TECHNICAL MEMORANDUM

DATE 9 June 2020 1777197-056-M-Rev0

TO State Resource Development Manager, Alkina Holdings Pty Ltd

CC

FROM Michael Wade **EMAIL** MiWade@Golder.com.au

ADDENDUM TO GREAT SOUTHERN LANDFILL STABILITY ANALYSIS FOR LEACHATE POND, RETENTION POND AND STORMWATER DAM

1.0 INTRODUCTION

Alkina Holdings Pty Ltd (Alkina) proposes to construct and operate the Great Southern Landfill (GSL), located on Allawuna Farm lot 4869, Great Southern Highway, St Ronans (approximately 80 km east of Perth near the western boundary of the Shire of York).

Alkina has received comments from the Environmental Protection Agency (EPA) on the draft Environmental Review Document (ERD) submitted for Great Southern Landfill. EPA's comments included a total of 11 'required amendments' to the ERD, based on the EPA's Environmental Scoping Document (ESD) requirements.

This Technical Memorandum has been prepared to address 'required amendment 6', in which EPA have requested that additional information be provided on the geotechnical stability of the proposed leachate pond, retention pond and stormwater dam. The memorandum presents the results of additional stability analyses undertaken on these proposed components of the landfill and has been prepared as an addendum to the previous stability analysis documentation prepared for Great Southern Landfill (refer to Section 2.0).

The work was conducted in accordance with Golder Proposal 1777197-054-L-Rev1 dated 22 May 2020, which was authorised by Alkina in purchase order 09059, issued on 22 May 2020.

2.0 PREVIOUS STABILITY ANALYSIS DOCUMENTS

The following stability analysis documentation has been prepared for GSL:

- Stability Analysis and Liner System Integrity Assessment for Landfill Development (Golder, 2015a).
- Allawuna Farm Works Approval Application: W5830/2015/1 Further Information – Appendix J – Stability Assessment (Golder, 2015b).
- Works Approval Application – Desktop Assessment – Stability Assessment (Golder, 2017a).

The above documentation relates to the stability of the landfill cells, in particular the liner interface stability (capping and basal liner), waste stability and embankment and foundation stability. No previous stability analyses have been conducted for the leachate pond, retention pond or stormwater dam, as qualitative assessment of the geometry of the ponds and dam found there to be a low risk of failure.

Golder Associates Pty Ltd
Level 3, 1 Havelock Street West Perth, Western Australia 6005 Australia T: +61 8 9213 7600 +61 8 9213 7611

A.B.N. 64 006 107 857

3.0 REQUESTED STABILITY INFORMATION

The EPA has requested the following information regarding the stability of the proposed leachate pond, retention pond and stormwater dam in 'required amendment 6':

> *"Provide an assessment of the stability of the proposed leachate pond, retention pond or stormwater pond embankment designs, and an assessment of the geotechnical suitability of the proposed locations of these ponds."*

4.0 DESIGN OVERVIEW

4.1 Design Documents

The proposed design for the GSL, upon which these stability analyses are based, is presented in the design documentation, including:

- Design Report: Design Report – Great Southern Landfill Cell 1, Cell 2 and Ancillary Works (Golder, 2017b).
- Technical Specification: Great Southern Landfill – Technical Specification for Construction of Cell 1 and Ancillary Works (Golder, 2017c).
- Design Drawings: Great Southern Landfill – Cell 1 and 2 Design Drawings (Golder, 2017d).

4.2 Leachate Pond, Retention Pond and Stormwater Dam

The proposed designs for the leachate pond, retention pond and stormwater dam are detailed in the design documentation as outlined in Section 4.1. In summary, these structures are to comprise the following:

- Leachate Pond: A lined earthfill embankment pond (with no external catchment) to be constructed upstream of the landfill and downstream from the proposed infrastructure area, to store the leachate collected and pumped from the leachate collection sumps.
- Retention Pond: A lined earthfill embankment pond (with no external catchment) to be constructed in close proximity to the south corner of the GSL cells. This pond has been designed to store the liquid collected by the subsurface drainage system.
- Stormwater Dam: An un-lined earthfill embankment dam constructed on a creek line to store the stormwater runoff from the GSL upstream catchments areas. Clean stormwater runoff will be diverted to this pond during the operation of the landfill.

The locations of the leachate pond, retention pond and stormwater dam are shown in Figure 1.

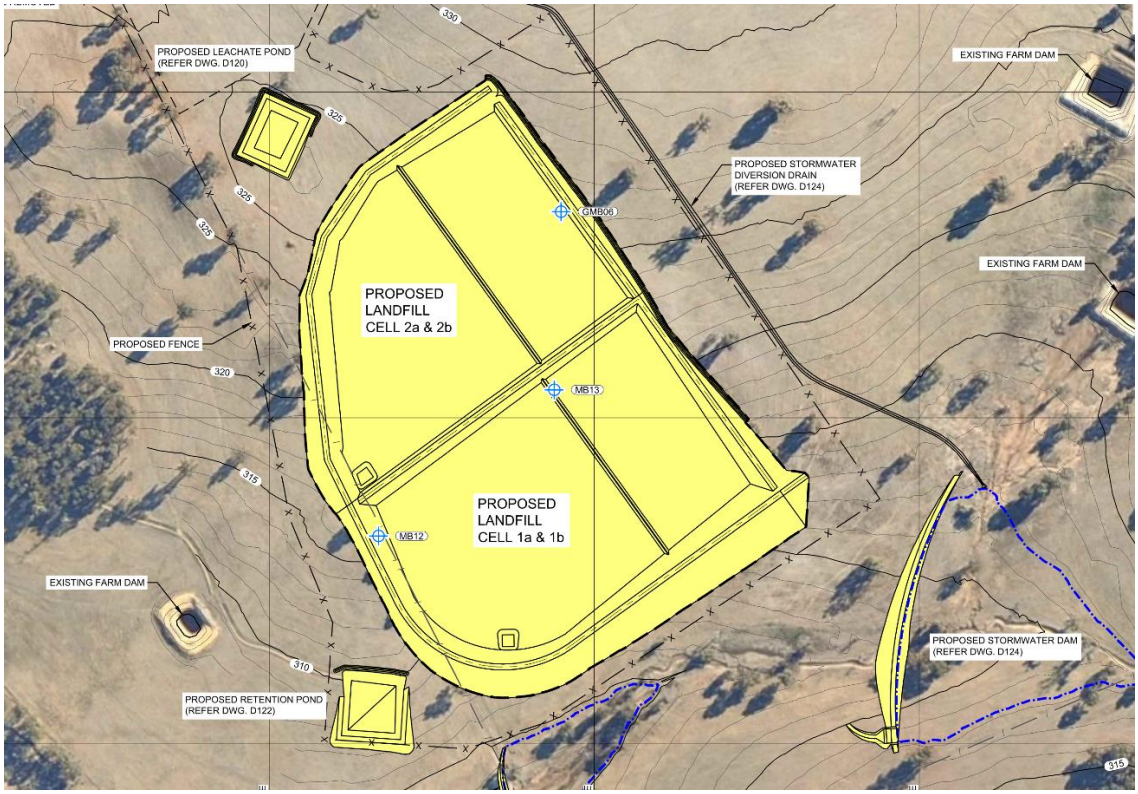


Figure 1: General Arrangement showing the location of the leachate pond, retention pond and stormwater dam (Golder, 2017d)

4.3 Hazard Category

The hazard category for the leachate pond, retention pond and stormwater dam were assessed in Golder (2017b) with reference to the ANCOLD “Guidelines on Assessment of the Consequences of Dam Failure” (ANCOLD, 2000). Based on the findings of the assessment, all three structures were designated a ‘very low’ hazard category.

5.0 FOUNDATION AND EMBANKMENT STABILITY ANALYSES

5.1 Approach

The global stability of the GSL leachate pond, retention pond and stormwater dam embankments and foundations were assessed using the 2D limit equilibrium slope stability analysis software SLIDE version 8.0 (Rocscience).

The analysis considered the situation where instability of the structure embankment or foundation soils results in loss of containment during the operational stage of the landfill (i.e. when the structures are expected to contain leachate/water).

A number of scenarios, boundaries and loading conditions were considered in the analyses. The sections considered to represent the highest risk of instability for each structure based on geometry and subsurface conditions were analysed using the Morgenstern-Price method.

5.2 Assumptions

The following assumptions have been made for the global stability analyses:

1) No reinforcement strength is provided by geosynthetic materials in tension.

2) The depth of refusal in the geotechnical field investigation report (Golder, 2017e) has been assumed to represent bedrock, which was considered to have infinite strength for the purposes of modelling.

5.3 Stability Model Inputs

5.3.1 Model Sections

One design cross-section was considered for the stability analyses for each of the three structures analysed. The identified sections were considered to represent the highest risk of instability for the structures based on geometry and subsurface conditions.

The sections used in the stability models are described as follows:

- Leachate Pond: This section extends approximately north to south through the southern perimeter embankment of the pond final landform, where the surrounding ground surface slopes down away from the structure.
- Retention Pond: This section extends approximately north to south through the southern perimeter embankment of the pond final landform, where the highest embankment height will be present.
- Stormwater Dam: This section extends approximately east to west through the centre of the final embankment landform, where the highest embankment height will be present.

The locations of the above sections are presented in Figures A1 to A3 in Attachment A.

5.3.2 Boundary and Loading Conditions

5.3.2.1 Phreatic Surface

The water level in the ponds/dam has been assumed to be at the maximum design levels of 324.5 m AHD[1] (leachate pond), 308.8 m AHD (retention pond) and 311.75 m AHD (stormwater dam), as applicable, for all scenarios except for the rapid draw-down scenario where it was assumed to be coincident with the base of the dam reservoir. For the leachate pond and retention pond analyses, the presence of water in the ponds was assumed to have negligible impact on pore pressures in the underlying soils due to the presence of the liner system and hence the rapid draw down scenario was not assessed.

Groundwater levels have been incorporated into the stability models based on the interpreted groundwater level contours presented in Golder (2017f).

5.3.2.2 Seismicity

To simulate the effect that a seismic event may have on the stability of the structures, a pseudo-static slope stability analysis has been undertaken. The site seismicity was reviewed in Golder (2017b) for the landfill cell stability analysis and the same peak ground acceleration (based on information attained from the *Atlas of Seismic Hazard Maps of Australia* (Leonard, Burbidge & Edwards, 2013) and horizontal seismic load coefficients have been adopted for the current analyses:

- Operating Basis Earthquake (OBE): 500 year return period, PGA 0.075g, which corresponds to a horizontal seismic load coefficient of approximately **0.094** (based on a site amplification factor of 1.25).
- Maximum Design Earthquake (MDE): 1000 year return period, PGA 0.125g, which corresponds to a horizontal seismic load coefficient of approximately **0.156** (based on a site amplification factor of 1.25).
- Maximum Credible Earthquake (MCE): 2000 year return period, PGA 0.200g, which corresponds to a horizontal seismic load coefficient of approximately **0.250** (based on a site amplification factor of 1.25).

[1] Australian Height Datum

The OBE event was applied to the ponds and dam structures.

5.3.3 Scenarios

The scenarios listed in Table 1 were considered as part of the stability analyses.

Table 1: Scenarios considered in the stability analyses

Scenario		Description
1	Operational geometry, Static, Maximum design water level	Assess the stability of the structures during normal operational conditions.
2	Operational geometry, Earthquake (OBE seismic load), Maximum design water level	Assess the impact of a seismic event on the stability of the structures during operational conditions.
3	Operational geometry, Static, Rapid draw-down Note: Stormwater dam only	Assess the impact of a rapid draw-down event on the stability of the stormwater dam during operational conditions.

5.3.4 Material Parameters

The findings of the geotechnical field investigation (Golder, 2017e) indicate that the subsurface conditions underlying the leachate pond, retention pond and stormwater dam, and the proposed embankment fill materials, will be generally consistent with that for the landfill cells. The material parameters used in the previous assessments (refer to Section 2.0) have therefore been adopted for the current analysis and summarised in Table 2.

Table 2: Summary of material parameters for geotechnical stability analyses (after Golder, 2015a)

Parameter		Material		
		Embankment and Subgrade[1]	*In Situ* Soil[2]	Bedrock[3]
Unit Weight (kN/m^3)	Unsaturated	18.5	18.5	-
	Saturated	22	22	
Drained	Cohesion/Adhesion (kPa)	5	5	-
	Friction Angle (degrees)	28	28	-

Notes: [1]Parameters for compacted Sandy Clay/Clayey Sand based on laboratory testing results.
[2]Parameters for uncompacted (i.e. *in situ*) Sandy Clay/Clayey Sand based laboratory testing results
[3]Material assumed as bedrock considered to have infinite strength for the purposes of modelling.

5.3.5 Minimum Factor of Safety

The minimum acceptable factors of safety (FoS) used to assess the outcome of the stability analyses for the structures were determined based on typical values used internationally earth structures and experience with similar projects in Australia. Currently, there are no specific requirements or guidelines from the Western Australian regulatory authorities.

Minimum factors of safety were applied in the stability analysis as follows:

- FoS of 1.5 or greater to provide acceptable stability under static loading; this has been applied for operational conditions that may be present for the operating life of the landfill containment facilities.
- FoS of 1.1 or greater to provide acceptable stability under earthquake loading, where the structure is subject to an OBE event.
- FoS of 1.1 or greater to provide acceptable stability under static loading, where the structure is subject to a rapid draw-down event (stormwater dam only).

5.4 Results of the Stability Analyses

A summary of the results of the stability analyses (i.e. minimum FoS) for each scenario are shown in Table 3. Figures showing these results (i.e. output figures) are presented in Attachment B.

Table 3: Summary of results for the foundation and embankment stability analyses

Scenario		Minimum FoS	Calculated FoS	Output Figures
Leachate Pond				
1	Operational, Static	1.5	7.8	B1
2	Operational, Earthquake (OBE)	1.1	4.8	B2
Retention Pond				
1	Operational, Static	1.5	3.1	B3
2	Operational, Earthquake (OBE)	1.1	2.3	B4
Stormwater Dam				
1	Operational, Static	1.5	1.9	B5
2	Operational, Earthquake (OBE)	1.1	1.4	B6
3	Operational, Rapid Draw-down	1.1	1.3	B7

6.0 OUTCOME

The foundation and embankment stability analyses undertaken for the leachate pond, retention pond and stormwater dam show acceptable factors of safety for the scenarios analysed. Based on the analyses the leachate pond, retention pond and stormwater dam are suitably located in regard to the underlying geology and materials on the site.

7.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled – "Important Information Relating to this Report", which is included in Attachment C of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

GOLDER ASSOCIATES PTY LTD

Michael Wade	Liza du Preez	Darren Webb
Geotechnical Engineer	*Principal Landfill Engineer*	*Associate, Principal Civil Engineer*

Attachments: A – Section Lines
B – Stability Analysis Output
C – Important Information

MW+LDP/DW/ds

https://golderassociates.sharepoint.com/sites/101511/shared documents/06 deliverables/correspondence out/056 - stability addendum/1777197-056-m-rev0 stability addendum.docx

REFERENCES

ANCOLD 2000. Guidelines on Assessment of the Consequences of Dam Failure. Australian National Committee on Large Dams, May 2000.

Golder 2015a. Allawuna Farm Landfill – Stability Analysis and Liner System Integrity Assessment for Landfill Development. Golder (ref. 47651033-012-R-Rev0), Perth, March 2015.

Golder 2015b. Addendum to the Allawuna Farm Landfill Works Approval Application – Landfill Stability. Golder (ref. 147651033-025-M-RevA), Perth, 14 July 2015.

Golder 2017a. Works Approval Application – Desktop Assessment – Stability Assessment. Golder (ref. 1777197-030-M-Rev0), Perth, 23 October 2017.

Golder 2017b. Design Report: Great Southern Landfill Cell 1, Cell 2 and Ancillary Works. Golder (ref. 1777197-019-R-Rev3, Perth, October 2017.

Golder 2017c. Great Southern Landfill: Technical Specification for Construction of Cell 1 and Ancillary Works. Golder (ref. 1777197-012-R-Rev1), Perth, September 2017.

Golder 2017d. Great Southern Landfill – Cell 1 and 2 Design Drawings (RevC, IFT). Golder (ref. 1777197-012-R), Perth, 15 September 2017.

Golder 2017e. Works Approval Application – Supporting Geotechnical Information. Golder (ref. 1777197-003-M-Rev0), Perth, 19 July 2017.

Golder 2017f. Hydrogeological Site Characterisation – Great Southern Landfill. Golder (ref. 1777197-008-R-Rev1), Perth, September 2017.

ATTACHMENT A

Section Lines

SECTION LINES

Leachate Pond

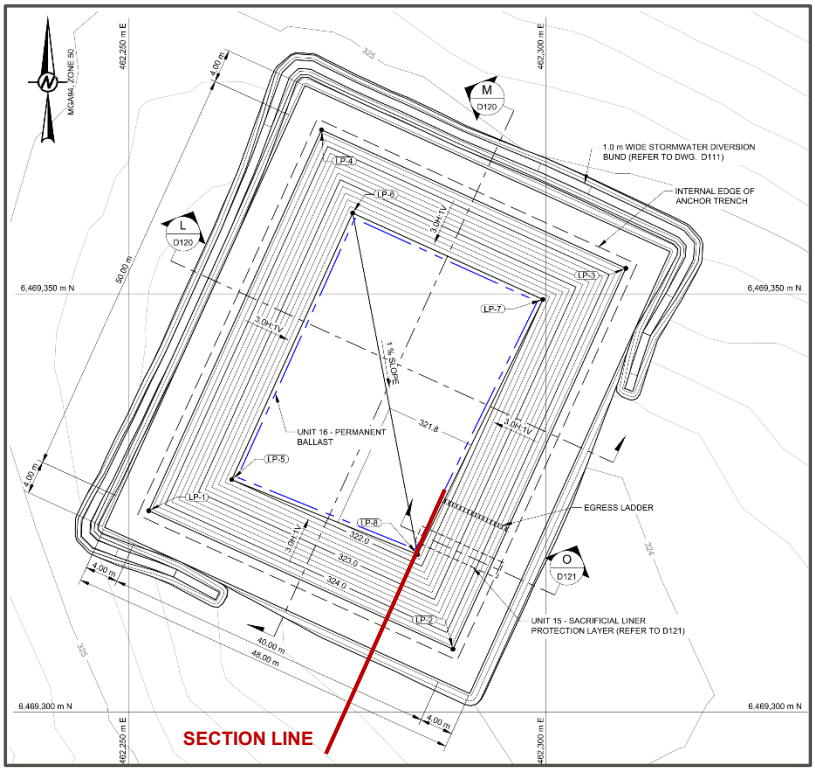


Figure A1: Approximate location of the section line for the leachate pond stability analysis

Retention Pond

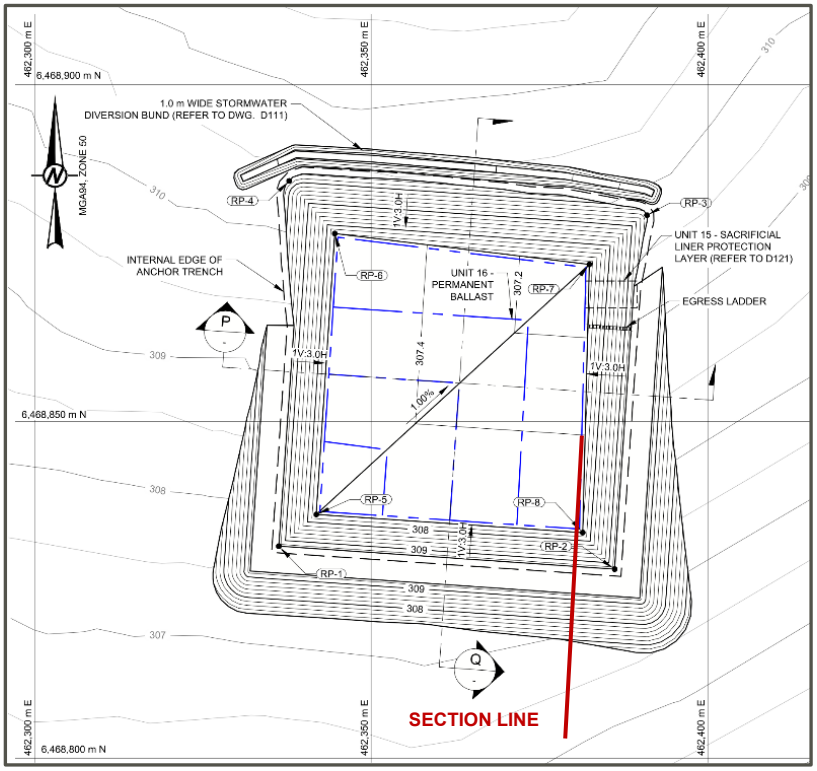


Figure A2: Approximate location of the section line for the retention pond stability analysis

Stormwater Pond

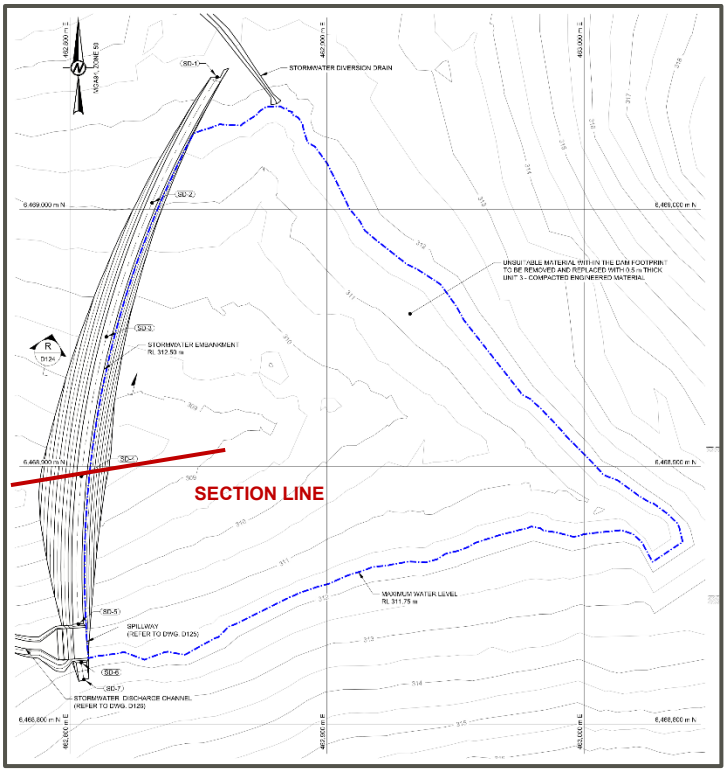
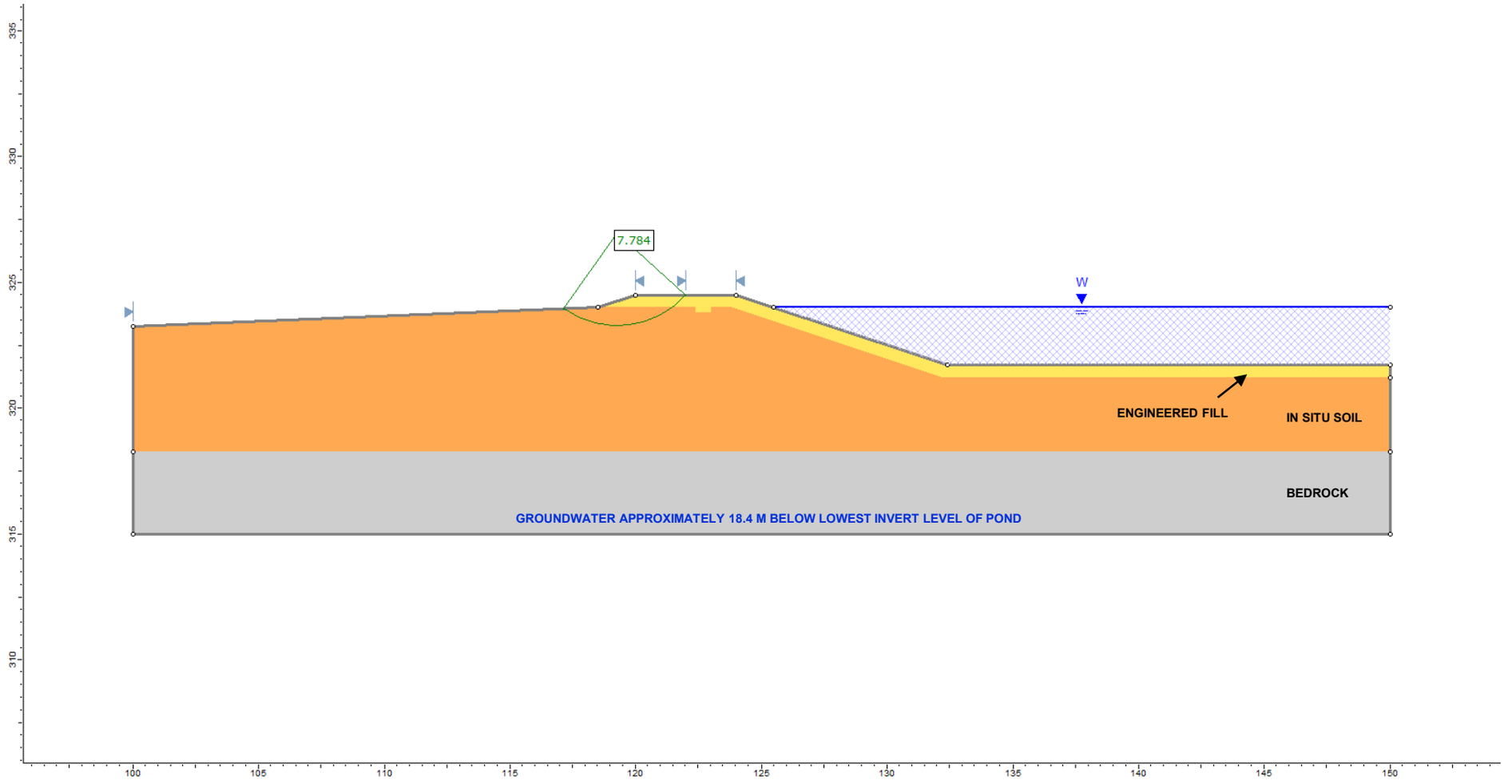


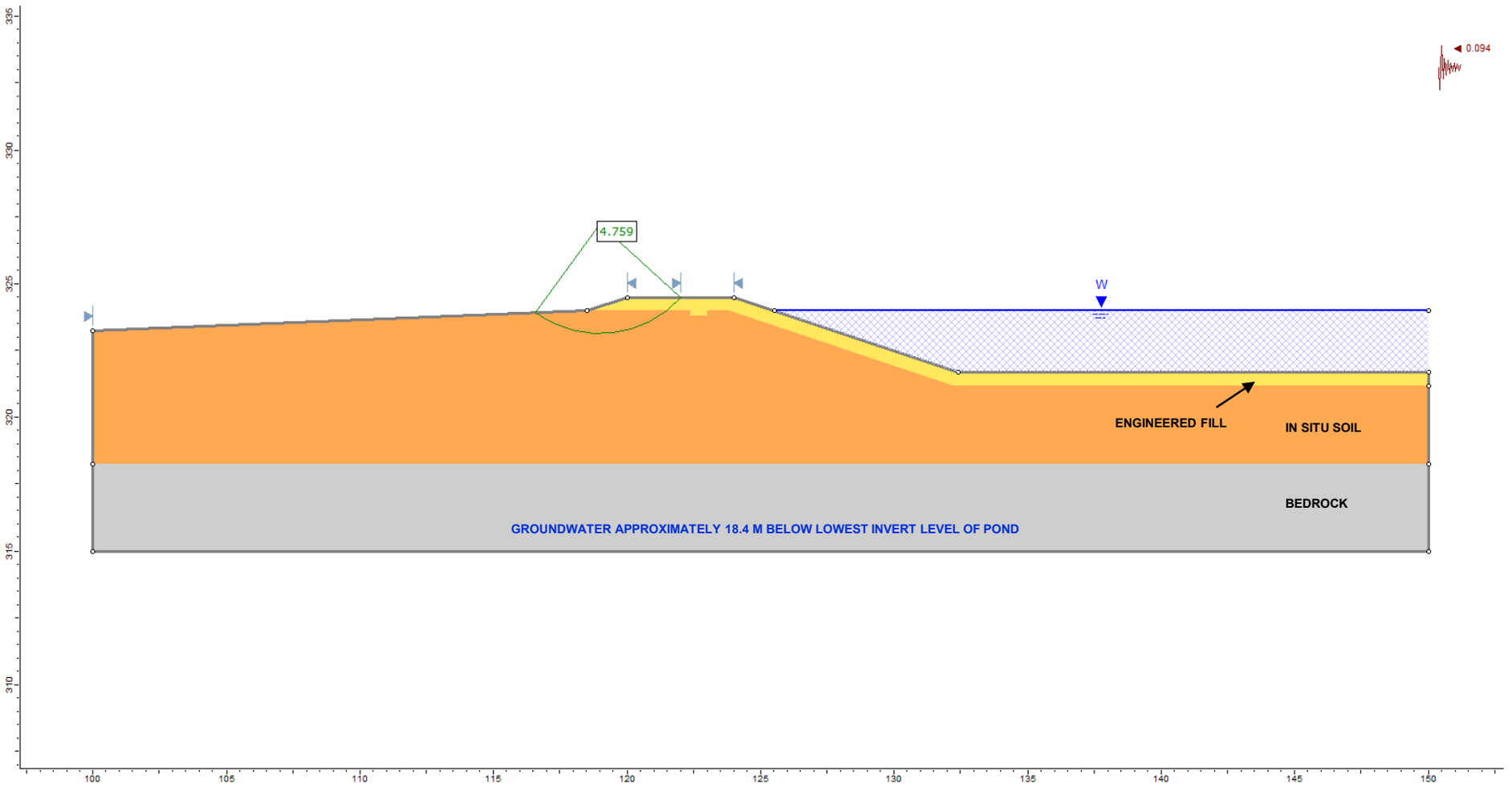
Figure A3: Approximate location of the section line for the stormwater dam stability analysis

ATTACHMENT B

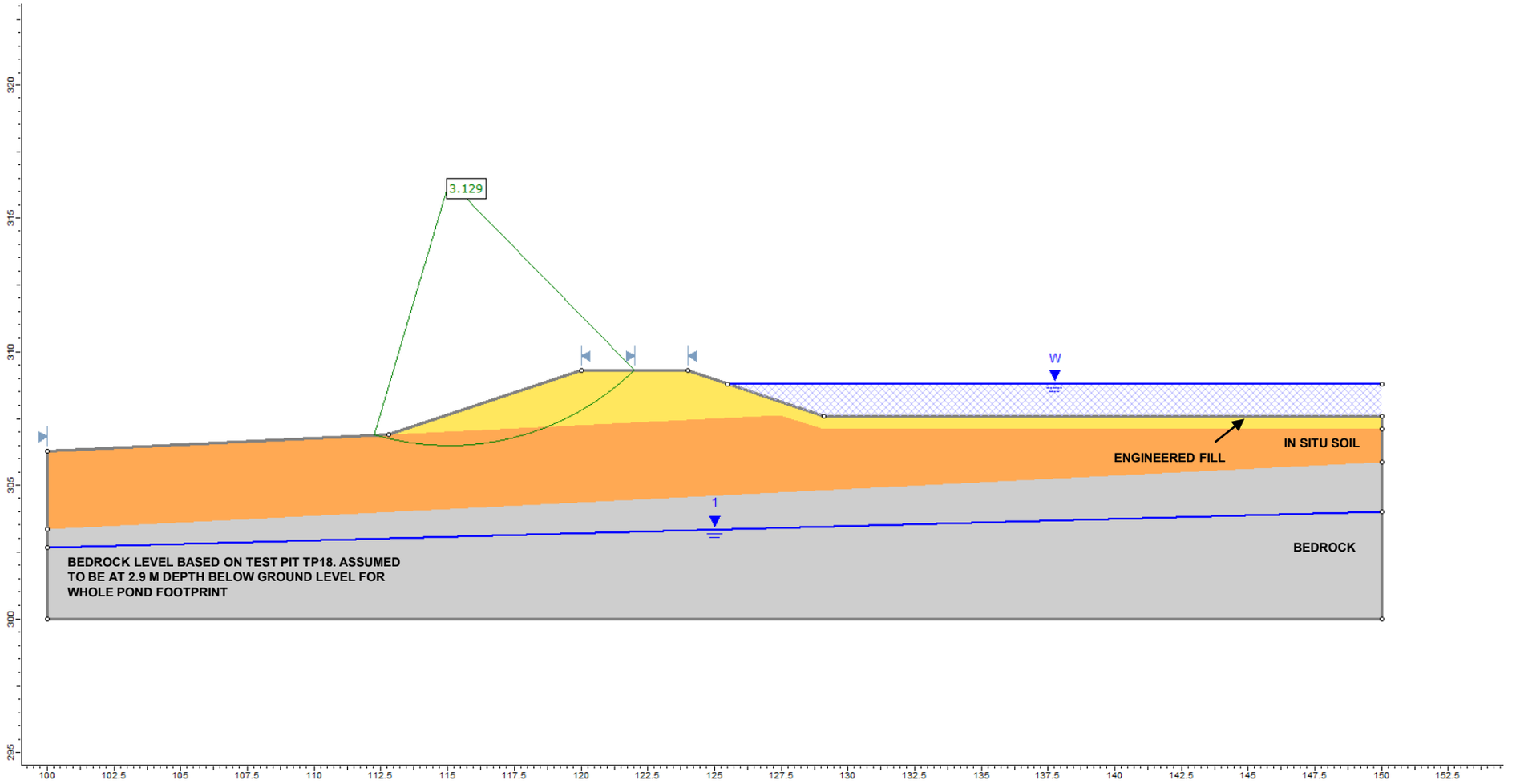
Stability Analysis Output



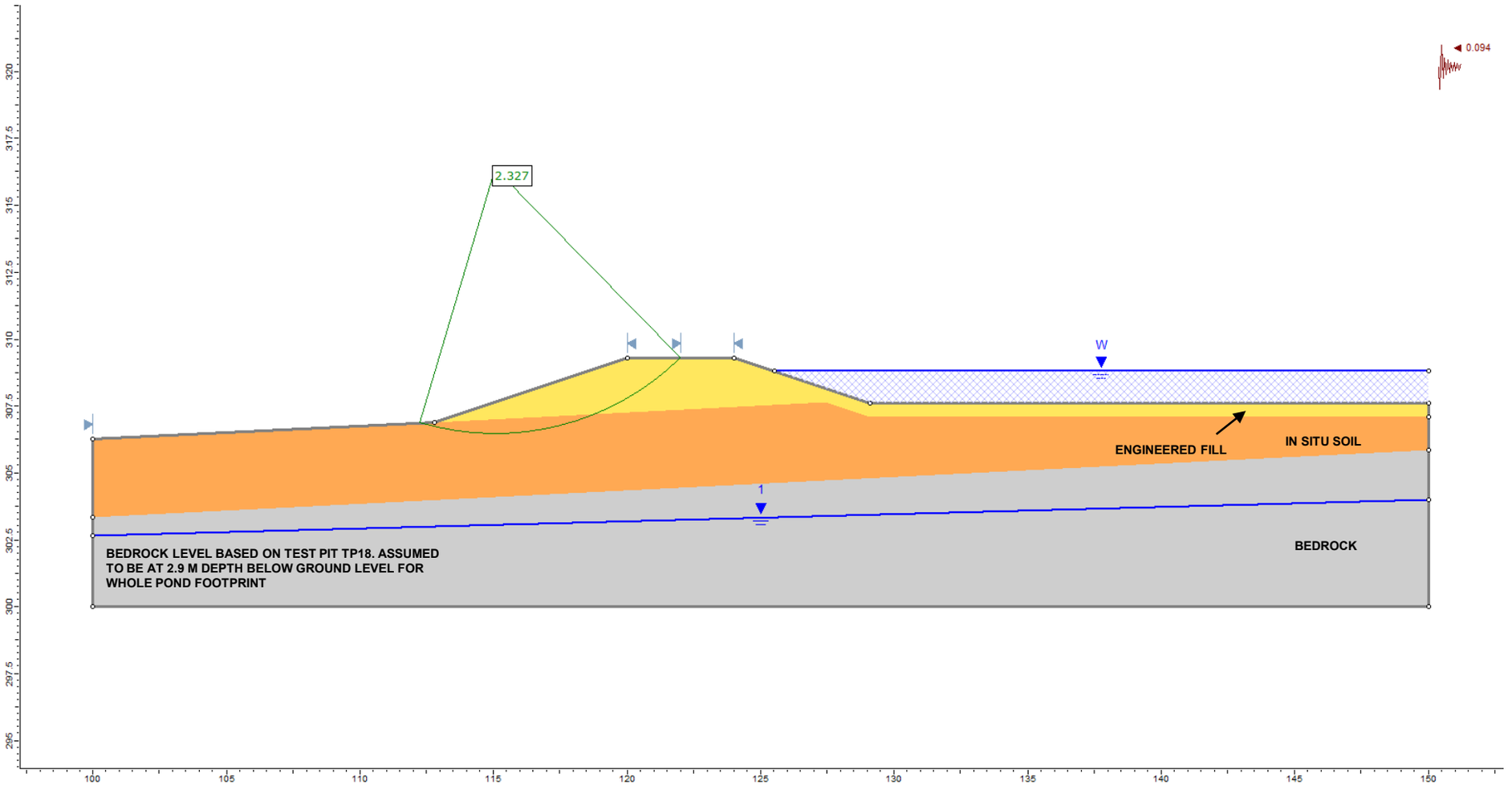
GOLDER	CLIENT	Alkina Holdings Pty Ltd		PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN	MW	DATE 05/06/2020	TITLE	Leachate Pond – Scenario 1
	CHECKED		DATE		
	SCALE	NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B1



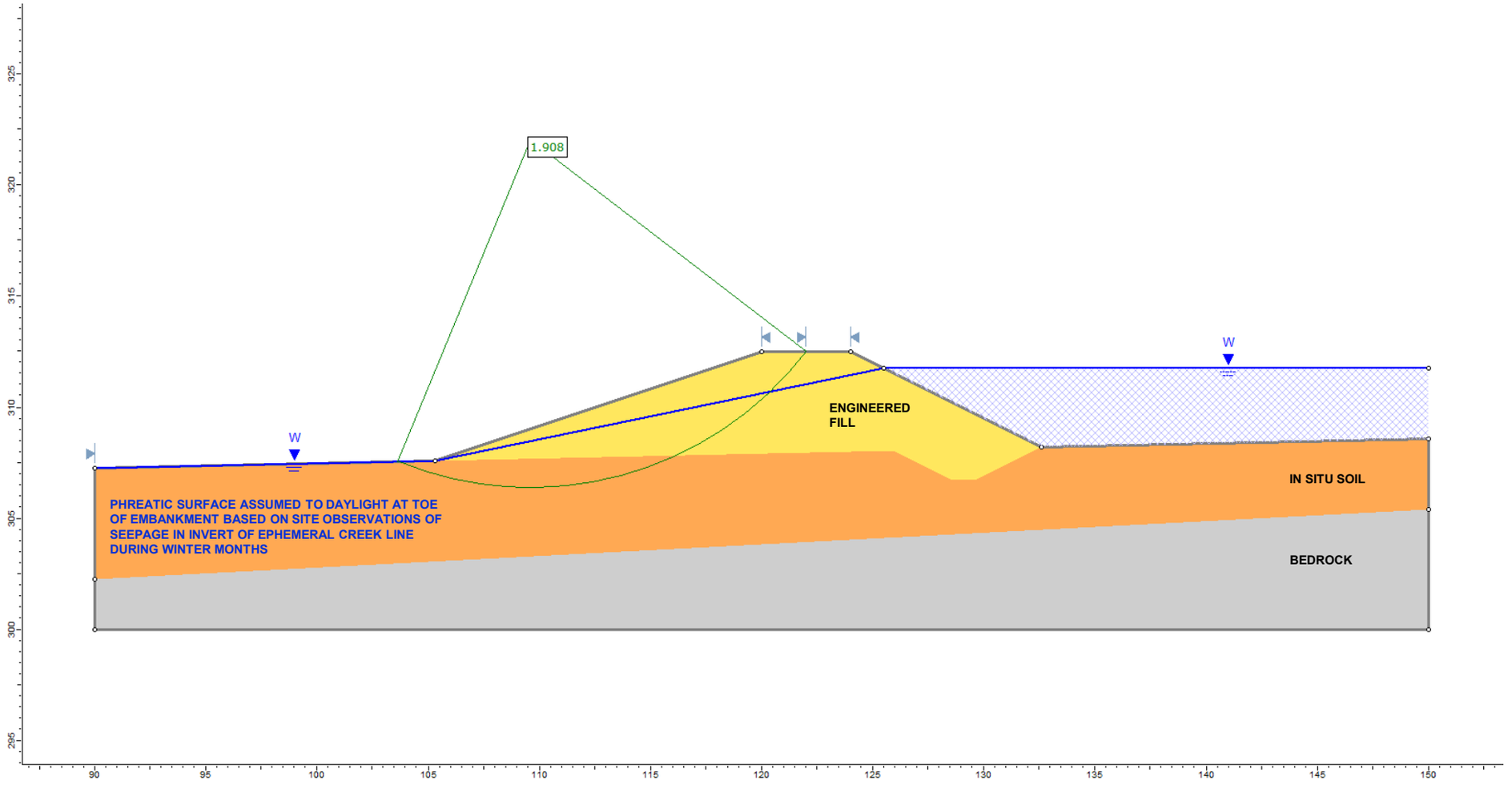
GOLDER	CLIENT	Alkina Holdings Pty Ltd		PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN	MW	DATE 05/06/2020	TITLE	Leachate Pond – Scenario 2
	CHECKED		DATE		
	SCALE	NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B2



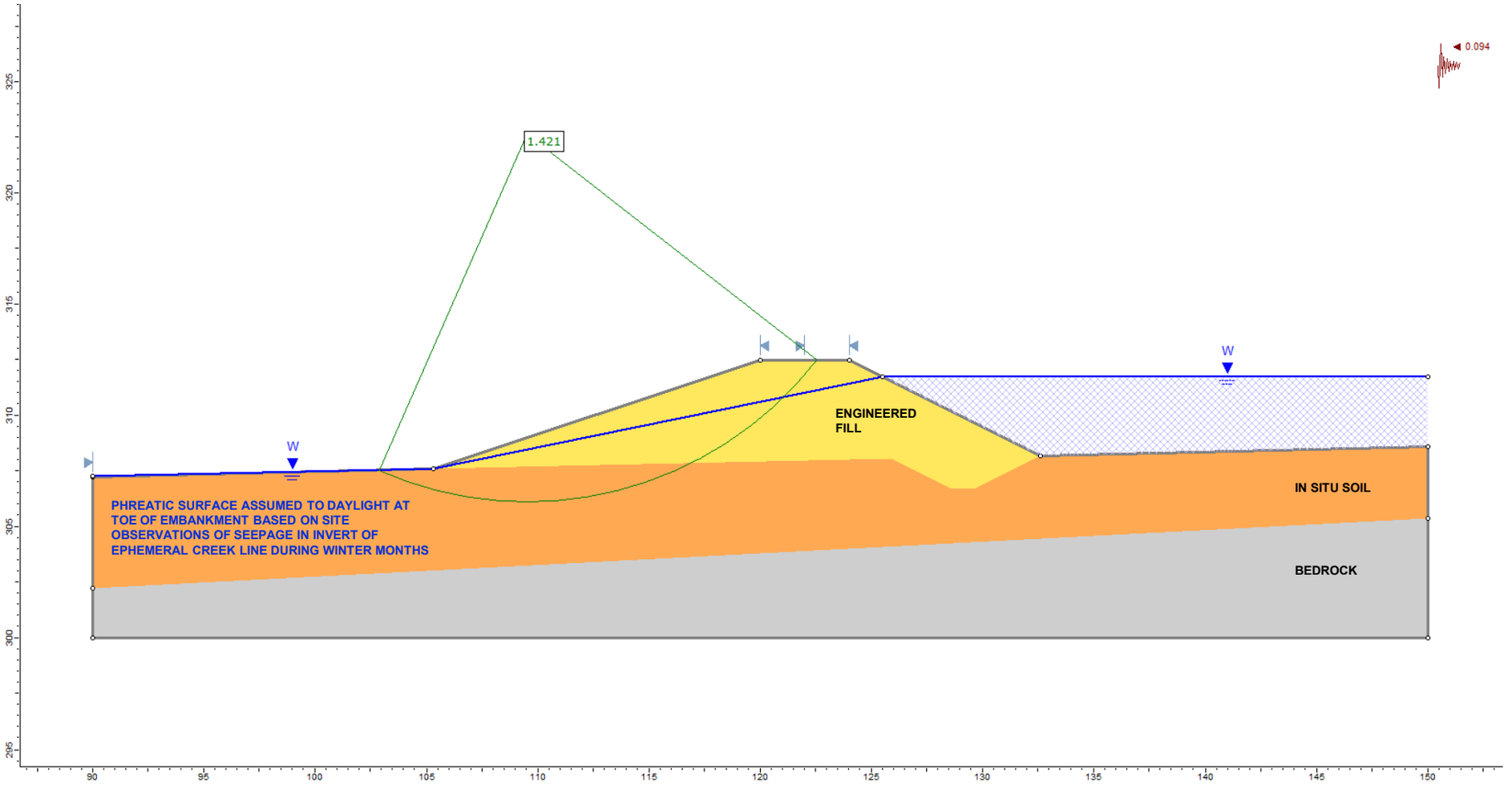
GOLDER	CLIENT	Alkina Holdings Pty Ltd		PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN	MW	DATE 05/06/2020	TITLE	Retention Pond – Scenario 1
	CHECKED		DATE		
	SCALE	NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B3



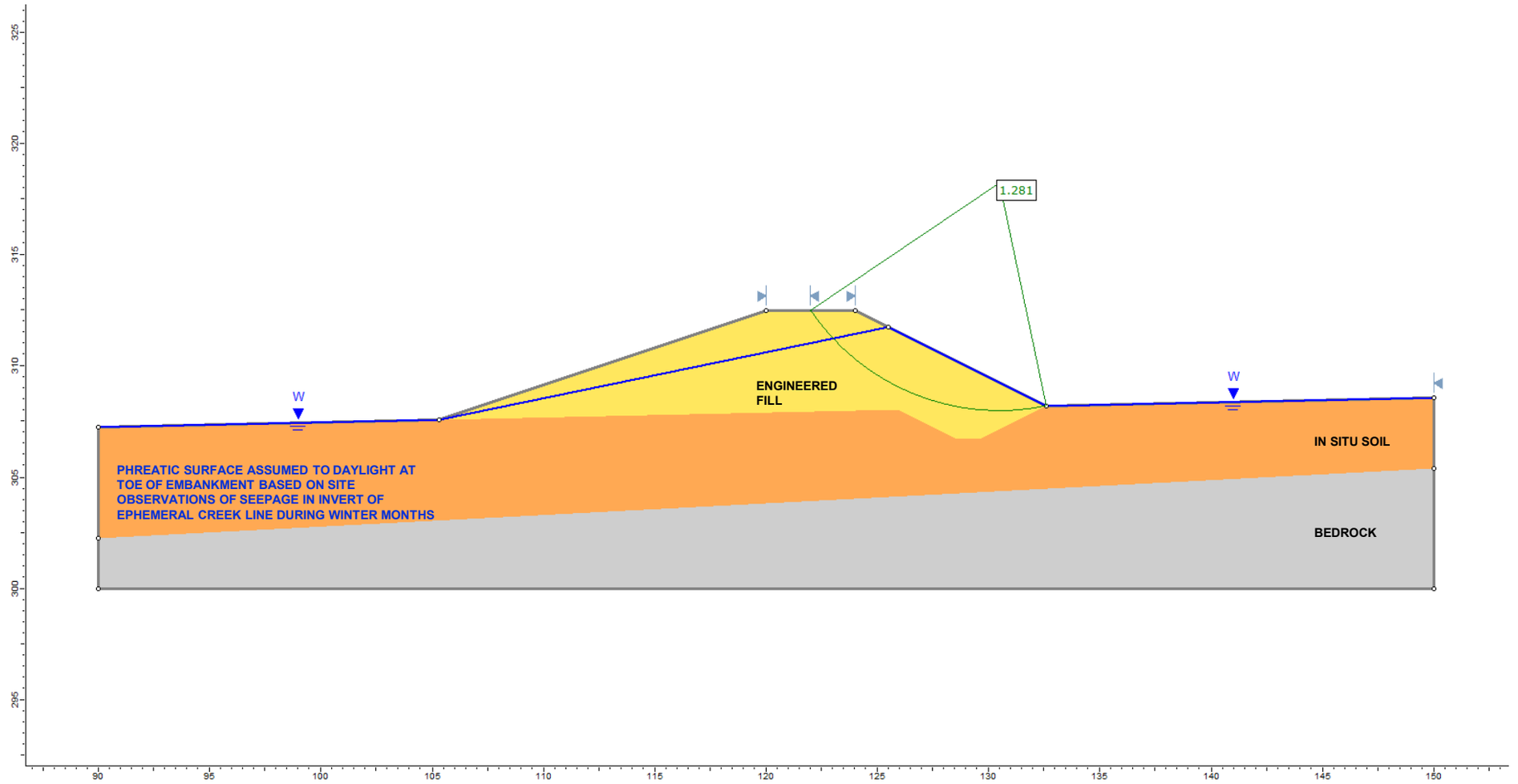
GOLDER	CLIENT	Alkina Holdings Pty Ltd		PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN	MW	DATE 05/06/2020	TITLE	Retention Pond – Scenario 2
	CHECKED		DATE		
	SCALE	NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B4



GOLDER	CLIENT	Alkina Holdings Pty Ltd		PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN	MW	DATE 05/06/2020	TITLE	Stormwater Dam – Scenario 1
	CHECKED		DATE		
	SCALE	NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B5



GOLDER	CLIENT	Alkina Holdings Pty Ltd	PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN MW	DATE 05/06/2020	TITLE	Stormwater Dam – Scenario 2
	CHECKED	DATE		
	SCALE NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B6



GOLDER	CLIENT	Alkina Holdings Pty Ltd		PROJECT	Great Southern Landfill – Stability Addendum
	DRAWN	MW	DATE 05/06/2020	TITLE	Stormwater Dam – Scenario 3
	CHECKED		DATE		
	SCALE	NTS	A4	PROJECT No 1777197-056-M-Rev0	FIGURE No Figure B7

ATTACHMENT C

Important Information

The document ("Report") to which this page is attached and of which this page forms a part has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.