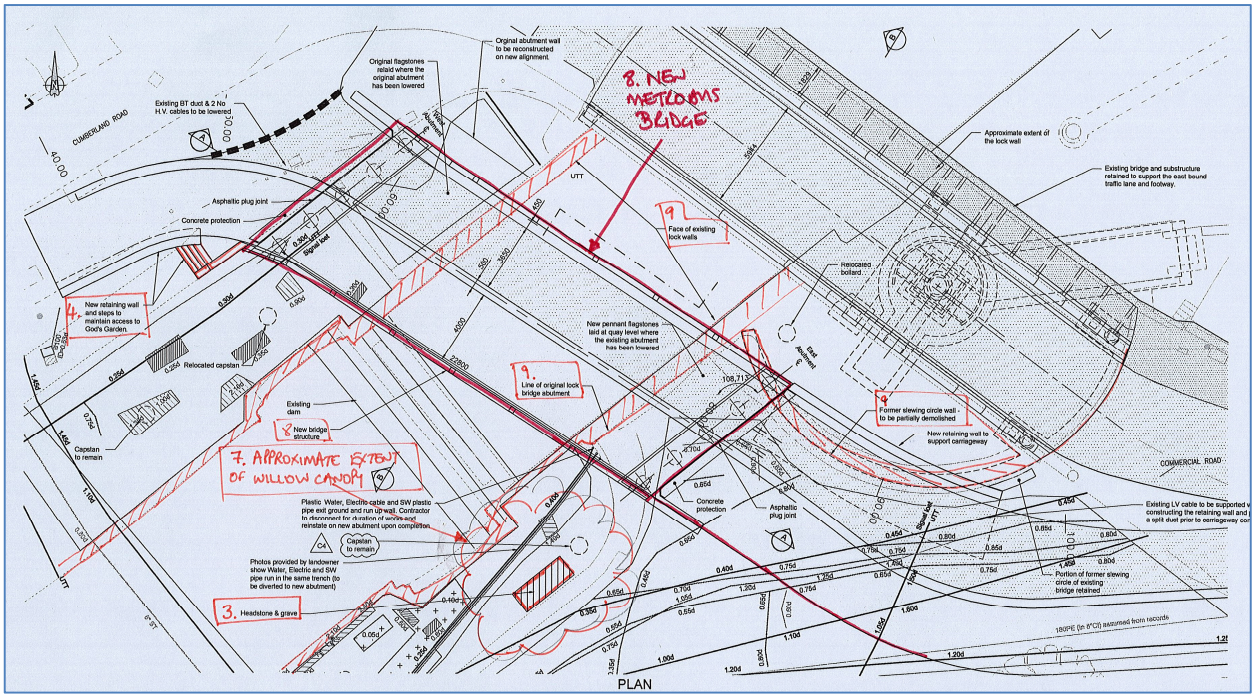


Figure 2-1 Constraints Plan

3. Rejected options

The previous defence alignment (reported April 2017) was rejected as the new Metrobus bridge passed too close to the crest of the dam This meant that the dam raising would conflict with the bridge structure and installation of the mass concrete to support the raising was no longer deemed safe. The new bridge alignment also restricted the available working area for the tie in walls which meant that there was insufficient space to construct the foundations for the proposed gravity (L shaped) walls on the eastern side of the quay. Alternative defence alignments and / or construction types were therefore considered.

Utilising the new Metrobus bridge and supporting structure and filling the flow route beneath with flood gates or a bund was rejected as the bridge was not designed to support the horizontal forces associated with acting as a flood defence an constructing the infill section would be difficult and costly.

An alternative alignment to the north east (shown in yellow on the plan below) which was rejected due to the potential for outflanking, the uplift pressures on the bridge deck and the need for the defence to cross Commercial Road to tie in to the upstream defences.

Alternative alignments to the south west were considered which offered considerable, additional non-monetary benefits as shown in blue and orange on the plan below. These were rejected as they were deemed to be too costly but could be revisited during design development if some of the residual issues with the preferred option (listed in section 7 below) cannot be overcome.

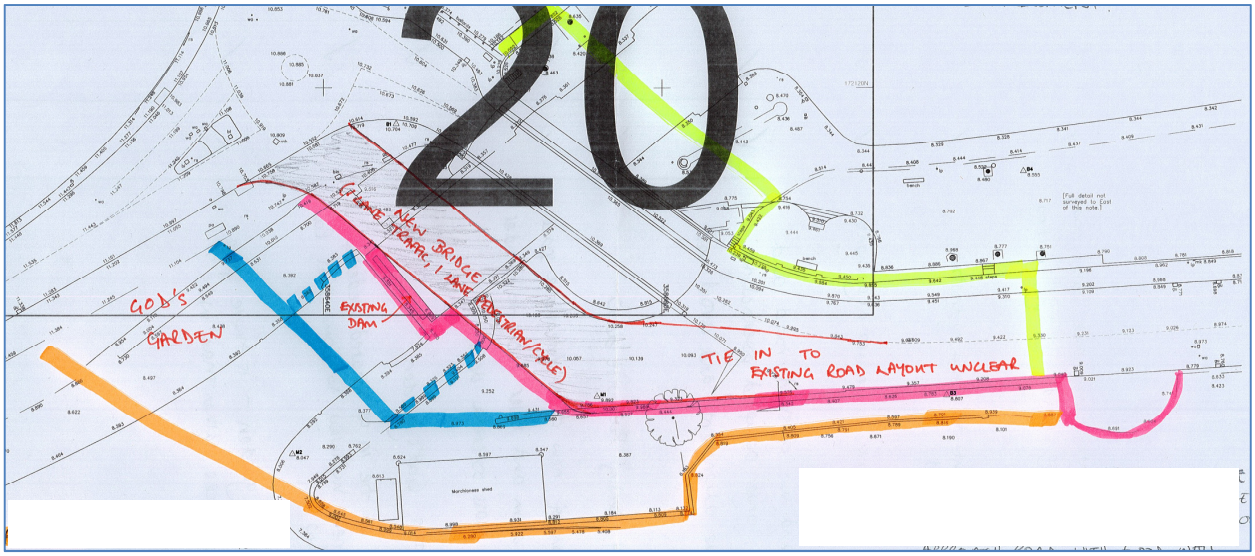


Figure 3-1 Rejected Alignments

4. Preferred Option

The revised alignment for the preferred option is shown in the sketch below, and the appended plan, along with a cross-section of the dam structure. This is based on engineering experience and judgement and no calculations have been undertaken to confirm that the proposed solutions are technically feasible. The alignment shown is indicative only to enable costing to be undertaken and the final route of the defences should be determined in the next phase of the project, taking into account the final layout and tie in details of the new bridge and an assessment of the quay walls (via the proposed BCC Harbour Asset Management Strategy).

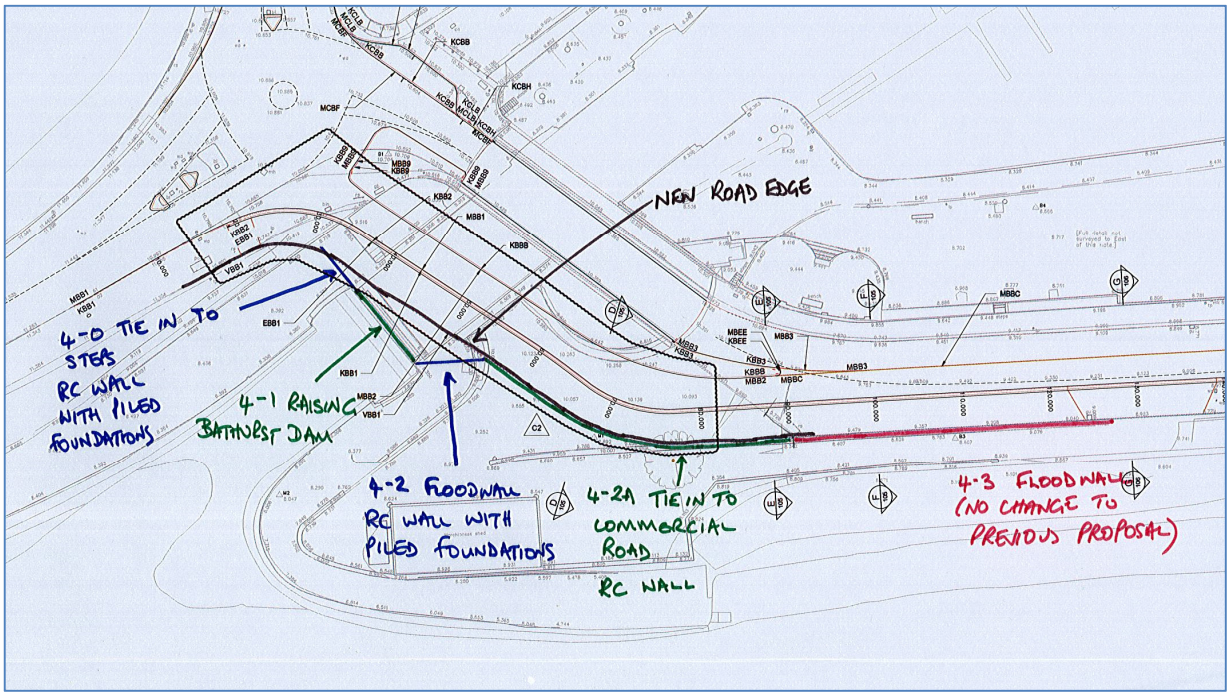


Figure 4-1 Proposed Alignment Plan

4-0 God's Garden – Tying into the access steps to God's Garden from Cumberland Road, a 6m long

wall would cut across the quay. The typical ground level on the quay is 8.4m requiring a 1.9m high wall. Above ground this is assumed to be a reinforced concrete stem. Foundations of the wall will need to be determined but are expected to be piled, either sheet piles, bored piles or screw piles depending on the ground conditions and condition and construction of the quay wall.

4-1 Bathurst Dam – the dam crest will be raised with a reinforced concrete stem which will be supported by a mass concrete gravity base, extending the existing concrete structure. (The extension will be on the River Avon side of the dam; previously the extension was on the basin side of the dam.) This is shown in the updated figure 4 of the Outline Design Report and reproduced below.

4-2 Quayside – An 8m long wall will tie the raised dam crest into the bridge abutment. The exact route of this wall will need to be determined once further details on the quay walls are known and details of the wall foundations are determined. The typical ground level in this area is 8.3m requiring a 2.0m high wall. Above ground this is assumed to be a reinforced concrete stem. Foundations of the wall will need to be determined but are expected to be piled, either sheet piles, bored piles or screw piles depending on the ground conditions and condition and construction of the quay wall.

4-2a Tie in to Commercial Road – The new bridge wing wall on the eastern approach will need to be raised by up to 200mm or a new L shaped (cantilevered) reinforced concrete gravity wall built in front. The proposed tie in between the new Metrobus lanes and the existing ground levels is unclear and further analysis will need to be undertaken once as built details are available. It appears that ground levels are such that defences will be required along the full length from the bridge wing wall to the start of the Commercial Road defences. It has been assumed for the purposes of costing that the existing retaining wall separating the highway from the access road to the boatyard will not be adequate for flood defence purposes and therefore that a new L shaped reinforced concrete retaining wall shall be required along the full length of this section rather than simply raising the existing. This sub reach in particular will need a thorough review once the Metrobus as built information becomes available to determine opportunities for cost savings.

5. Cost

The original base cost of the works only for the Bathurst Reach was £176k broken down as shown in Table 5-1 below. This base cost was then increased by 52% to take account of other costs associated with the project including (but not limited to):

- client costs
- design
- investigations
- landscaping
- dealing with services
- environmental mitigation and enhancement

An additional 60% risk allowance (also known as optimism bias) was also added.

This increased the total cost of the original proposal to £427k.

Table 5-1 Costs of Original Alignment

Reach ref	Proposed Works	Reach Length	Unit Rate Low Defences	Total Low defences	Unit Rate High defences	Total Low defences	TOTAL
4-1	Raising of Bathurst Dam crest level	12m	£2,080	**£24,960**	£120	**£1,440**	**£26,400**
4-2	RC Floodwall to tie-in to high ground behind Bathurst Dam	27m	£4,398.	**£118,746**	£1127	**£30,429**	**£149,175**
						CONSTRUCTION COST TOTAL	**£175,575**
						OTHER PROJECT COSTS (52% OF CONSTRUCTION COST)	**£91,299**
						OPTIMISM BIAS (60% OF CONSTRUCTION & OTHER PROJECT COSTS)	**£160,124**
						GRAND TOTAL	**£426,998**

The updated cost of the preferred option, as a consequence of the revised alignment, has been calculated using the same methodology and is shown in the table below.

Table 5-2 Costs of Revised Alignment

Reach ref	Proposed Works	Reach Length	Unit Rate Low Defences	Total Low defences	Unit Rate High defences	Total Low defences	TOTAL
4-0	RC floodwall with piled foundation	4m	£9,373	**£37,492**	£1,146	**£4,584**	**£42,076**
4-1	Raising of Bathurst Dam crest level	12m	£2,080	**£24,960**	£120	**£1,440**	**£26,400**
4-2	RC floodwall with piled foundation	8m	£9,411	**£75,293**	£1,244	**£9,952**	**£85,245**
4-2a	RC Floodwall to tie-in to high ground	35m	£4,476	**£156,639**	£1,244	**£43,540**	**£200,180**
						CONSTRUCTION COST TOTAL	**£353,901**
						OTHER PROJECT COSTS (52% OF CONSTRUCTION COST)	**£184,028**
						OPTIMISM BIAS (60% OF CONSTRUCTION & OTHER PROJECT COSTS)	**£322,758**
						GRAND TOTAL	**£860,687**

With the additional costs as described above the total is £861k, an increase of £434k. The major

additional cost is the mobilisation of the piling rig for only short sections of defence and the associated potential temporary works which will be required to ensure a safe working area.

This increase is 0.4% of the total revised strategy cost of £106.0m and there is therefore negligible impact on the Present Value whole life cost and Partnership Funding score.

6. Buildability

The construction of the Metrobus bridge and the location has constrained the site to the extent that the working area, particularly on the eastern side of the quay is insufficient to safely construct the scale of works needed.

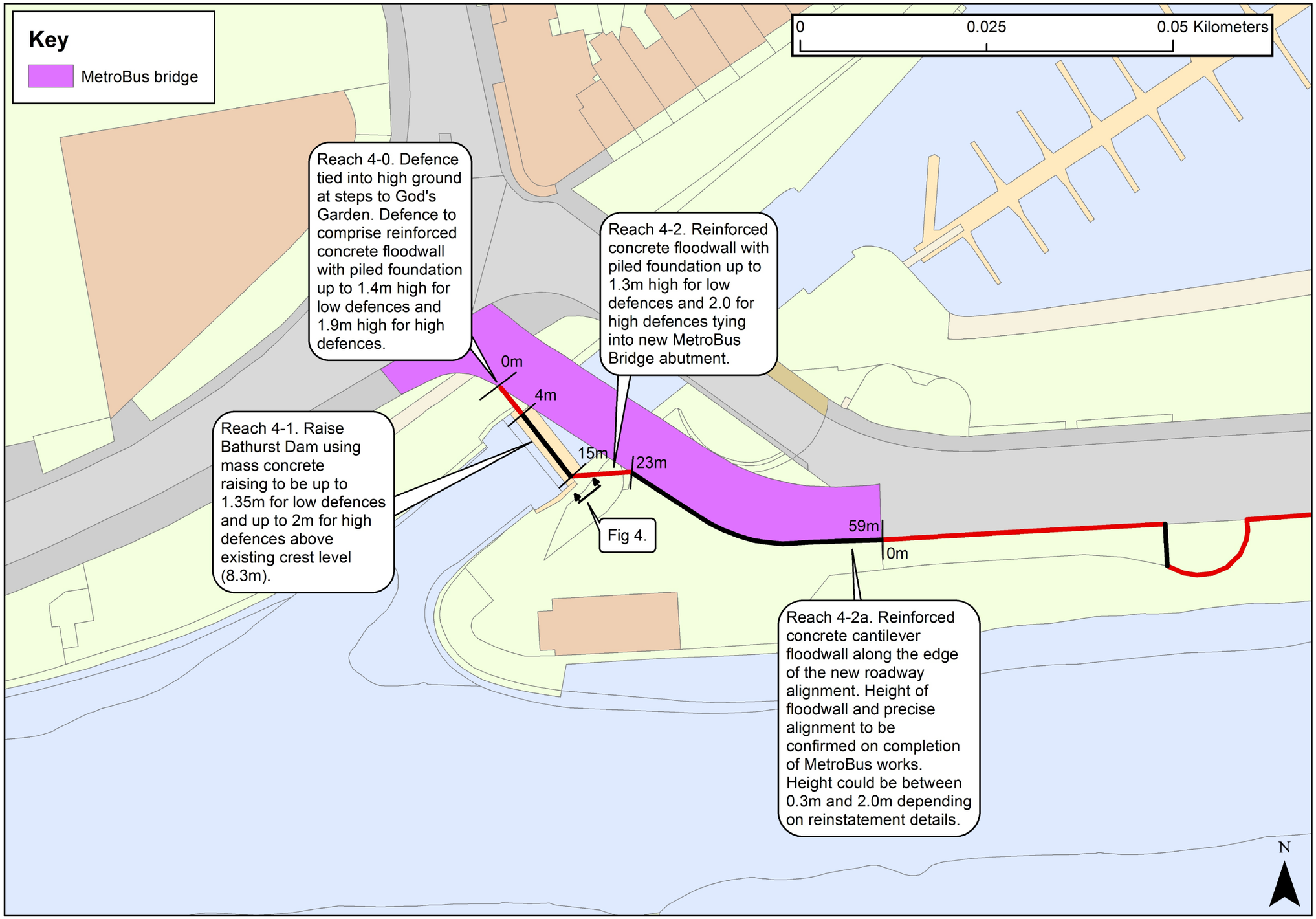
To construct the retaining wall on the eastern side of the basin it will be necessary to create additional working areas to site the piling rig and other plant. This could be achieved by either:

- Closing the Metrobus bridge to traffic and using this to site the piling rig and associated plant.
- Temporarily infilling the Bathurst Basin channel and using this to site the piling rig and associated plant.

7. Design Development

When developing the design from the current concept the following issues should be considered:

- The stability and construction of the existing quay walls and their ability to withstand additional loading during and post construction
- The type of foundation piles and how they would be installed on the quaysides
- Visual impact on the listed structures. It is assumed that the walls could be stone clad to blend with the quay walls but that the plain mass concrete of the raised dam would be acceptable given the existing finish of the dam. Alternative finishes should be considered during design development.
- Investigation into any below ground structures associated with the original swing bridge which may affect the foundations of the walls should be undertaken.
- Engagement with the boatyard owner and other key stakeholders to identify and incorporate their requirements into the design



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Project Title:

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client:

BRISTOL CITY COUNCIL

- Alignments and defence heights are indicative only and will need to be confirmed during detailed design.

- Defence heights quoted are above existing adjacent ground level.

- Design level for low defences (including 200mm freeboard) = 9.65m

- Design level for high defences (including 200mm freeboard) = 10.30m

- Structure references relate to the contents of the associated table

- Under no circumstances must this drawing be used for construction

Issue/Revision:

	24/10/17	V1

AECOM Internal Project No:

60478613

Drawing Title:

BATHURST DAM DEFENCES

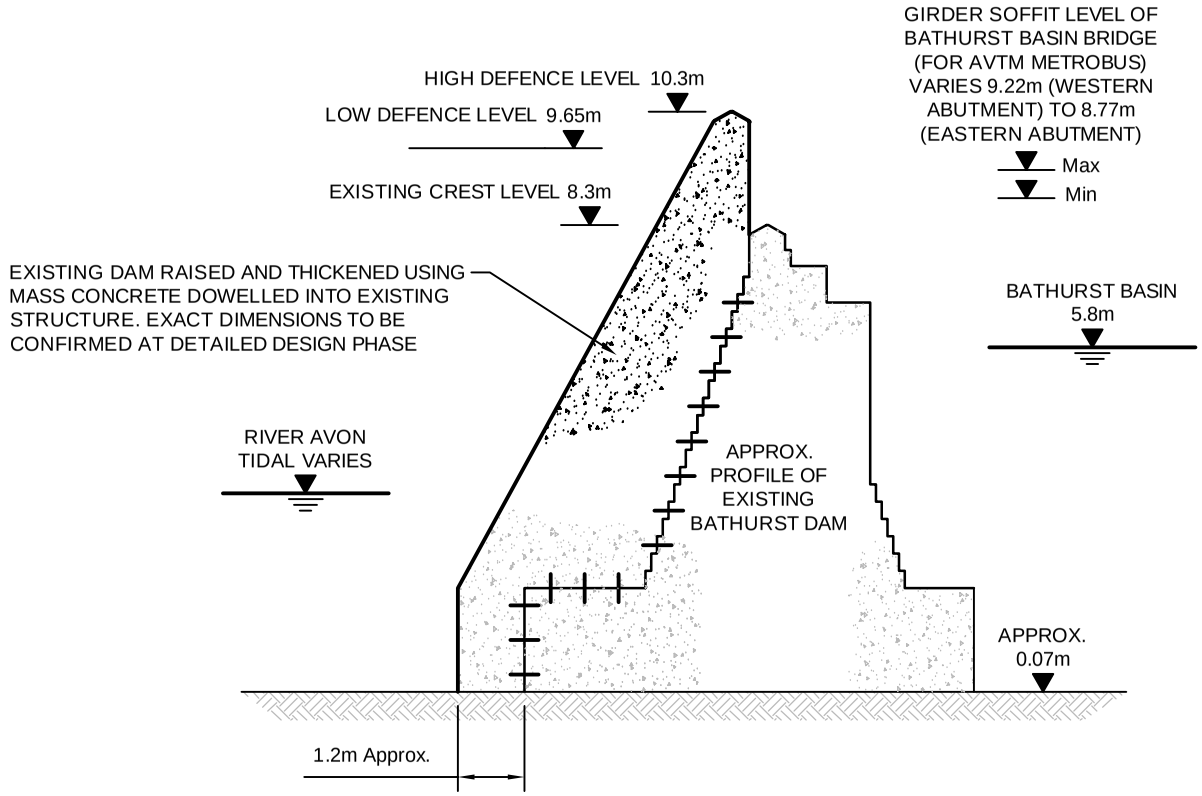
Scale at A3:

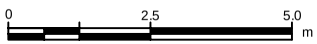
Drawing No: **Rev:**

V1

Drawn:	Chk'd:	App'd:	Date:
BT	NC	JD	31/10/17

Filename: L:\Water\Projects & Jobs\River Avon TFRMS\20 CAD_GIS\GIS Workspace\Outline design alignments - updated Oct17\Template versions\Bathurst Dam update template.mxd





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Project Title

RIVER AVON TIDAL FLOOD RISK MANAGEMENT STRATEGY

Client

BRISTOL CITY COUNCIL

Notes

1. No calculations have been undertaken to confirm the viability of this solution which has been developed based on engineering judgement. All layouts and dimensions are indicative and will need to be determined at detailed design.
2. Bathurst Basin Bridge levels provided via email by BCC Project Manager on 14 July 2017
3. Levels are referred to Ordnance Datum Newlyn

ISSUE/REVISION

I/R	DATE	DESCRIPTION
4	01.11.17	CLIENT COMMENTS ADDED
3	12.10.17	DAM PROFILE AMENDED
2	09.08.17	AMENDED TO ACCOMMODATE METROBUS BRIDGE
1	08.12.17	GENERAL AMENDMENTS

AECOM Internal Project No:

60478613

Drawing Title:

Bathurst Dam Cross Section

Scale at A4: 1:150

Drawing No: Figure 4 **Rev:** 4

Drawn:	Chk'd:	App'd:	Date:
BKW	NJC	JD	Nov. 2016