I hereby give notice of an Ordinary meeting of the:

Meeting	**Raupo Drainage Committee**
Date	Thursday 15 November 2018
Venue	Raupo Drainage Board Offices – Wharf Road, Ruawai
Time	10.00am

Open Agenda

Membership

Chair: Ian Beattie

Members: Greg Gent, David Hart, Brian Madsen, Ross McKinley, Ken Whitehead, Councillor Anna Curnow, Mayor Jason Smith

Staff and Associates:

Land Drainage Co-ordinator, Governance Advisor (Minute-taker)

Contents

Ordinary meeting of the Raupo Drainage Committee
Thursday 15 November 2018 in Ruawai

1 Opening

1.1 Present

1.2 Apologies

1.3 Confirmation of Agenda

The Committee to confirm the Agenda.

1.4 Conflict of Interest Declaration

Committee members are reminded of the need to be vigilant to stand aside from decision-making when a conflict arises between their role as a Committee member and any private or other external interest they might have. It is also considered best practice for those members to the Executive Team attending the meeting to also signal any conflicts that they may have with an item before the Committee.

1.5 Deputations and Presentations

2 Confirmation of Minutes

2.1 Raupo Drainage Committee Minutes 16 August 2018

General Manager Governance, Strategy and Democracy **1603.23**

Recommended

That the unconfirmed minutes of the Raupo Drainage Committee meeting held on 16 August 2018 be confirmed as a true and correct record.

Meeting	**Raupo Drainage Committee**
Date	Thursday 16 August 2018
Venue	Raupo Drainage Board Offices – Wharf Road, Ruawai
Time	Meeting commenced at 10.00am Meeting concluded at 12.05pm
Status	Unconfirmed

Minutes

Membership

Chair: Ian Beattie

Members: Greg Gent, David Hart, Brian Madsen, Ross McKinley, Ken Whitehead, Mayor Jason Smith, Councillor Anna Curnow

Staff and Associates:

Land Drainage Co-ordinator, Executive Assistant, Governance Advisor (Minute-taker)

Jason Marris

General Manager Governance, Strategy and Democracy

Contents

Minutes of the Ordinary meeting of the Raupo Drainage Committee
Thursday 16 August 2018 in Ruawai

1 Opening

1.1 Present

Chair: Ian Beattie

Members: Councillor Anna Curnow, Greg Gent, David Hart, Brian Madsen, Ross McKinley and Mayor Jason Smith

In Attendance

Name	Designation	Item(s)
Shelley Paniora	Executive Assistant	All (Minute-taker)
Wayne Crump	Drainage Co-ordinator	All
Matt Smith		
Donnick Mugutso	Acting General Manager Infrastructure	All

1.2 Apologies

Nil.

1.3 Confirmation of Agenda

The Committee to confirm the Agenda.

1.4 Conflict of Interest Declaration

Nil.

1.5 Deputations and Presentations

Nil.

2 Confirmation of Minutes

2.1 Raupo Drainage Committee Minutes 11 May 2018

General Manager Governance, Strategy and Democracy **1603.22**

Moved **Beattie/Gent**

That the unconfirmed minutes of the Raupo Drainage Committee meeting held on 11 May 2018 be confirmed as a true and correct record, with the following amendment:

Item	*Amendment*
4.1 'General Business – Extension to Raupo Drainage District A	*Sentences to be added at end of paragraph:* *"… The new drain would be numbered 6C in the network. The drain needs to be at an acceptable standard to the Land Drainage Co-ordinator prior to the Drainage District taking the drain on."*

Carried

3 General

3.1 Asset Management Report: August 2018

Land Drainage Co-ordinator **4303.24**

Moved **Curnow/Smith**

That the Raupo Drainage Committee receives the Land Drainage Co-ordinator's report 'Asset Management Report: August 2018' dated 07 August 2018. This will enable the Committee to be informed of the current issues.

Carried

3.2 Financial report for period ended 30 June 2018

Financial Services Manager **4303.24**

Moved **McKinley/Hart**

That the Raupo Drainage Committee receives the Raupo Drainage District financial report for period ended 30 June 2018.

Carried

3.3 Murphy Bower Stopbank, August 2018

Acting General Manager Infrastructure **4303.24**

Moved **Beattie/Gent**

That Raupo Drainage Committee:

1 *Receives the Acting General Manager Infrastructure's report 'Murphy Bower Stopbank – August 2018' dated 09 August 2018; and*

2 *Believes it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with the provision of s79 of the Act determines that it does not require further information prior to making a decision on this matter; and*

3 *Wants a third option explored and included in the consultation letter to Raupo residents of a reinstated stopbank on the Bowergate Property built on the ground to a height of the existing bank as a benchmark with the associated risk profile analysis associated with each option included; and*

4 *The Committee will reconvene once the information is available to be included in the public consultation letter.*

Carried

Closure 12.05pm

Confirmed ……

Chair ……

Kaipara District Council

Dargaville

3 General

KAIPARA DISTRICT

Kaipara te Oranganui • Two Oceans Two Harbours

KAIPARA DISTRICT COUNCIL

File number:	4303.24	**Approved for agenda ☒**
Report to:	Raupo Drainage Committee	
Meeting date:	**15 November 2018**	
Subject:	**Asset Management Report: November 2018**	
Date of report:	**06 November 2018**	
From:	Wayne Crump, Land Drainage Co-ordinator	
Report purpose:	☐ Decision	☒ Information
Assessment of significance:	☐ Significant	☒ Non-significant

Summary

This report summarises the work that has been undertaken over the last month and work that is planned or recommended in the forthcoming months. The Committee is asked to receive the report.

Recommendation

That the Raupo Drainage Committee receives the Land Drainage Co-ordinator's report 'Asset Management Report: November 2018' dated 06 November 2018. This will enable the Committee to be informed of the current issues.

Reason for the report

To inform the Committee of the current issues.

Background

The Raupo Drainage Committee meets four times each year to consider maintenance and renewal works that are required in the Raupo Drainage District. The Land Drainage Co-ordinator's report summarises the maintenance and renewal work that has been done over the period and outlines the future work programme.

Issues

Winter has been an overall quiet period with little to no issues.

Stopbanks

No issues with stopbanks this winter with continued inspections. Stopbank gates have been rehung on new railway iron posts. As weather permits work will begin on the limestone cycleway track from Floodgate 39 to Simpson Road.

Floodgates

Repairs have been made to floodgates door at Armstrong and Smith Canal Road. A new door has been fabricated for Floodgate 41 (Double Creek). Door face timbers are to be replaced prior to fitting this door.

Machine cleaning

Weed raking has was completed in drains 24, 26 and 20 in July at a cost of $6,406.

Drain Spraying

First round of the new seasons drain spraying is presently underway.

Factors to consider

Community views

The community expects the Committee to have a good understanding of and to govern the land drainage requirements for the Raupo District.

Policy implications

There are no policy implications created by this report.

Financial implications

There are no financial implications created by this report. All work recommended falls within the approved budget for the Raupo Drainage District.

Legal/delegation implications

There are no legal implications created by this report and the Committee has the delegated authority to receive the report and make recommendations as to the work required.

Assessment of significance

This report does not trigger Council's Significance and Engagement Policy.

3.2 Financial report for the period ended 30 September 2018

Financial Services Manager **4303.24**

Recommended

That the Raupo Drainage Committee receives the Raupo Drainage District financial report for the period ended 30 September 2018.

Raupo Drainage District
Financial report for the period ended 30 September 2018

Raupo Drainage District	Actual year ended 30.06.2018	Budget year ended 30.06.2019	Actual period ended 30.9.2018
Funds/Deficit from prior period	308,754	-	369,902
Rent received	8,960	8,016	2,490
Rates	348,421	394,968	98,743
Funds avaliable	**666,135**	**402,984**	**471,134**
Administration Costs	6,435	56,708	350
Committee Costs	1,200	2,580	-
Maintenance Costs (note 1)	149,509	188,588	14,189
Total Operating Costs	**157,144**	**247,876**	**14,539**
Total Capital costs (note 2)	**278,935**	**128,500**	**4,000**
Total Costs	**296,234**	**376,376**	**18,539**
Funds Passing to Future Period	**369,902**	**26,608**	**452,595**

Note 1

Maintenance Analysis	Actual year ended 30.6.2018	Budget year ended 30.06.2019	Actual period ended 30.9.2018
Floodgates	25,374	24,996	209
Pumps	1,200	5,004	-
Machine Cleaning	20,592	20,000	6,406
Spraying	81,294	83,000	4,211
Stopbanks	11,514	40,000	-
Miscellaneous (incl garage)	2,717	9,996	1,122
Power	3,255	996	1,724
Insurance	415	1,500	110
Rates payments	1,994	2,100	-
Rate remissions	1,152	996	407
Total maintenance	149,509	188,588	14,190

Note 2

Capex Analysis	Actual year ended 30.6.2018	Budget year ended 30.06.2019	Actual period ended 30.9.2018
Floodgates	190,427	128,500	4,000
Pumps			
Stopbanks	64,677		-
Miscellaneous	23,832		
Total capital expenditure	278,935	128,500	4,000

KAIPARA DISTRICT

Kaipara te Oranganui • Two Oceans Two Harbours

KAIPARA DISTRICT COUNCIL

File number:	4303.24	**Approved for agenda** ☒
Report to:	Raupo Drainage Committee	
Meeting date:	**15 November 2018**	
Subject:	**Murphy Bower Stopbank Options Report**	
Date of report:	05 November 2018	
From:	Donnick Mugutso, Waters and Waste Manager	
Report purpose	☒ **Decision** ☐ **Information**	
Assessment of significance	☐ **Significant** ☒ **Non-significant**	

Summary

Through a raft of historical issues the original stopbank was removed and a new stopbank was instituted in its current location. The main issue is that the stopbank has been created in an unsuitable way and that the original stopbank that was removed has caused a section of the Raupo Drainage network to become a liability. This has left the Raupo Drainage District, the Kaipara District Council (KDC) and the residents of the nearby township of Ruawai open to flooding issues if the unsuitable stopbank fails in an irredeemable way.

Previous reports have been submitted to the Council regarding issues and costs associated with remediation, and the Raupo Drainage Committee has asked for an option regarding remediation of the stopbanks using a different methodology due to significant cost implications, hence an addendum report has been commissioned and received and the findings are attached in Appendix A of this report.

The addendum Geotech report was commissioned asking the questions surrounding construction of the target stopbanks using the same methodology as the existing stopbanks in the district, and the findings are that stopbanks constructed in this fashion would not meet the minimum factor of safety required by the current design standards, although there is a valid argument that the remainder of the stopbanks (69.4km) in the district are currently constructed in the original fashion, and therefore it is reasonable to assume the risk associated with a roughly 300m portion of the stopbank proposed to be constructed will be similar.

Option 1 (see Fig 1 Appendix A): refers to the remediation of the substandard stopbank on the existing alignment of the stopbank on **SECT 73-75 PT 44 BLK XV TOKATOKA SD.**

Option 2 (see Fig 1 Appendix A): refers to the remediation of the substandard stopbank on the pre-existing alignment of the stopbank on **SECT 73-75 PT 44 BLK XV TOKATOKA SD.**

Recommendation

That the Raupo Drainage Committee:

1 *Receives the Waters and Waste Manager's report 'Murphy Bower Stopbank Options Report' dated 05 November 2018 and its circulated Appendix A; and*

2 *Believes it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with the provision of s79 of*

the Act determines that it does not require further information prior to making a decision on this matter; and

3 *Recommends to Council that the Murphy Bower stopbank located on **SECT 73-75 PT 44 BLK XV TOKATOKA SD** is remediated as per Option C of the aforementioned report – the remediation of the stopbank along the approximately 300m long section outlined under **New Stop Bank** and the upgrade of the existing section of the stopbank as highlighted by the area marked under **Option 2** as per Fig 1 in Appendix A of the aforementioned report, without associated ground improvements i.e. construct the proposed stopbank to a standard no less than the existing stopbanks within the Raupo Drainage District at an estimated cost of $375,000 + GST; and*

4 *Recommends to Council to defer the following capital works and operational projects to fund the proposed stopbank:*

a. $128,000 to come from financial year capital works projects;

b. $50,000 from Management services (identified to start hydraulic modelling);

c. *$42,000 from the stopbank maintenance budget; and*

5 *Recommends to Council to approve an additional budget of $45,000 to be loan funded.*

Reason for the recommendation

To confirm the Raupo Drainage Committee's preferred method of remediation prior to seeking additional capital funds for the reinstatement of the Murphy Bower stopbank in the Raupo Land Drainage District.

Reason for the report

To present alternative options to effectively replace the unacceptable portion of the Raupo Land Drainage District stopbank that was replaced with a substandard stopbank on a new alignment, additional to the previously submitted reports.

Background

A section of the Raupo stopbank network has been removed during the course of time on SECT 73-75 PT 44 BLK XV TOKATOKA SD in order to open up a section of farmland that has been reclaimed during the same period of time. The reclaimed land sits behind a stopbank that has been poorly constructed and does not meet the standards required to protect both the drainage network and the nearby township of Ruawai. Several attempts have been made since 15 May 2003 to get the owner of the substandard stopbank to bring it up to standard thus repairing a known at-risk section in the Raupo network, or otherwise to allow the reinstatement of the original stopbank to the preferred standard.

Option 1 (see Fig 1 Appendix A): refers to the remediation of the substandard stopbank on the existing alignment of the stopbank on **SECT 73-75 PT 44 BLK XV TOKATOKA SD.**

Option 2 (see Fig 1 Appendix A): refers to the remediation of the substandard stopbank on the pre-existing alignment of the stopbank on **SECT 73-75 PT 44 BLK XV TOKATOKA SD.**

Issues

Reason for final report

Previous reports have been commissioned and discussions have identified the requirement for an alternative option due to restrictive budgets on the Raupo Drainage District, so an addendum report to the original geotechnical assessment was undertaken and is attached in Appendix A of this report. This report is based on:

1 A finished height of the bank as RL 3.2m which is the standard of the remainder of the drainage district.

2 Assumed flood levels of RL 0.0m, 1.5m, and 3.0m.

3 Two groundwater scenarios of steady state seepage (groundwater is at or near peak flood level for a long period of time causing the bank to become fully saturated), and Sudden Drawdown (a prolonged flood scenario saturates a portion of the stopbank and then suddenly drops faster than the soil can drain i.e. the Wairoa is full for a period of days and then suddenly clears with the outgoing tide).

Findings

1 Under all of the above scenarios the stopbank is predicted to have a factor of safety less than 1.5 (a 1.5 safety factor is the minimum required by current design standards).

2 The construction of the stopbank will be the same as the remainder of the Drainage District, therefore the risks associated with failure are no more than are currently existing through various processes of over topping, or rotational failure due to poor founding conditions.

3 It will be of a higher standard than the existing substandard stopbank.

Factors to consider

Community views

There is a possible known weak point in the existing drainage network that needs to be repaired for the good of the wider community.

Policy implications

Procurement has been through an invitation to local contractors who understand the conditions and have provided costs for this issue in the past.

Financial implications

In order to repair the land drainage stopbank back to its original design and capabilities utilising the most up to date construction standards, with associated factors of safety to protect the community from the risk of inundation through coastal flooding processes by bringing it back up to the currently identified height of RL 3.2m OTP, the repair methodology identified as construction of the original 300m alignment of the historical stopbank would incur capital works costs of $718,000 (approximately) which is approximately $608,000 above the current remaining budget of $110,000.

1 There is $130,000 allocated to Raupo Land Drainage for the 2018/2019 fiscal year, utilising these funds would not achieve the desired result but would not increase the current rates.

2 An additional $588,000 capital expenditure (loan funded) would result in an increase of the Raupo District Land Drainage targeted rate of approximately 12%.

3 Any additional capital expenditure would also result in an increase in Council's external level of debt.

To repair the stopbank utilising the new methodology minus the ground improvements (i.e. to the same standard as the remainder of the stopbanks), capital works would be approximately $375,000, which is approximately $265,000 above the current budget of $110,000.

There is $130,000 allocated to Raupo Land Drainage for the 2018/2019 fiscal year, utilising these funds would not achieve the desired result but would not increase the current rates. There are existing funds within the current year's budget that could be utilised, though it would mean deferring some capital and operational projects.

a $128,000 to come from financial year capital works projects.

b $50,000 from Management services (identified to start hydraulic modelling).

c $42,000 from the stopbank maintenance budget.

This would leave the required budget short by $45,000 which would need to be loan funded.

Legal/delegation implications

There is a risk that the affected parties may seek alternative legal advice upon receipt of Council's decision, this may result in a higher cost to Council either in defending this, or in instituting an alternative repair methodology.

Another risk is that if the property owner disapproves the Council's request to undertake construction work on his property, getting approval may be through the District Court and this process is time-consuming and has legal financial implications.

Options

Option A: Status quo.

Option B: Council to reinstate the historical stopbank located on **SECT 73-75 PT 44 BLK XV TOKATOKA SD** along the approximately 300m long section outlined under **New Stop Bank** and the upgrade of the existing section of the stopbank as highlighted by the area marked under **Option 2** as per Fig 1 in the Appendix A report. This allows for consolidation, settlement and increase in shear strength with a minimum factor of safety of 1.5, utilising the most recent construction standards, angles of the banks shoulders to be at 27° up to a height of 3.5m RL OTP to allow for settlement, ground improvements to be carried out to improve side slope stability, and bearing capacity that will comprise a 0.5m thick and 7.5m wide 'brown rock' filled berm with two layers of geogrid underneath both the sides and the stopbank. An estimated cost of this would be $718,000.

Option C: Council to reinstate the historical stopbank located on **SECT 73-75 PT 44 BLK XV TOKATOKA SD** along the approximately 300m long section outlined under **New Stop Bank** and the upgrade of the existing section of the stopbank as highlighted by the area marked under **Option 2** as per Fig 1 in the Appendix A report, without associated ground improvements. Whilst this would come at a more reasonable cost of $375,000 (approximately), the risks associated with future failure would lie solely with Council, though the risks would be no greater than the remainder of the Raupo Drainage District's

stopbanks (69.4km), and as such it would be reasonable to assume this risk as it is the current level of service.

Option D: Council to reinstate the existing substandard stopbank, section is approximately 1,400m long and identified as **Option 1** on the Appendix A report but without the associated ground improvements. This would come at a cost of $746,000 (approximately) and the risks associated with future failure would lie solely with Council, though the risks would be no greater than the remainder of the Raupo Drainage District's stopbanks (69.4km), and as such it would be reasonable to assume this risk as it is the current level of service.

Option E: Council to reinstate the existing substandard stopbank, section is approximately 1,400m long and identified as **Option 1** on the Appendix A report, allowing for consolidation settlement and increase in shear strength with a minimum factor of safety of 1.5, utilising the most recent construction standards, angles of the banks shoulders to be at 27° up to a height of 3.5m RL OTP to allow for settlement, ground improvements to be carried out to improve side slope stability, and bearing capacity that will comprise a 0.5m thick and 7.5m wide 'brown rock' filled berm with two layers of geogrid underneath both the sides and the stopbank. An estimated cost of this would be $1,600,000.

Assessment of options

Option A would not improve the level of surface by eliminating the risk of failure as a result of the substandard stopbank, and would unlikely be well received by the potentially affected residents of the Raupo Land Drainage District. Failure to address the issue that has been raised may not absolve Council of responsibility in the event of a stopbank failure.

Option B would provide an appropriate level of service and protection of the Raupo Land Drainage District as per current standards. This will also provide a better platform for future improvements in response to changes in the environment.

Option C - based on historical information and performance of the Raupo Land Drainage District stopbanks, there is an opinion that as they have performed well in the past, the risks associated with constructing a stopbank contrary to current engineering advice is acceptable. This has a risk of being proven false in the face of expected best practice guidelines and the changing environment, and it does not have 100 years of settlement and consolidation prior to having to perform in a significant weather event. This option would require additional works in the future should Council elect to increase the height of all the stopbanks to defend against sea level rise.

Option D would be the same as the above option with associated risks, but would be along a greater length with more cost.

Option E: This would provide the same level of service and protection as Option B, though the extra portion of cost is likely to be at an unacceptable level to the Drainage District ratepayers, though this would be a good result for the drainage district and the property owner as all affected land and residents would be appropriately protected by the Raupo Land Drainage District stopbanks.

Assessment of significance

Option B would involve more than $588,000 unbudgeted expenditure and would trigger the Significance and Engagement Policy because the proposal requiring consultation with the community:

- does involve $300,000 or more unbudgeted expenditure; and
- will impact by increasing individual rate levies by more than 10%.

Option C would involve an extra $265,000 of unbudgeted expenditure, though as identified in the document it may be able to be mostly covered by the existing financial expenditure within the Raupo Drainage District by possibly deferring other projects that may not be of such a high priority. This proposal would not trigger the Significance and Engagement Policy.

Recommended option

Option C is the recommended option as this is the most cost-effective option to provide the same level of service as per the remainder of the scheme's stopbanks.

Next step

If approved, undertake consultation with the affected property owner and the Raupo Drainage Committee; Limited public consultation may still need to be undertaken with the Raupo community who pay the targeted rate for the Raupo Drainage District.

Attachments

- Appendix A – Opus Addendum Geotechnical Appraisal Report.

Addendum Geotechnical Appraisal Report

Bowergate Farms - Ruawai, Dargaville

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
DRAFT 1	28/08/18	S. Rotatori	-	E.Foschieri	For Review
Final	04/09/18	S. Rotatori	Glyn East	E.Foschieri	Final

Revision Details

Revision	Details

Executive Summary

This report outlines the stability analyses performed on the proposed stopbank upgrade and new stopbank construction without the proposed ground improvement (as presented on the previous WSP-Opus "Preliminary Geotechnical Appraisal and Options Report" dated 09 February 2018).

The outcomes of the analyses revealed that the adequate margin of safety for all the groundwater scenarios considered are NOT achieved and potential failure of the stopbank is expected to occur.

A summary of the geotechnical and construction risks for both the stopbank upgrade and new stopbank is presented in Table 2 and Table 3.

1 Scope

Kaipara District Council (KDC) has engaged WSP Opus (the Consultant) to consider new design scenarios with respect to those presented within our *Preliminary Geotechnical Appraisal and Options Report* referenced as 1-13583.00 and dated 09/02/2018.

The new analyses comprise a review of the existing stopbank upgrade and new stopbank construction considering different flood levels to assess the sensitivity of the models to groundwater without the recommended ground improvement.

2 Introduction

KDC provided the following inputs that have been taken into account in our analyses:

- Target protection height of stop banks should be minimum at 3.0mRL[1]. In accordance to our settlement analyses, the stopbank height should be constructed at minimum 3.5m R.L. as settlement are estimated in 500mm (versus 3.2m RL suggested by KDC). Thus, the level of 3.5m R.L. has been considered as target for the construction of the stopbank;
- Stopbank crest should be 3.0m wide for providing vehicle accessibility;
- Stopbank face gradients should consider access and grazing requirements.

As requested by KDC, we have analysed two scenarios nominated as Option 1 and Option 2.

2.1.1 Option 1

It consists in upgrading the existing stop banks located at the north and southwest side of the site up to the required height for flooding protection level. This will involve the widening and top-up of the existing stop bank. Stop bank widening will be carried out only on one side of the existing stop bank to facilitate construction operation. Once the stopbank has been widened, a fill top-up will be carried out to achieve the required protection height.

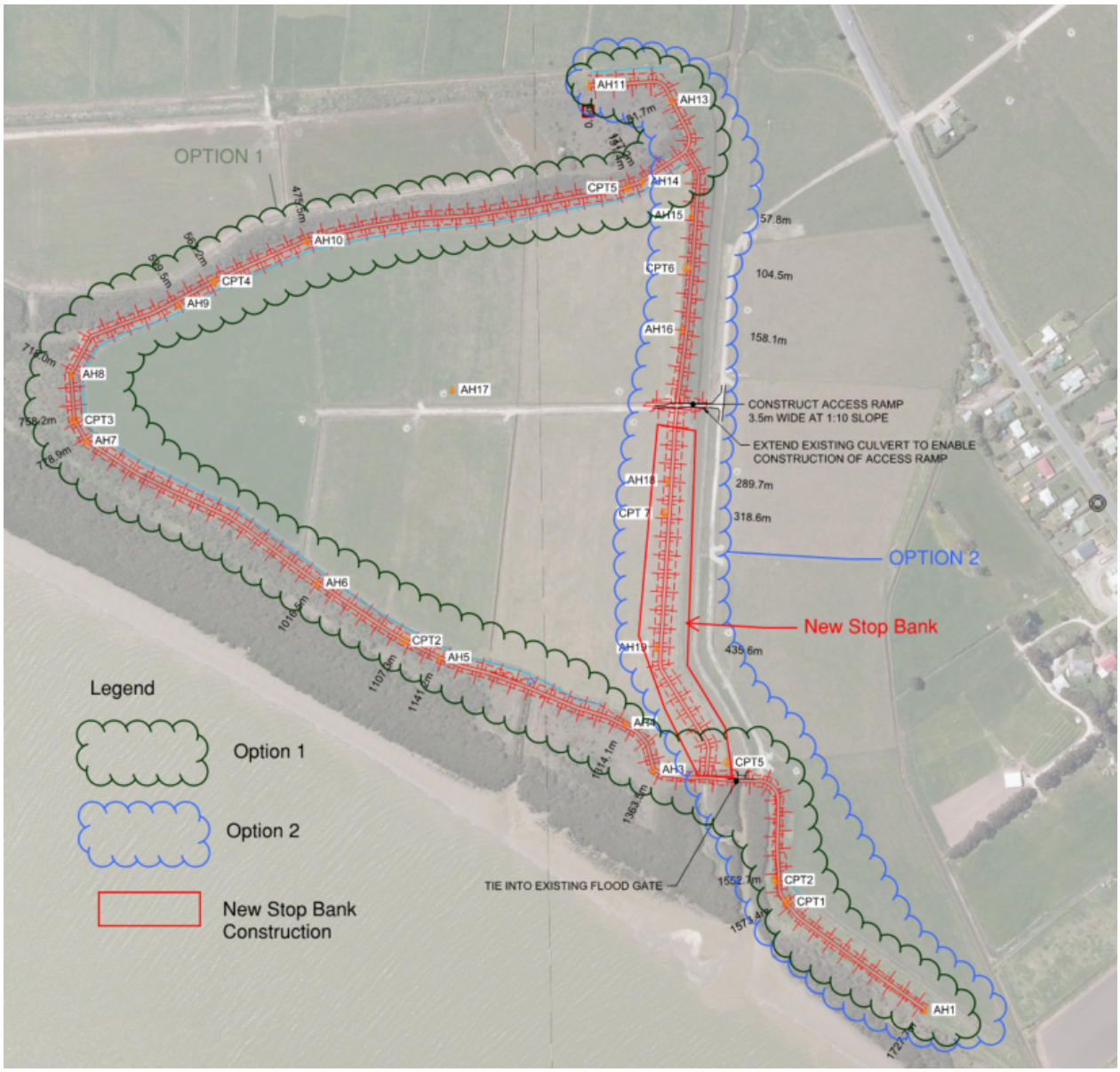
2.1.2 Option 2

It consists of the upgrading of the eastern stop bank as described in Option 1 and rebuilding approximately 300m long section of the south-eastern stop bank.

Figure 1 below depicts locations of Option 1 and Option 2 interventions.

[1] Levels are in terms of NZ Vertical Datum

Figure 1: Option 1 & Option 2 Interventions



3 Additional Geotechnical Analyses

3.1 Flood Levels

A stability assessment of the existing stopbank upgrade and for the new stopbank construction has been carried out considering different flood levels to assess the sensitivity of the models to water table. We have considered three water levels as 0m; 1.5 and 3.0m. The former level representing the projected target protection level of the stopbank (after settlement occur).

3.2 Groundwater Scenarios

Two groundwater scenarios have been analysed to simulate the groundwater variations:

- Scenario 1 – Steady State / Seepage Conditions

This condition occurs when the water remains at or near peak flood level long enough that the embankment becomes fully saturated and a condition of steady seepage occurs. This condition may be critical for landside slope stability, because steady seepage may develop an excess of pore water pressure in the landside of the stopbank.

- Scenario 2 – Sudden Groundwater Drawdown

This case represents the condition whereby a prolonged flood stage saturates at least the major part of the water side slope and then falls faster than the soil can drain. This causes the development of excess pore water pressure which may result in the waterside slope becoming unstable.

3.3 Analyses

An assessment of the stopbank stability for the existing stopbank upgrade and for the new stopbank construction has been carried out varying the groundwater levels and, adopting the two groundwater scenarios described in sections above. Long and short-term conditions have been considered in the design. Specifically, both the short term and long-term conditions have been considered for Scenario 1, and the long-term conditions have been considered for Scenario 2, as more relevant for this design case. Short-term conditions represent the normal operating conditions before the full consolidation of the foundation soils occurs (long term conditions).

No ground improvement has been considered within the modelling.

The stopbank stability analyses have been undertaken using the computer software Slide by Rocscience, to determine the global stability of the stop banks.

Results of these analyses are presented as a Factor of Safety (FoS) which is a ratio of the forces resisting failure (RF) versus the forces driving the slope toward failure (DF)i.e.:

$$FOS = RF/DF$$

The Factor of Safety Design Criteria in Table 1 have been adopted for this analytical check and are based on the NZ Transport Agency's Bridge manual SP/M/022. Slope stability was modelled using the general limit equilibrium Bishop simplified method for circular failure surfaces. In accordance with the Bridge Manual SP/M/022 a FoS in excess of 1.5 is considered to be stable, while a FoS of less than 1.5 is considered to be unstable for the static case.

The sudden drawdown cases allow for a safety factor of 1.25 unless there is potential for significant damage or loss of life in which case a minimum factor of safety of 1.5 shall apply. On this project a factor of safety of 1.5 has been applied for the rapid drawdown case.

Table 1 and Table 2 provide a summary of the results of the stability analysis for the stopbank upgrade and for the new stop bank construction, respectively. Stability analyses have been carried out for two typical cross sections, and for both the short and long-term conditions, considering a 1V:2H embankment slope.

Table 1: Slide Software Analysis Results for the Existing Stopbank Upgrade

Interventions	Modelled Conditions	Groundwater Level (m)	Groundwater Scenario	Required F.S.	F.S.	Result	Risks
Existing Stop Bank Upgrade	Static Case – Short Term (Undrained) No ground improvement	0	Scenario 1: Steady State / Seepage Conditions	≥1.5	1.4	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
		1.5		≥1.5	1.3	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
		3.0		≥1.5	1.0	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
	Static Case – Long Term (Drained) No ground improvement	0	Scenario 1: Steady State / Seepage Conditions	≥1.5	1.3	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
		1.5		≥1.5	1.2	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
		3.0		≥1.5	1.0	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
	Static Case – Long Term (Drained) No ground improvement	1.5	Scenario 2 – Sudden Groundwater Drawdown	≥1.5	1.0	Not OK	Potential Failure expected in the waterside slope. Impervious layers placed on the waterside slope would be beneficial
		3.0		≥1.5	0.8	Not OK	Potential Failure expected in the waterside slope. Impervious layers placed on the waterside slope would be beneficial

Table 2: Slide Software Analysis Results for the New Stopbank Construction

Interventions	Modelled Conditions	Groundwater Level (m)	Groundwater Scenario	Required F.S.	F.S.	Result	Risks
New Stop Bank Construction	Static Case – Short Term (Undrained) No ground improvement	0	Scenario 1: Steady State / Seepage Conditions	≥1.5	1.4	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
		1.5		≥1.5	1.4	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
		3.0		≥1.5	1.1	Not OK	Potential Failure expected in the landside slope. Ground Improvement is required
	Static Case – Long Term (Drained) No ground improvement	0	Scenario 1: Steady State / Seepage Conditions	≥1.5	1.4	Not OK	Potential failure on the landside expected. Ground Improvement is required.
		1.5		≥1.5	1.4	Not OK	Potential failure on the landside expected. Ground Improvement is required.
		3.0		≥1.5	1.2	Not OK	Potential failure on the landside expected. Ground Improvement is required.
	Static Case – Long Term (Drained) No ground improvement	1.5	Scenario 2 – Sudden Groundwater Drawdown	≥1.5	1.1	Not OK	Potential Failure expected in the waterside slope. Impervious layers placed on the waterside slope would be beneficial
		3.0		≥1.5	0.8	Not OK	Potential Failure expected in the waterside slope. Impervious layers placed on the waterside slope would be beneficial

The analyses indicate that for different groundwater levels and for both the groundwater scenarios, all the design cases do not achieve an adequate margin of safety against shear failure within the stopbank sides and foundation. Also, the bearing capacity failure could be a potential issue without any ground improvement.

The stability analysis models are attached to this report as Appendix A.

3.4 Summary of the Instability Risks

In Table 3 and Table 4 below there is a summary of the instability risks for the both the stopbank upgrade and new stopbank construction.

Table 3: Instability Risks of the upgraded stopbanks without ground improvement

Interventions	Feature	List of Risks without Ground Improvement
Existing Stop Bank Upgrade	Stopbank Foundation / Stopbank Sides	• The existing ground is extremely sensitive, consisting of very sift-soft clays and silty clays. Instability of the proposed stopbank widening and top up may occur due to the lack of capacity of the founding ground. • Foundation failures is likely to occur and it could be preceded by lateral displacement of material beneath the embankment toe and by noticeable heave of material just beyond the toe. • Instability has been observed within the stability analyses at the base of the stopbank widening (landside slope) for all the groundwater scenarios and water levels analysed. Ground improvement would increase the global stability of the stopbanks to acceptable levels in the landside slope. . • Also, seepage control measures such as placement of impervious layers could be beneficial for the stability of the waterside slope, of which stability is decreased in case of rapid groundwater drawdown. The impervious layers would reduce the volume of seepage entering the stopbank and foundation. • Stability and settlement of mud foundation can be minimised by the proposed ground improvement.
	Construction	• Constructability of the stopbank widening and top up would be difficult because the saturated and soft founding material (mud) will make the compaction of the new material difficult, and compaction standards problematic to achieve. • Construction operation will be difficult on site as the proposed ground improvement, consisting of a “brown rock” filled berm with two layers of geogrid, would be used as a working path for excavators, trucks during construction, minimising the risk of sticking in the mud.

Table 4: Instability Risks of the new stopbank construction without ground improvement

Interventions	Feature	List of Risks without Ground Improvement
New Stop Bank Construction	Stopbank Foundation / Stopbank Sides	• The existing ground is extremely sensitive, consisting of very sift-soft clays and silty clays. Instability of the proposed new stopbank construction may occur due to the lack of capacity of the founding ground. • Foundation failures is likely to occur and it could be preceded by lateral displacement of material beneath the embankment toe and by noticeable heave of material just beyond the toe. • Instability has been observed within the analyses within the waterside and landside of the stopbank for both the groundwater scenarios and ground water levels. Ground improvement would increase the global stability of the stopbanks to acceptable levels. • Stability and settlement of mud foundation can be minimised by the proposed ground improvement.
	Construction	• Constructability of the new stopbank would be difficult because the saturated and soft founding material (mud) will make the compaction of the new material difficult, and compaction standards problematic to achieve. • Construction operation will be difficult on site as the proposed ground improvement, consisting of a "brown rock" filled berm with two layers of geogrid, would be used as a working path for excavators, trucks during construction, minimising the risk of sticking in the mud.

4 Limitations

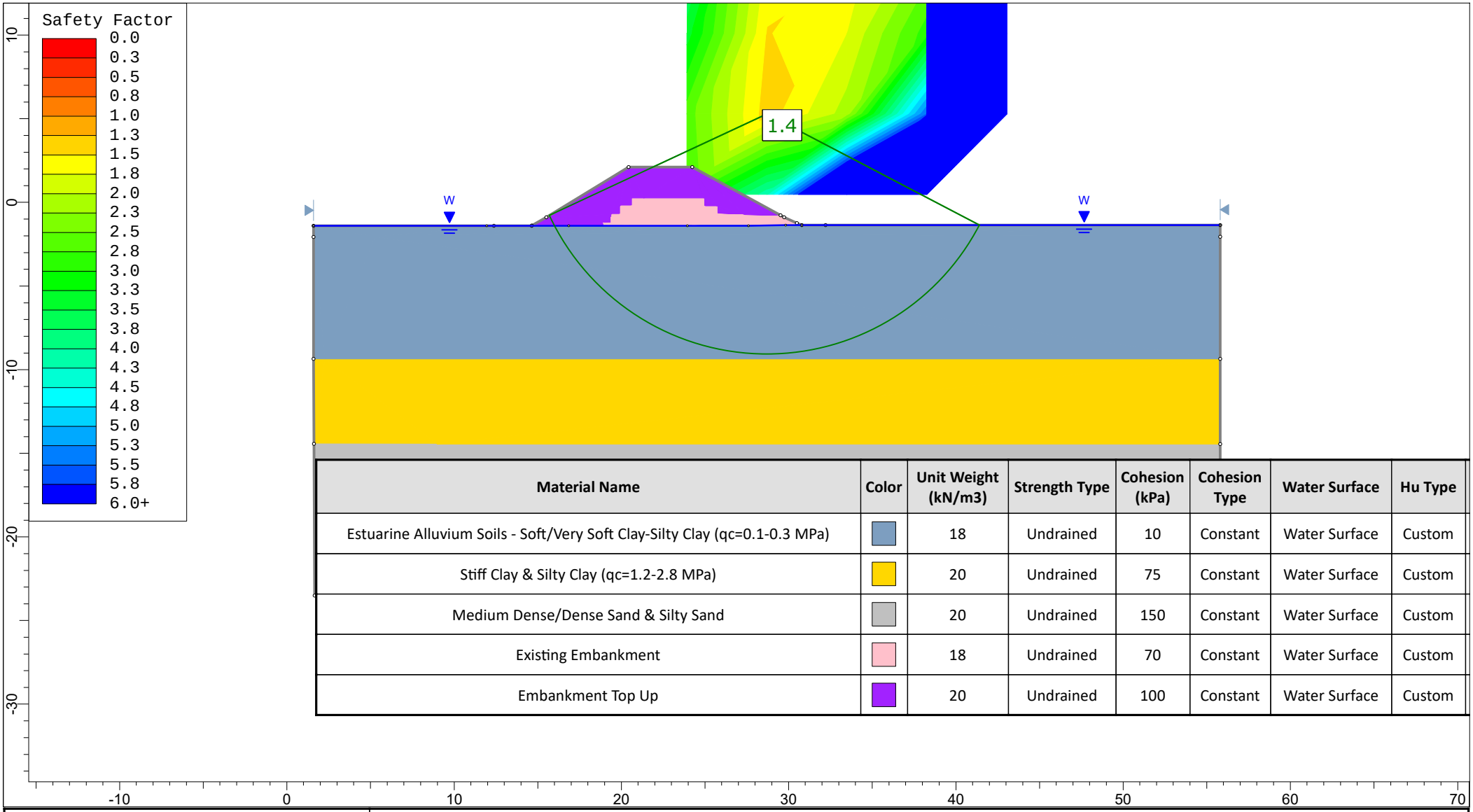
The results presented in this report are taken from discrete test locations associated with the geotechnical investigations. Ground conditions may change from those described or inferred from the specific test sites. This report has been prepared for the benefit of the Kaipara District Council only, for the purpose of providing geotechnical information on the ground conditions at the site. It is not to be relied upon or used out of context by any other person without further reference to WSP Opus.

5 References

- Rocscience, Slide Modeler Version 8.016 64-bit - a 2D limit equilibrium slope stability program.
- Opus International Consultants Ltd, Preliminary Geotechnical Appraisal and Options Report, February 2017.
- NZ Transport Agency's Bridge manual SP/M/022 Third edition, Amendment 2, Effective from May 2016.
- T+T Report – Coastal Flood Hazard Zones for Select Northland Sites, May 2016.
- Linz Data Servicehttps://www.linz.govt.nz/data/geodetic-system/datums-projections-and-heights/vertical-datums/tidal-level-information-for-surveyors.
- Stopbank Design and Construction Guidelines, Bay of Plenty Regional Council Guideline 2014/01.

Appendix A

Slope Stability Analysis Outputs



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Cohesion Type	Water Surface	Hu Type
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10	Constant	Water Surface	Custom
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75	Constant	Water Surface	Custom
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150	Constant	Water Surface	Custom
Existing Embankment		18	Undrained	70	Constant	Water Surface	Custom
Embankment Top Up		20	Undrained	100	Constant	Water Surface	Custom

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SLIDEINTERPRET 8.016

Project	Bowergate Farm				
Analysis Description	Short Term - Existing Stop Bank upgrade without ground improvement (GW=0m - Scenario 1)				
Drawn By	SR	*Scale*	1:317	*Company*	WSP - Opus International Consultants
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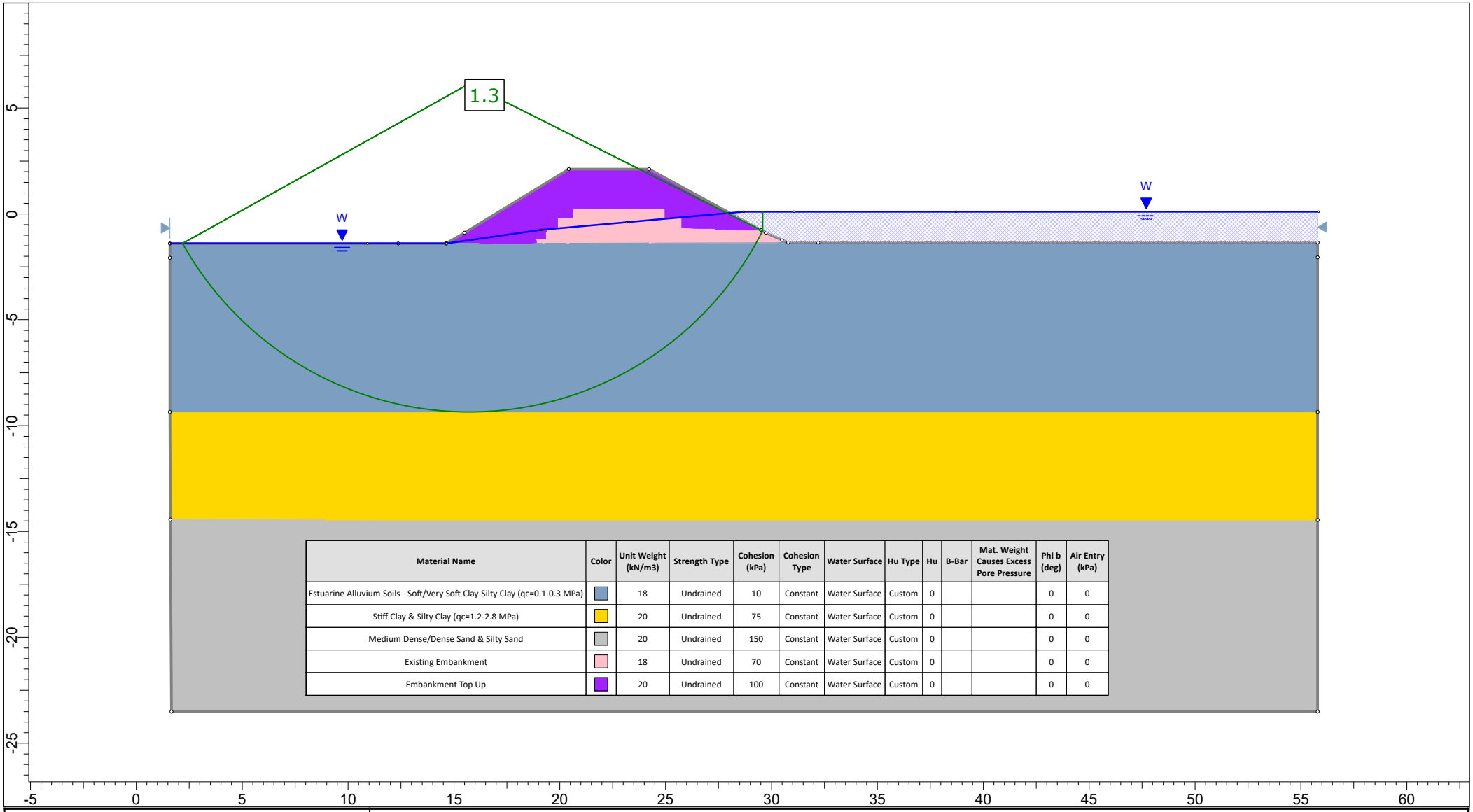

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Cohesion Type	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10	Constant	Water Surface	Custom	0			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75	Constant	Water Surface	Custom	0			0	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150	Constant	Water Surface	Custom	0			0	0
Existing Embankment		18	Undrained	70	Constant	Water Surface	Custom	0			0	0
Embankment Top Up		20	Undrained	100	Constant	Water Surface	Custom	0			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Short Term - Existing Stop Bank upgrade without ground improvement (GW=1.5m - Scenario 1)		
Drawn By	SR	*Scale* 1:250	*Company* WSP - Opus International Consultants
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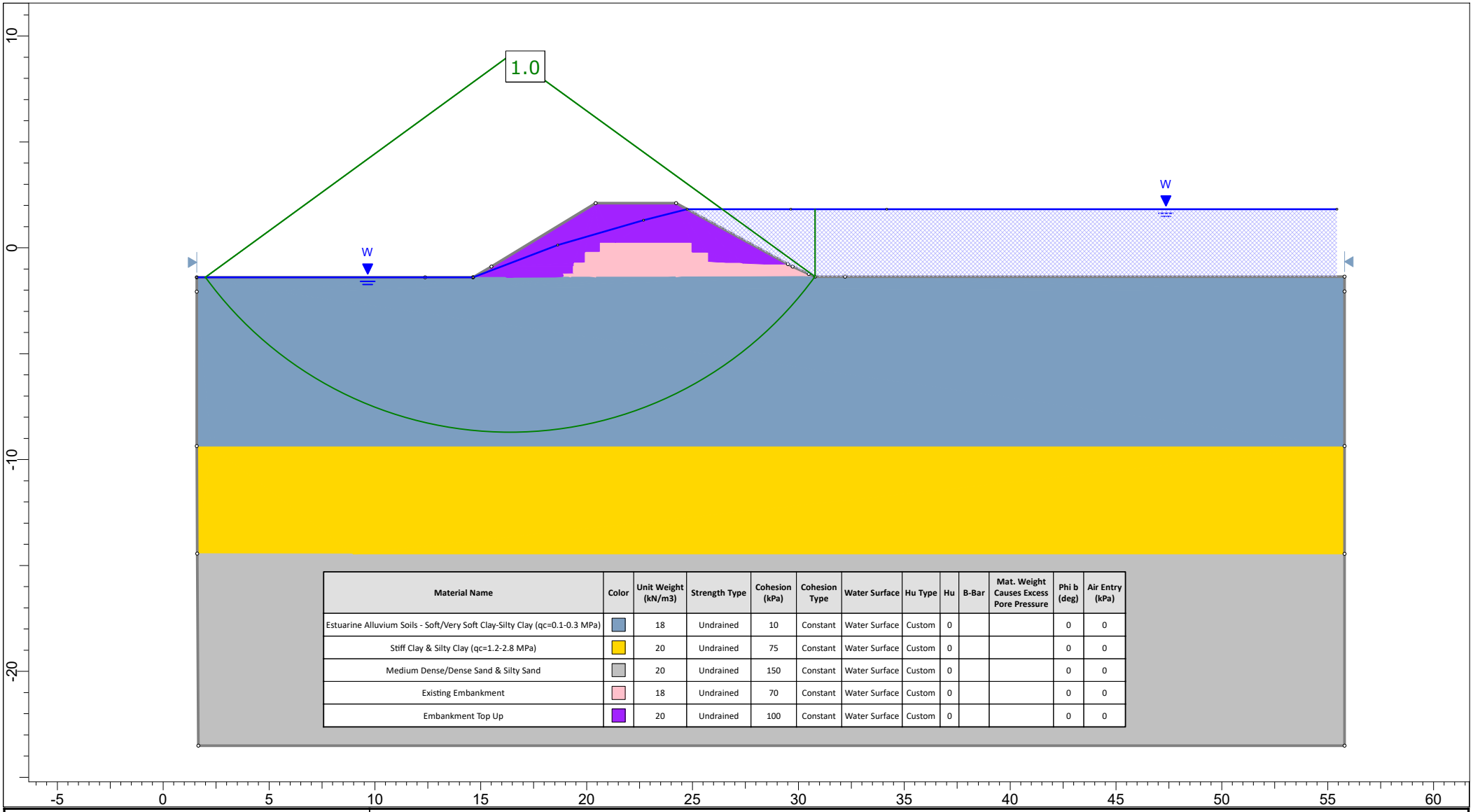

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Cohesion Type	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10	Constant	Water Surface	Custom	0			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75	Constant	Water Surface	Custom	0			0	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150	Constant	Water Surface	Custom	0			0	0
Existing Embankment		18	Undrained	70	Constant	Water Surface	Custom	0			0	0
Embankment Top Up		20	Undrained	100	Constant	Water Surface	Custom	0			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Short Term - Existing Stop Bank upgrade without ground improvement (GW=3.0m - Scenario 1)		
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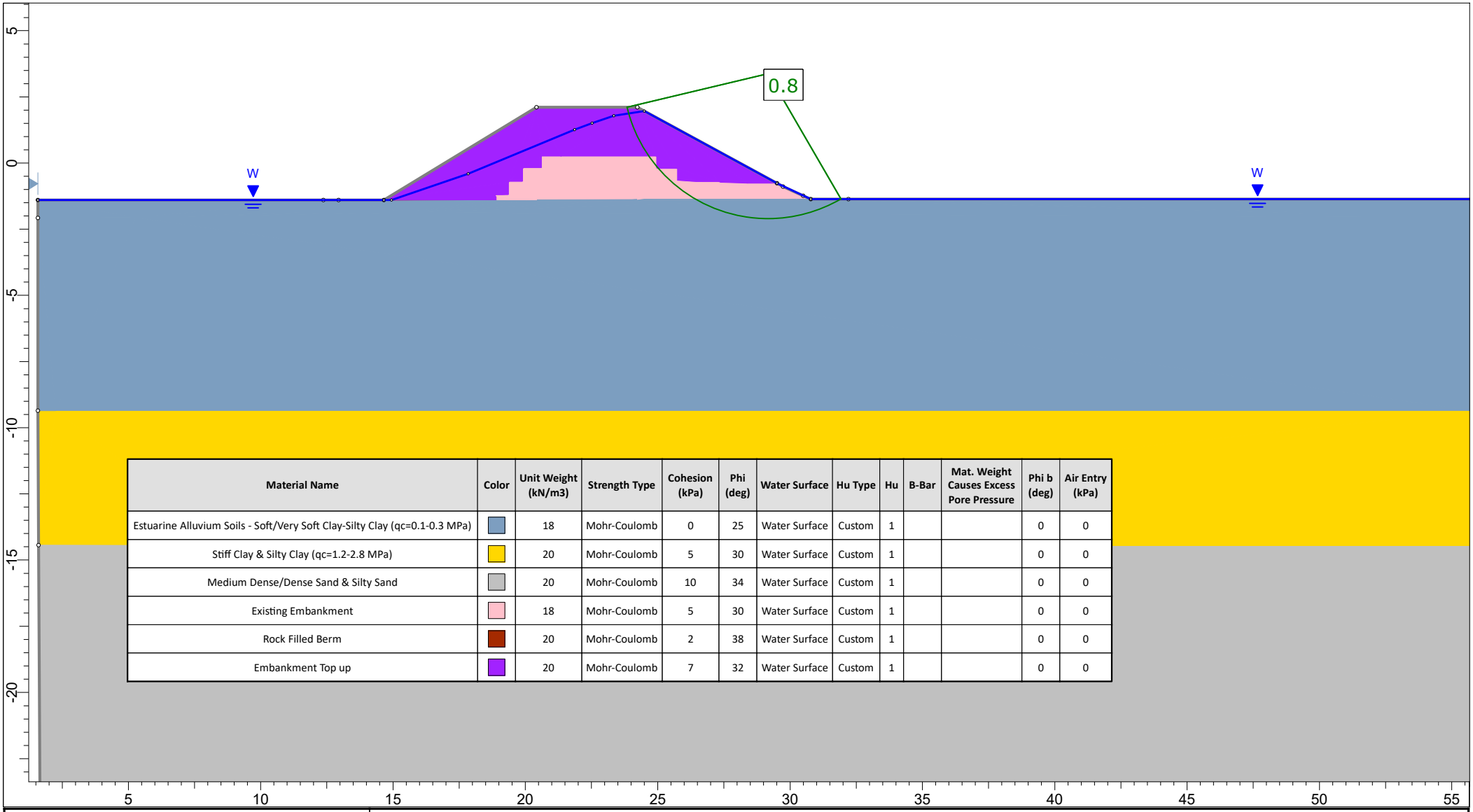

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	Custom	1			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	Custom	1			0	0
Existing Embankment		18	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Rock Filled Berm		20	Mohr-Coulomb	2	38	Water Surface	Custom	1			0	0
Embankment Top up		20	Mohr-Coulomb	7	32	Water Surface	Custom	1			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Long term - Existing Stop Bank upgrade without ground improvement (GW=3.0m, Scenario 2)		
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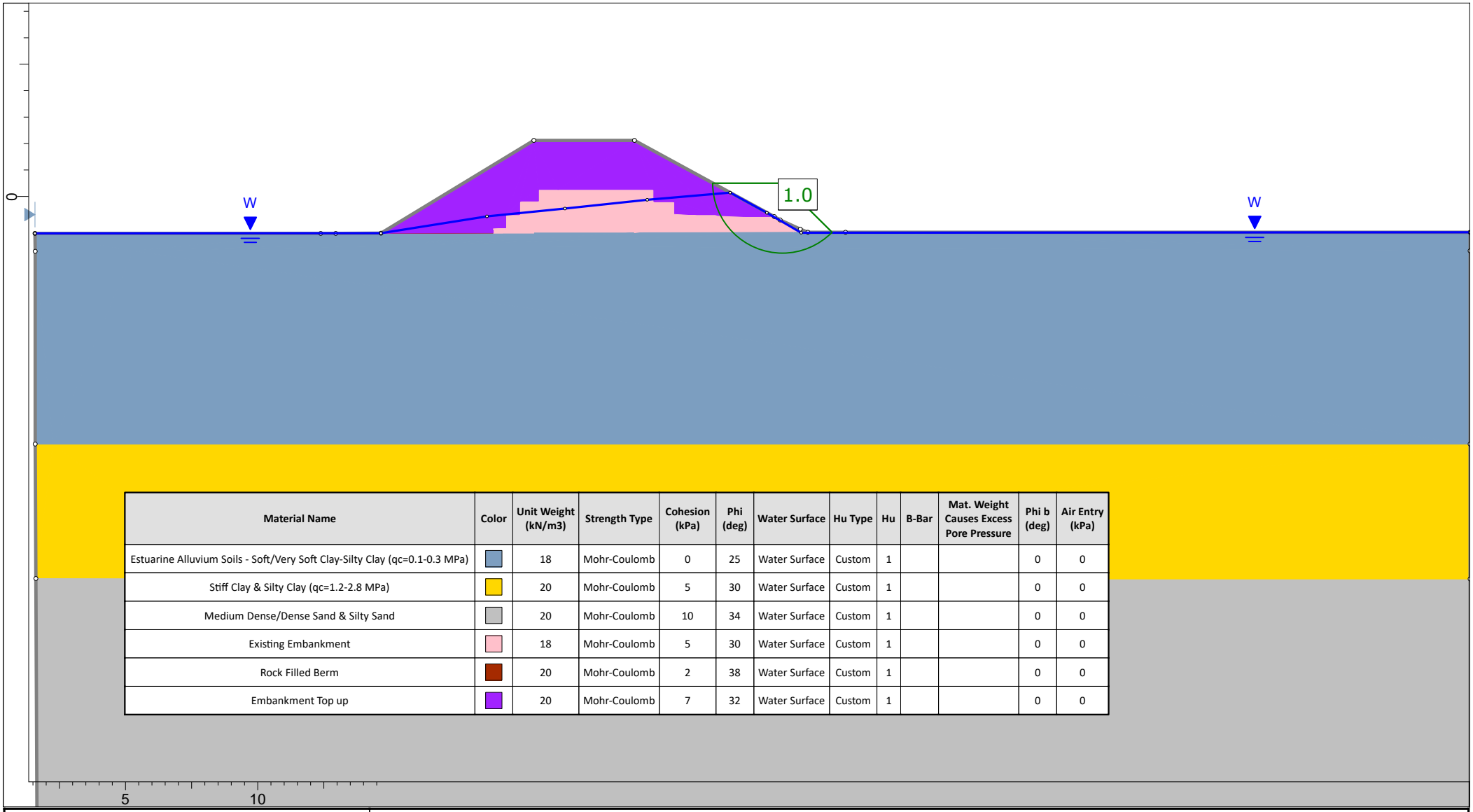

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	Custom	1			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	Custom	1			0	0
Existing Embankment		18	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Rock Filled Berm		20	Mohr-Coulomb	2	38	Water Surface	Custom	1			0	0
Embankment Top up		20	Mohr-Coulomb	7	32	Water Surface	Custom	1			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Long term - Existing Stop Bank upgrade without ground improvement (GW=1.5m, Scenario 2)		
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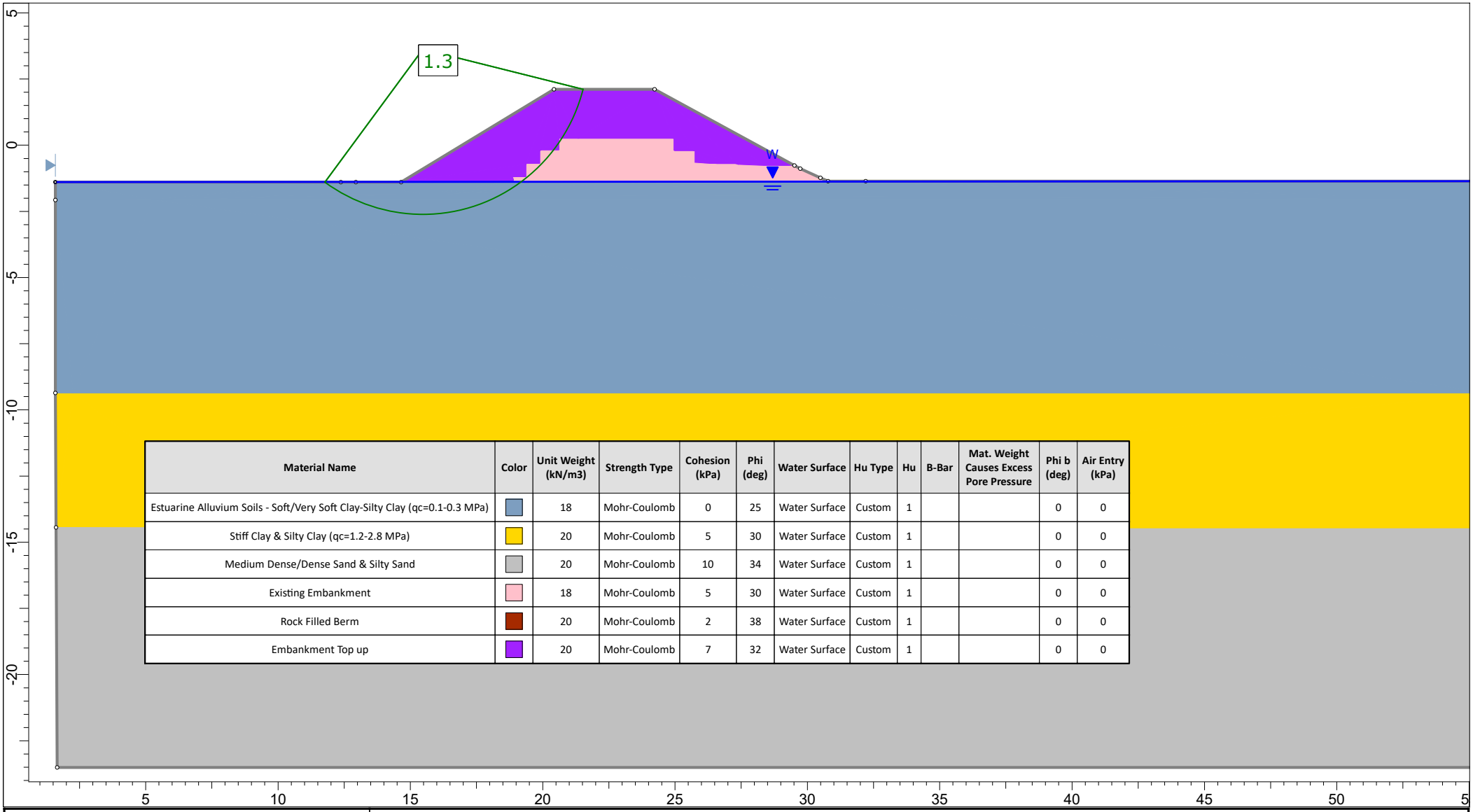

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	Custom	1			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	Custom	1			0	0
Existing Embankment		18	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Rock Filled Berm		20	Mohr-Coulomb	2	38	Water Surface	Custom	1			0	0
Embankment Top up		20	Mohr-Coulomb	7	32	Water Surface	Custom	1			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Long term - Existing Stop Bank upgrade without ground improvement (GW=0m, Scenario 1)		
Drawn By	SR	*Scale* 1:200	*Company* WSP - Opus International Consultants
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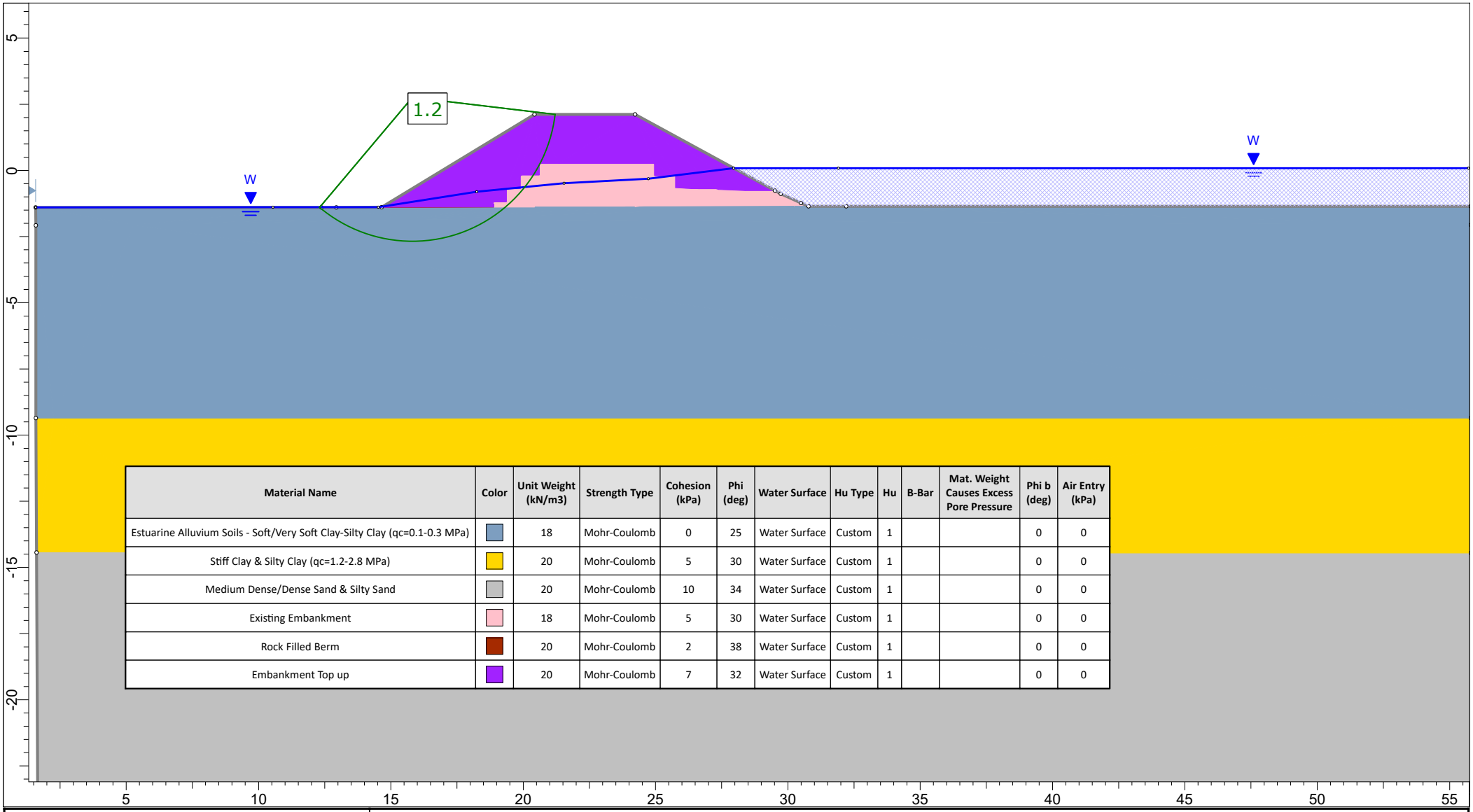

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	Custom	1			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	Custom	1			0	0
Existing Embankment		18	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Rock Filled Berm		20	Mohr-Coulomb	2	38	Water Surface	Custom	1			0	0
Embankment Top up		20	Mohr-Coulomb	7	32	Water Surface	Custom	1			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Long term - Existing Stop Bank upgrade without ground improvement (GW=1.5m, Scenario 1)		
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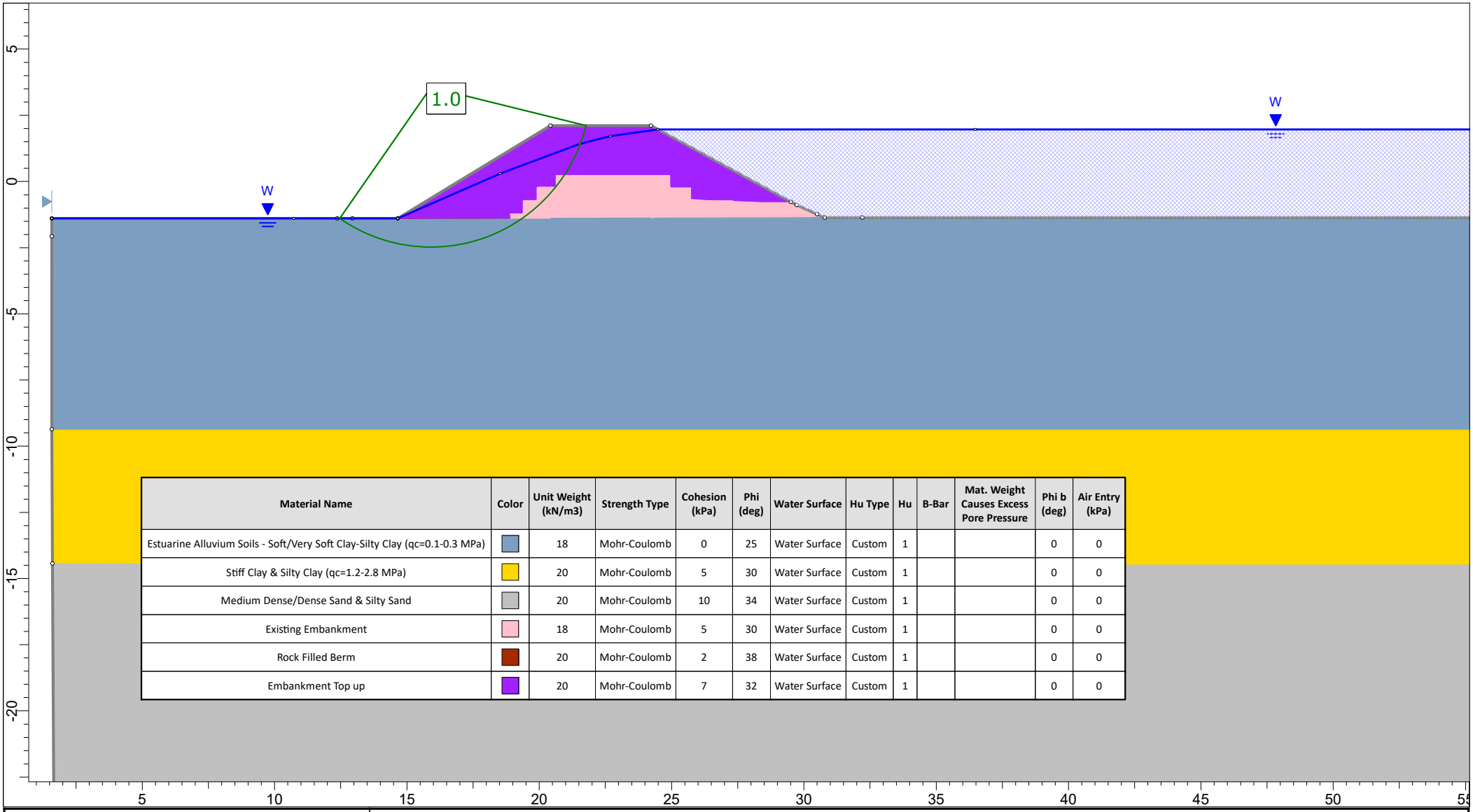

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	B-Bar	Mat. Weight Causes Excess Pore Pressure	Phi b (deg)	Air Entry (kPa)
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	Custom	1			0	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	Custom	1			0	0
Existing Embankment		18	Mohr-Coulomb	5	30	Water Surface	Custom	1			0	0
Rock Filled Berm		20	Mohr-Coulomb	2	38	Water Surface	Custom	1			0	0
Embankment Top up		20	Mohr-Coulomb	7	32	Water Surface	Custom	1			0	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Long term - Existing Stop Bank upgrade without ground improvement (GW=3.0m, Scenario 1)		
Drawn By	SR	*Scale* 1:200	*Company* WSP - Opus International Consultants
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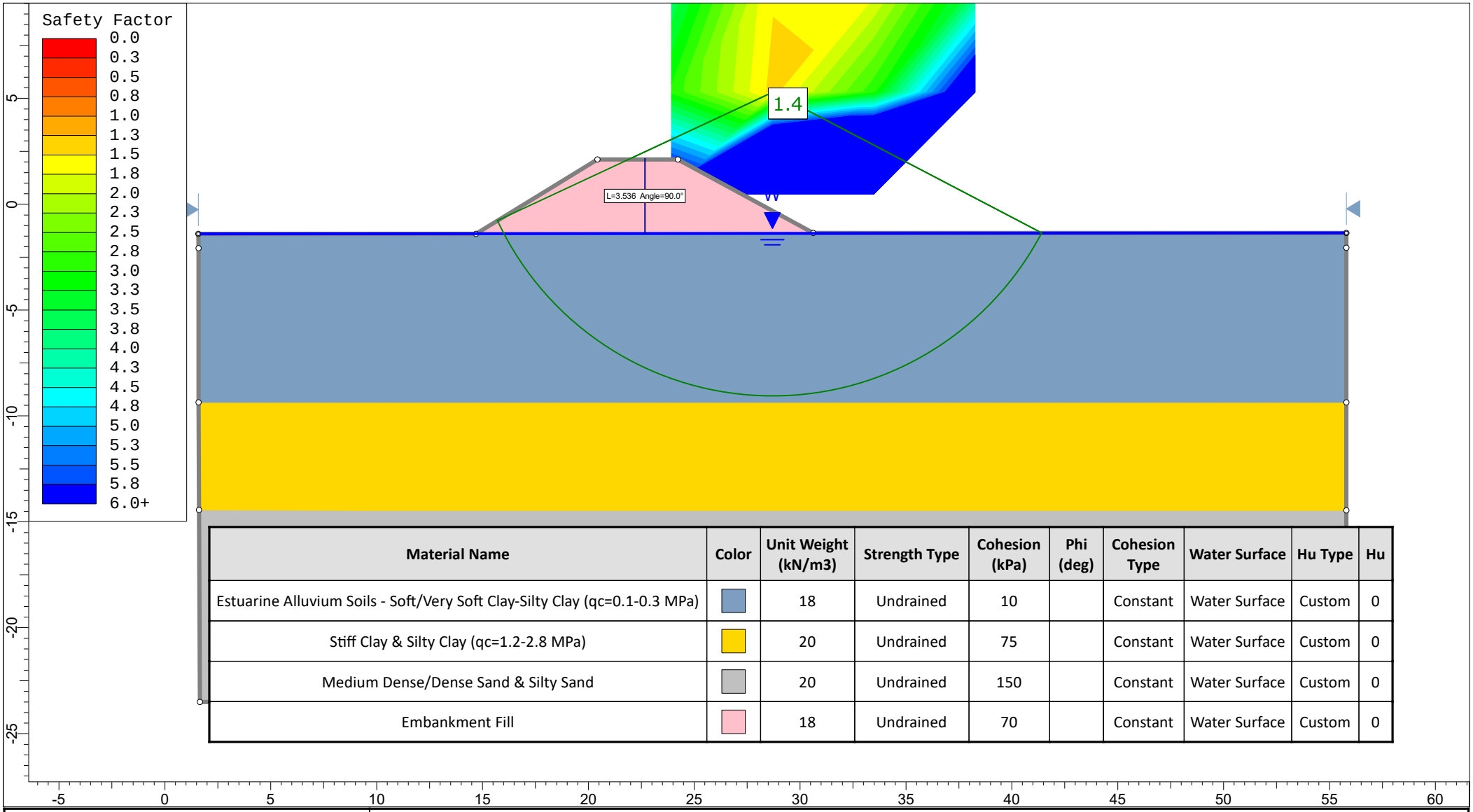

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10		Constant	Water Surface	Custom	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75		Constant	Water Surface	Custom	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150		Constant	Water Surface	Custom	0
Embankment Fill		18	Undrained	70		Constant	Water Surface	Custom	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank (GW=0m, Scenario 1)		
Drawn By	SR	*Scale* 1:250	*Company* WSP - Opus International Consultants
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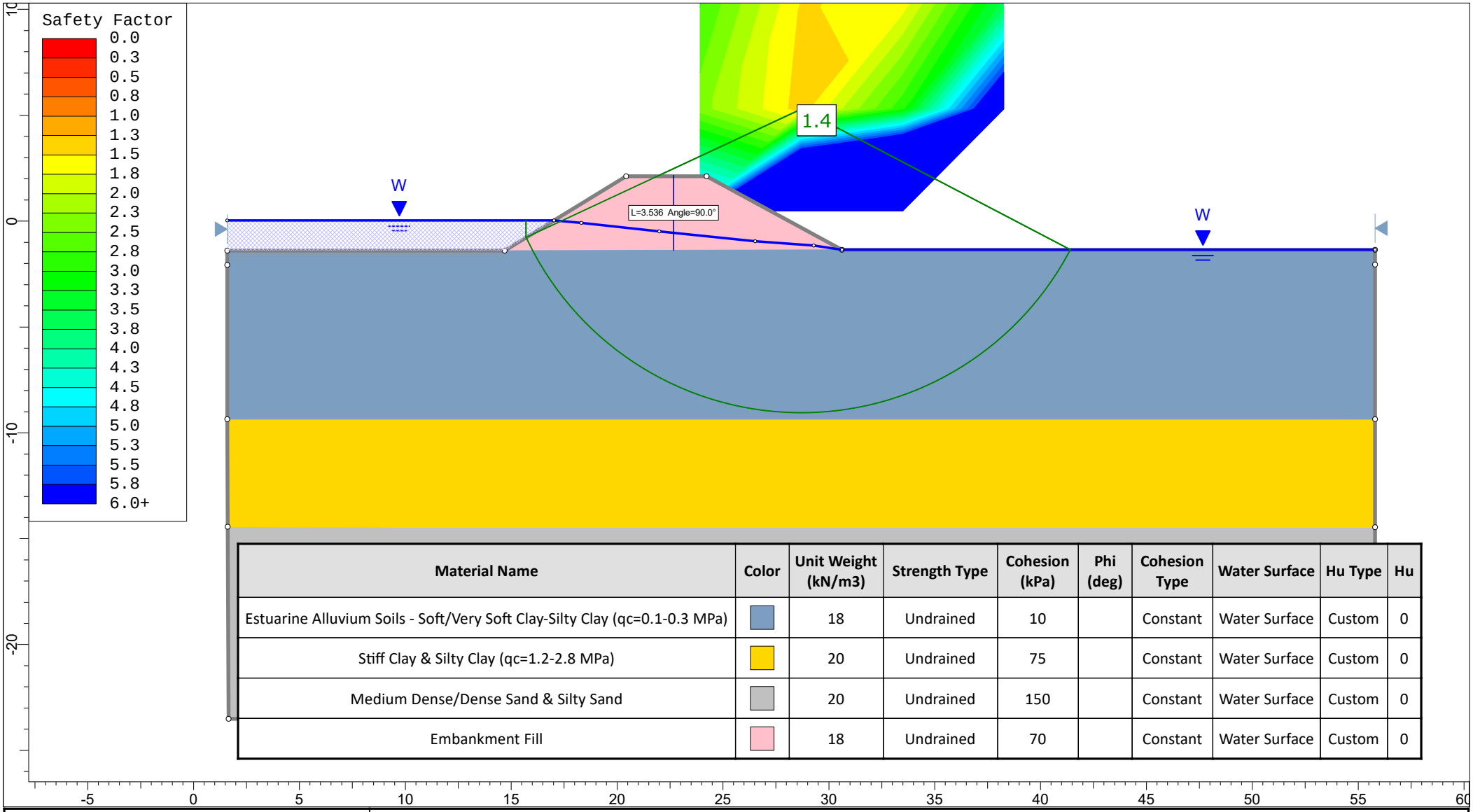

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10		Constant	Water Surface	Custom	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75		Constant	Water Surface	Custom	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150		Constant	Water Surface	Custom	0
Embankment Fill		18	Undrained	70		Constant	Water Surface	Custom	0

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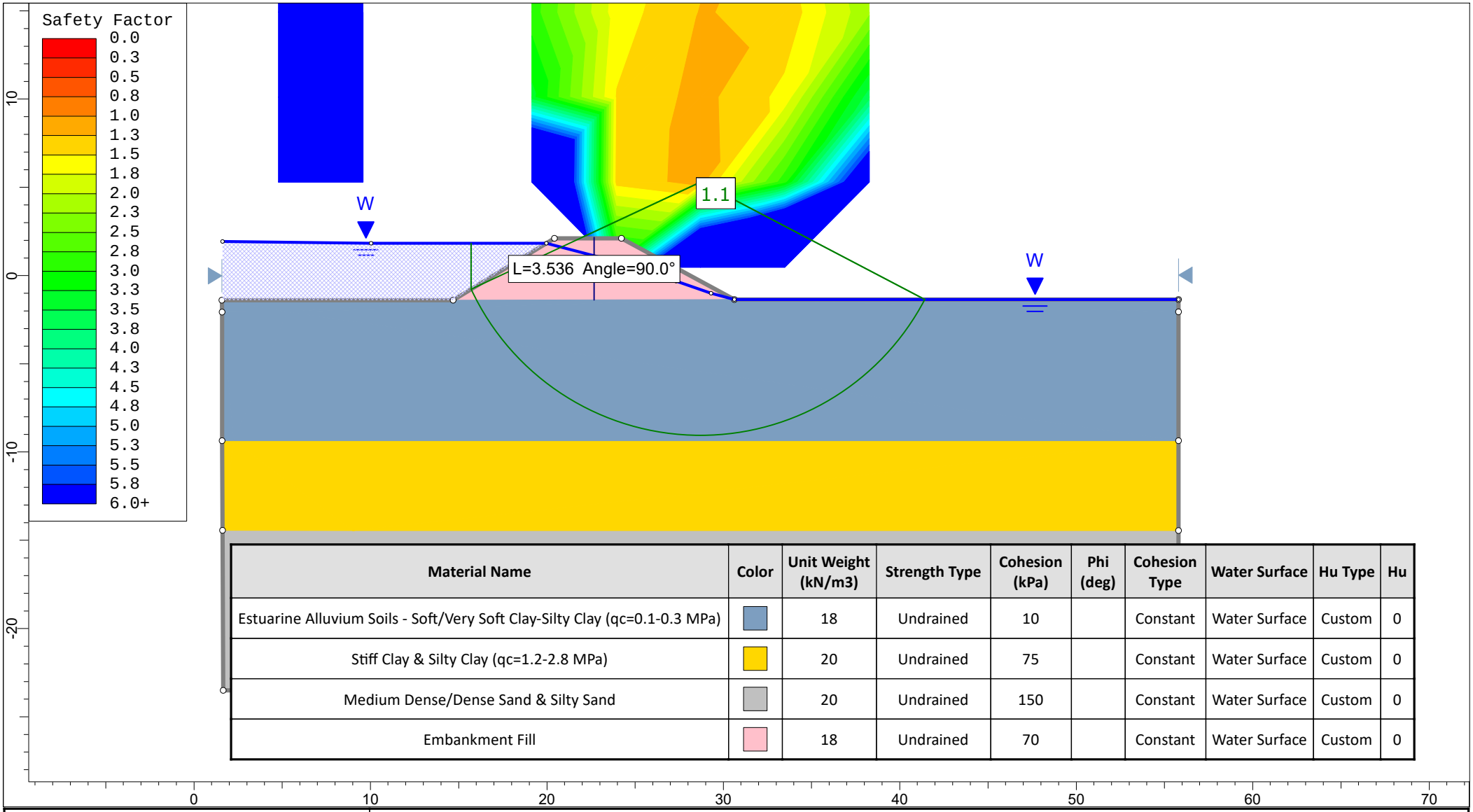
SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank (GW=1.5m, Scenario 1)		
Drawn By	SR	*Scale* 1:250	*Company* WSP - Opus International Consultants
Date	02/02/2018, 3:59:23 PM		*File Name* New Embankment - Static Conditions-Undrained-no GI (GW=1.5m, Scearip 1) - Copy slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10		Constant	Water Surface	Custom	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75		Constant	Water Surface	Custom	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150		Constant	Water Surface	Custom	0
Embankment Fill		18	Undrained	70		Constant	Water Surface	Custom	0

OPUS

SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank (GW=3.0m, Scenario 1)		
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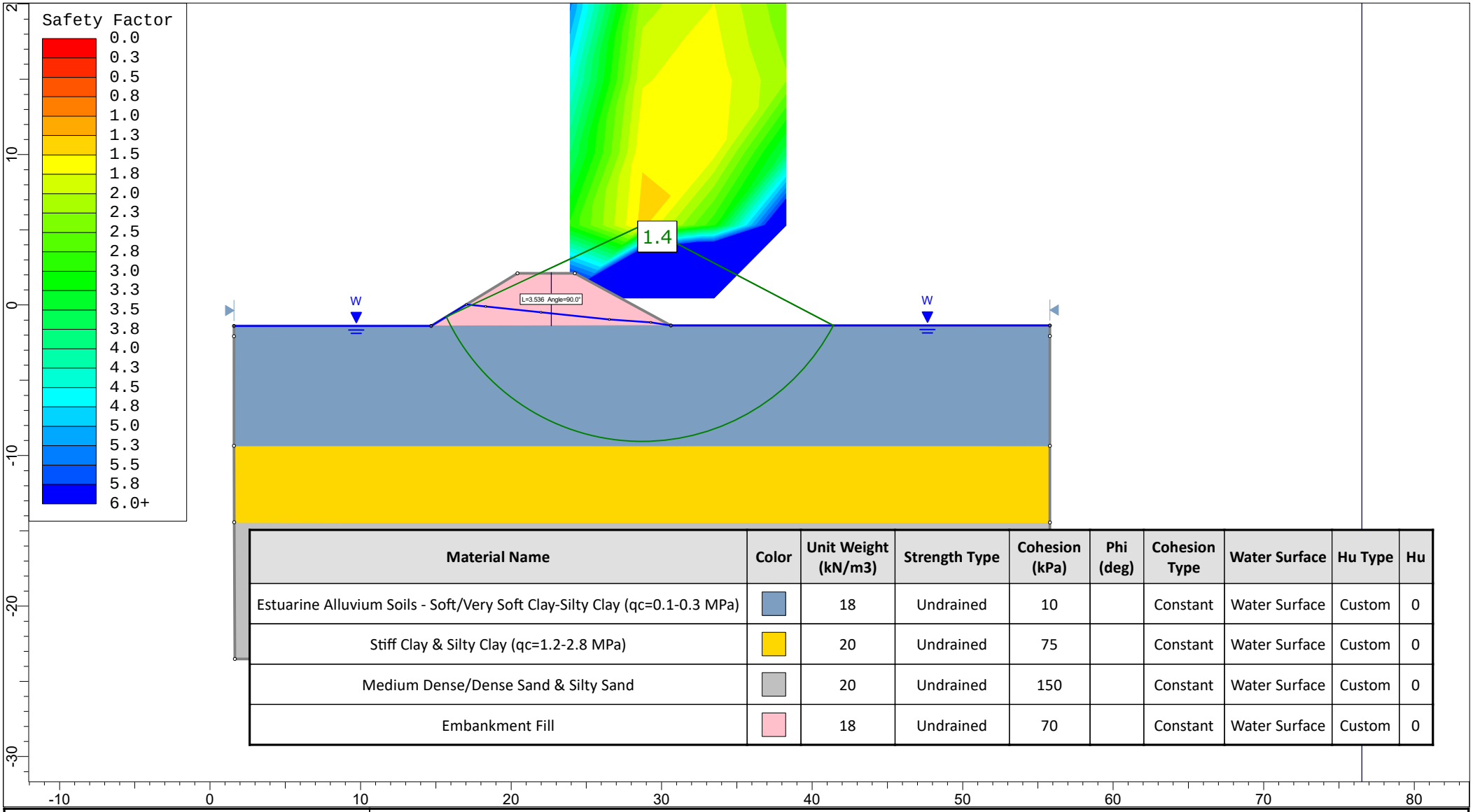

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10		Constant	Water Surface	Custom	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75		Constant	Water Surface	Custom	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150		Constant	Water Surface	Custom	0
Embankment Fill		18	Undrained	70		Constant	Water Surface	Custom	0

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank (GW=1.5m, Scenario 2)		
Drawn By	SR	*Scale* 1:352	*Company* WSP - Opus International Consultants
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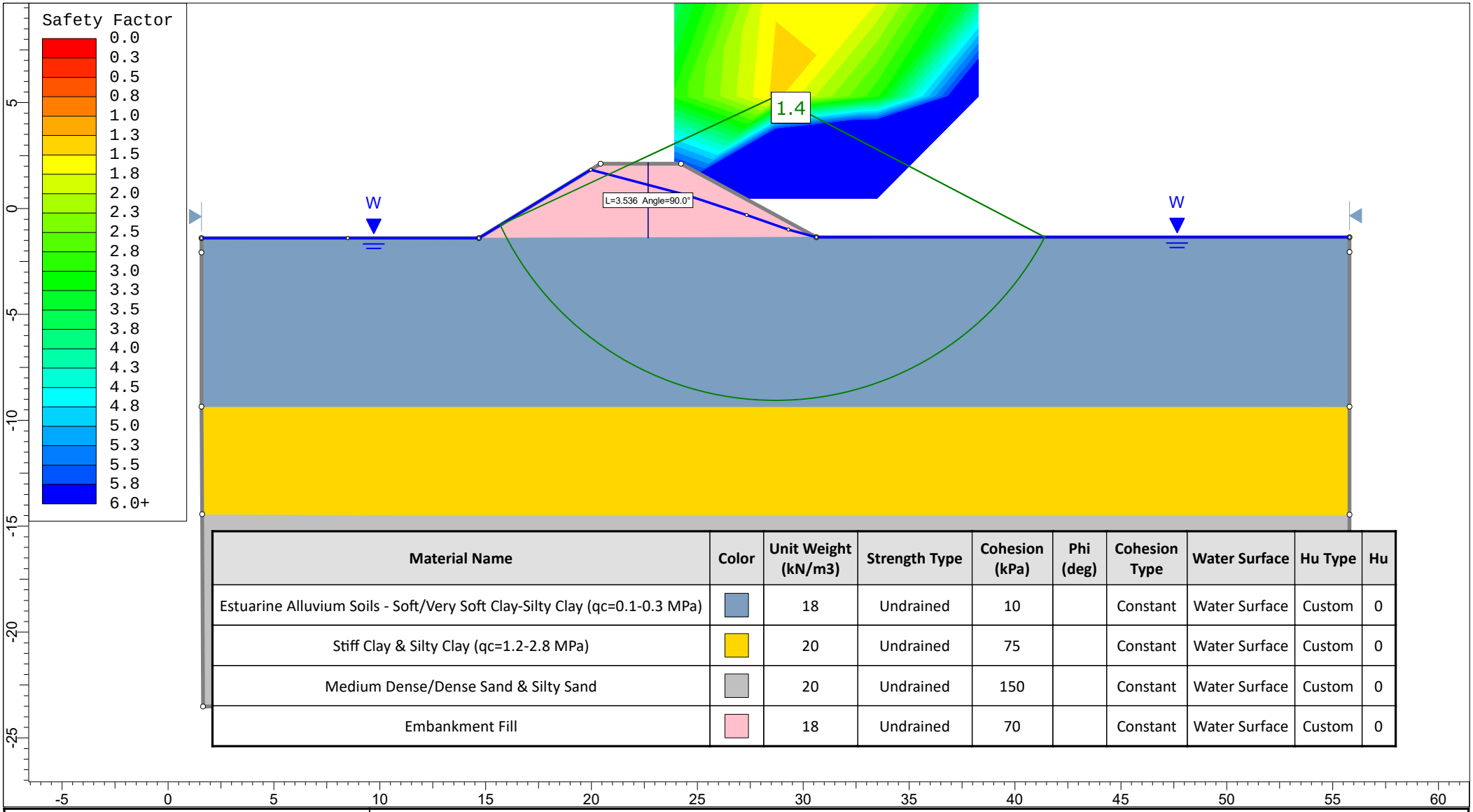

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Undrained	10		Constant	Water Surface	Custom	0
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Undrained	75		Constant	Water Surface	Custom	0
Medium Dense/Dense Sand & Silty Sand		20	Undrained	150		Constant	Water Surface	Custom	0
Embankment Fill		18	Undrained	70		Constant	Water Surface	Custom	0

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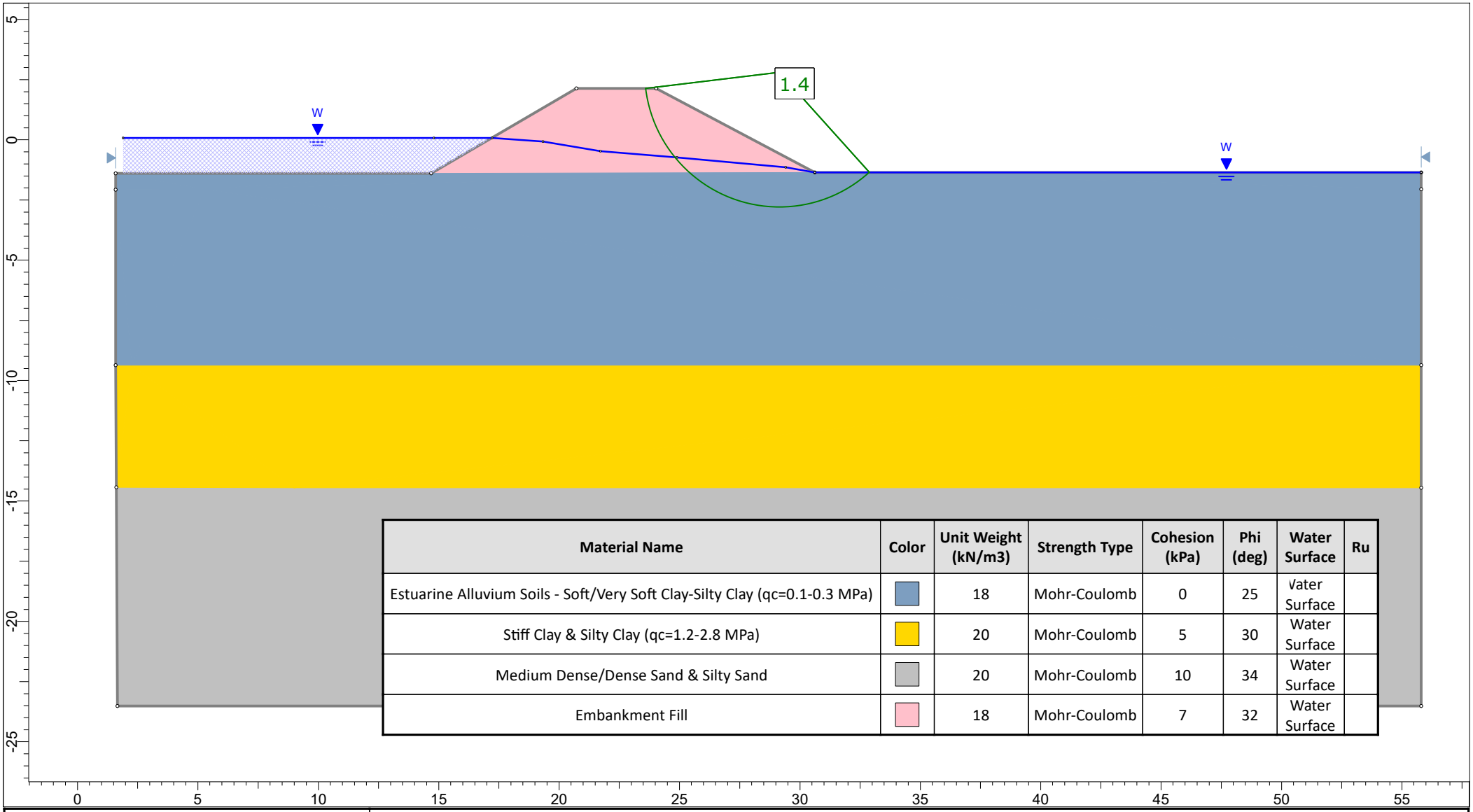
SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank (GW=3.0m, Scenario 2)		
Drawn By	SR	*Scale* 1:250	*Company* WSP - Opus International Consultants
Date	02/02/2018, 3:59:23 PM		*File Name* New Embankment - Static Conditions-Undrained-no GI (GW=3.0m, Scenario 2).slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	
Embankment Fill		18	Mohr-Coulomb	7	32	Water Surface	

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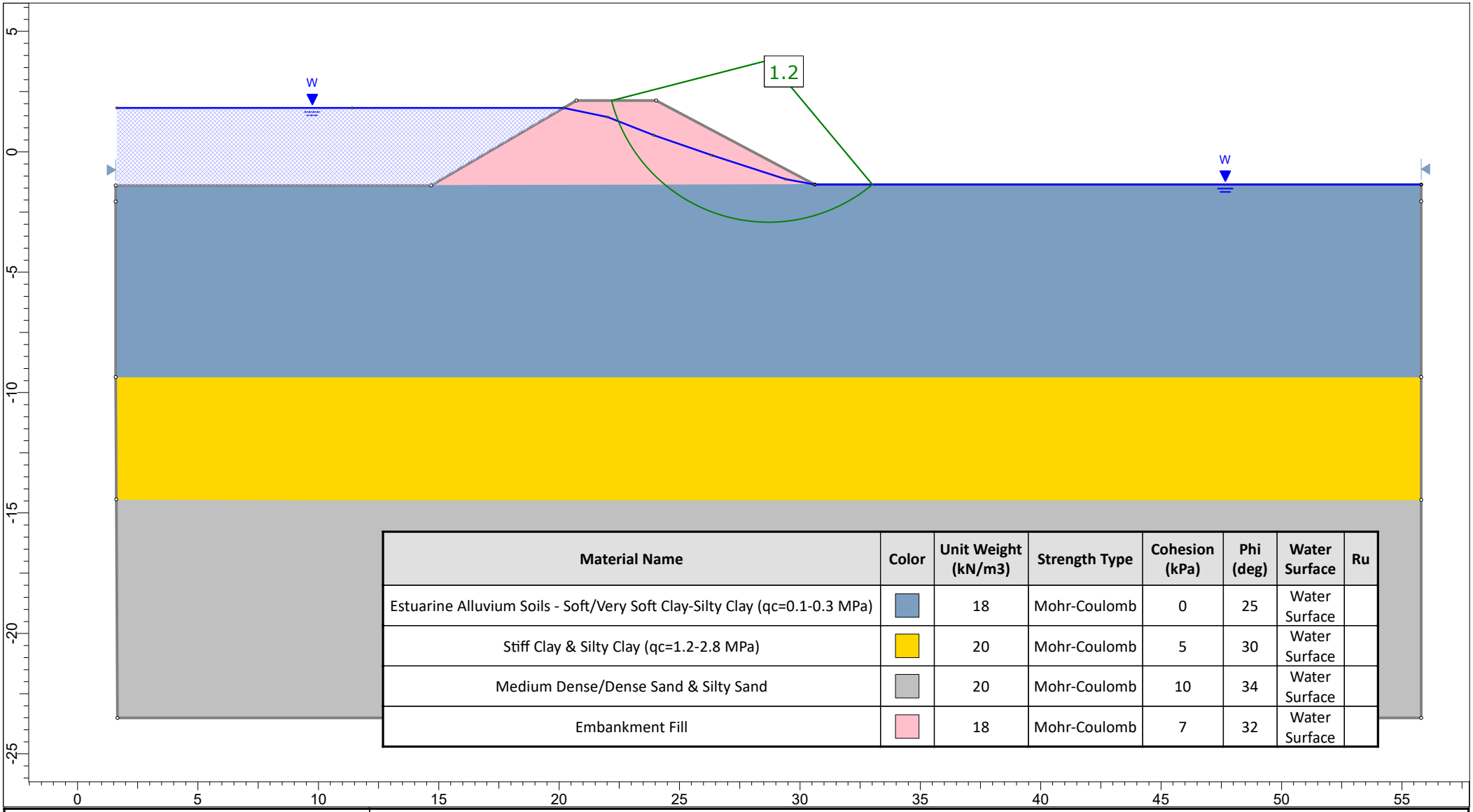
SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank no GI (GW=1.5m, Scenario 1)		
Drawn By	SR	*Scale* 1:220	*Company* WSP-Opus International Consultants
Date	23/08/2018, 3:59:23 PM		*File Name* New Embakment - Static-Drained-no GI (GW=1.5m, Scenario 1).slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	
Embankment Fill		18	Mohr-Coulomb	7	32	Water Surface	

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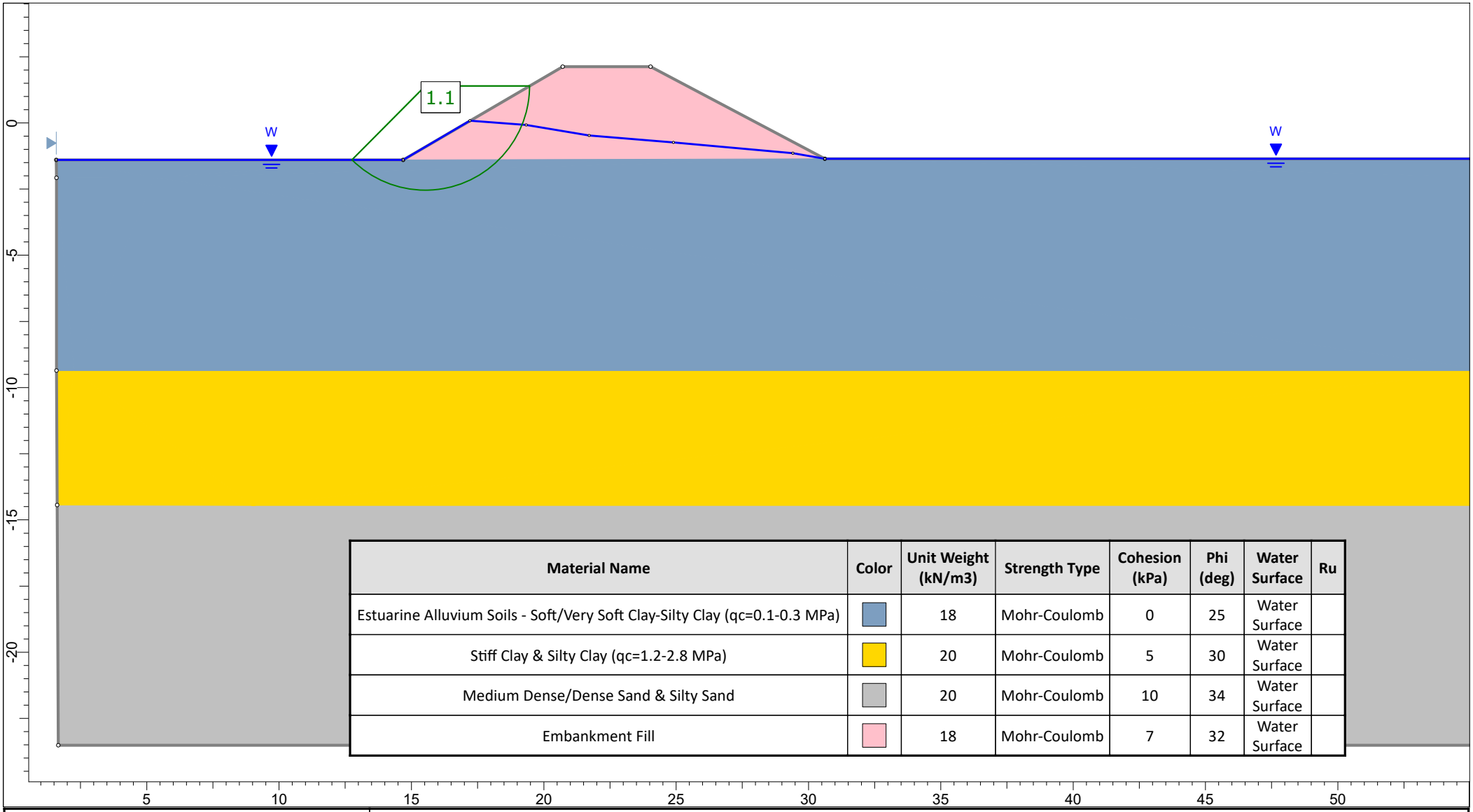
SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank no GI (GW=3.0m, Scenario 1)		
Drawn By	SR	*Scale* 1:220	*Company* WSP-Opus International Consultants
Date	23/08/2018, 3:59:23 PM		*File Name* New Embakment - Static-Drained-no GI (GW=3.0m, Scenario 1).slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	
Embankment Fill		18	Mohr-Coulomb	7	32	Water Surface	

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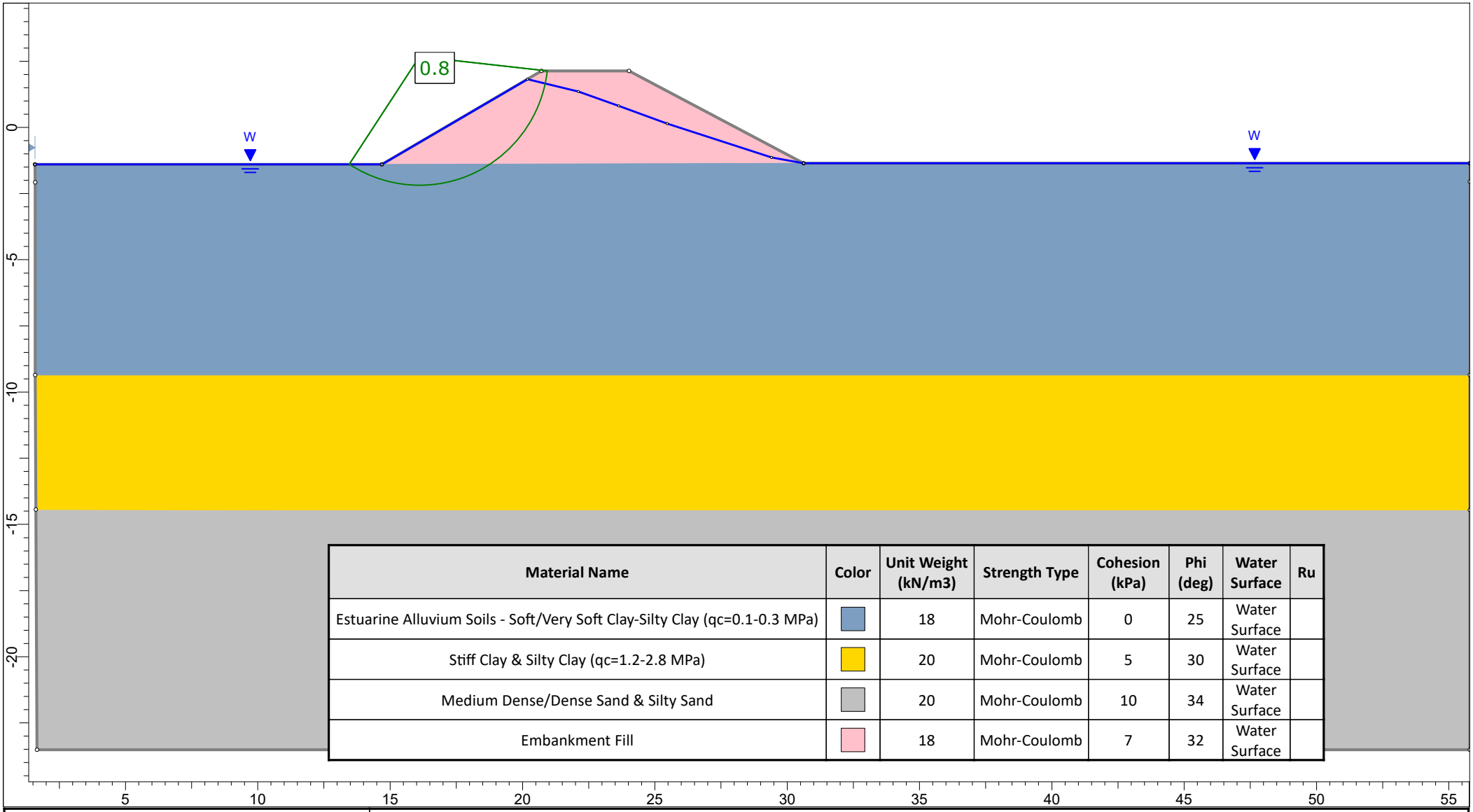
SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Short term - New Stop Bank no GI (GW=1.5m, Scenario 2)		
Drawn By	SR	*Scale* 1:200	*Company* WSP-Opus International Consultants
Date	23/08/2018, 3:59:23 PM		*File Name* New Embakment - Static-Drained-no GI (GW=1.5m, Scenario 2).slim



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Estuarine Alluvium Soils - Soft/Very Soft Clay-Silty Clay (qc=0.1-0.3 MPa)		18	Mohr-Coulomb	0	25	Water Surface	
Stiff Clay & Silty Clay (qc=1.2-2.8 MPa)		20	Mohr-Coulomb	5	30	Water Surface	
Medium Dense/Dense Sand & Silty Sand		20	Mohr-Coulomb	10	34	Water Surface	
Embankment Fill		18	Mohr-Coulomb	7	32	Water Surface	

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SLIDEINTERPRET 8.016

Project	Bowergate Farm		
Analysis Description	Static conditions - Long term - New Stop Bank no GI (GW=3.0m, Scenario 2)		
Drawn By	SR	*Scale* 1:200	*Company* WSP-Opus International Consultants
Date	23/08/2018, 3:59:23 PM		*File Name* New Embakment - Static-Drained-no GI (GW=3.0m, Scenario 2).slim

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Closure

Kaipara District Council

Dargaville