



28 September 2012

CONCEPT DESIGN REPORT

Expansion of Pasminco Cockle Creek Smelter Containment Cell

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REPORT



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Executive Summary

This report presents a concept design for expansion of the PCCS containment cell to provide increased cell storage volume, referred to as 'airspace', to contain IFL site materials. The expansion design comprises a revised containment cell landform that provides an increased airspace of 450,000 cu.m. through raising the top of the cell by 3 to 4 m. The expansion design does not involve any changes to the cell footprint or the slope angle of the cell batters.

The IFL site materials proposed to be placed within the PCCS containment cell are substantially similar to the PCCS site materials. No detrimental effects are foreseen with comingling of the materials.

The effects of the expansion design on the components of the containment cell are summarised in Table 1.

Table 1: Effects of Expansion Design on Containment Cell Components

Cell Component	Overall Effects of Cell Expansion Design
Surface water mgmt. - runoff originating external to cell	<ul style="list-style-type: none">External surface water management design and operation remains the same because cell footprint unchanged.
Surface water mgmt. - runoff from cell	<ul style="list-style-type: none">Surface water management features on cell require realignment to suit the new landform.The design philosophy for surface water management on the cell remains the same.An additional bench has been designed on the western cell batter to manage surface water flow.
Groundwater cutoff drain	<ul style="list-style-type: none">Cutoff drain design (i.e., drain alignment and depth) and operation remains the same because cell footprint unchanged.No significant effect on amount of groundwater collected because drain design unchanged.
Leachate collection system	<ul style="list-style-type: none">Leachate collection system design remains the same.Increased, but acceptable, load on some leachate collection pipes due to increased cell height.No significant effect on amount of leachate collected because cell capping area unchanged.
Leachate mgmt. system	<ul style="list-style-type: none">Leachate management system design and operation remains the same.No significant effect on amount of groundwater and leachate collected for treatment.No significant effect on quality of groundwater and leachate collected for treatment because no significant change in composition of material placed in cell.
Landfill gas collection system	<ul style="list-style-type: none">Landfill gas collection system components already installed will be removed and reconstructed at a higher elevation. Some components not yet installed require relocation to suit the new landform.The design philosophy for landfill gas collection remains the same.No significant effect on overall gas generation and collection because no significant change in overall composition of material placed in cell.



CONTAINMENT CELL CONCEPT DESIGN

Cell Component	Overall Effects of Cell Expansion Design
Capping system	<ul style="list-style-type: none">■ Capping system design remains the same. The new landform will result in a reduction of 3.5 Ha in the cell platform area and an equal increase in the cell batter area.■ Capping system already installed on the cell platform will be removed and reconstructed at a higher elevation.
Landform	<ul style="list-style-type: none">■ Increased, but acceptable, risk of surface water ponding on cell platform due to increased settlement potential from increased cell height and associated loading increase.■ Decreased, but acceptable, slope stability factors of safety for cell batters due to increased cell height.
Effect of potential mining subsidence	<ul style="list-style-type: none">■ No significant effect on resistance to impacts from mining subsidence because the design of the leachate collection system and the capping system remains the same.

In summary, the components of the containment cell are either not affected or only affected in a minor and acceptable way by the expansion design. Required changes to the design of cell components are considered feasible, and relatively minor, and will be further developed during detailed design of the cell expansion.



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1.0 INTRODUCTION

1.1 Terms of Reference

Ferrier Hodgson, as the Deed Administrator of Pasminco Cockle Creek Smelter Pty Ltd (Subject to Deed of Company Arrangement) – (PCCS), appointed Golder Associates Pty Ltd (Golder) to design an expansion for the PCCS containment cell. This report was prepared in accordance with our proposal 06623099-774-P-Rev1, dated 01 August 2012 and acceptance by Ferrier Hodgson via email, dated 01 August 2012.

1.2 Background

The PCCS site is a former lead and zinc smelter located approximately 13 km south west of Newcastle and just above the northernmost point of Lake Macquarie at Boolaroo as shown on Figure 1 and Figure 2. Smelting operations have caused contamination of the site with heavy metals, chiefly lead, zinc and cadmium. PCCS Services (PCCSS) is currently remediating the PCCS lands associated with the former on-site lead and zinc smelting operations. Remediation of the PCCS lands comprises excavation of contaminated soil and placement of the soil in a containment cell within the PCCS site.

The original PCCS containment cell design, the '2008 Approved Cell Design', was prepared by Golder Associates (Golder 2007) and subsequently approved by the NSW EPA.

In 2010, the footprint of the cell was extended to accommodate a larger than expected amount of contaminated soil. Design drawings and calculations (Golder 2010c) were provided to EPA. The extended cell is referred to herein as the '2010 Approved Cell Design,' as shown in Figure 3.

Recently, at the request of Ferrier Hodgson on behalf of PCCS, Golder prepared a submission proposing changes to the containment cell capping system design and the surface slopes (Golder 2011) on the top of the landform. The top of the cell landform is referred to as the cell 'platform'. Although the proposed changes included revision of the cell platform slopes, a specific landform design was not included. The proposed changes have been approved by the DoPI, subject to the conditions outlined in the August 2012 s75W Modification issued on 10 August 2012.

The currently approved project comprises the 2008 Approved Cell Design, the 2010 Approved Cell Design and the August 2012 s75W Modification and is referred to herein as the 'Consolidated PCCS Part 3A Approval' design.

Incitec Fertiliser Limited (IFL) owns the site of a former fertiliser manufacturing plant that is adjacent to the PCCS lands. The IFL site is understood to be impacted by contamination similar to the PCCS lands. PCCS has recently come to an agreement with IFL to manage contaminated material from the IFL site by placing it in the PCCS containment cell.

1.3 Scope and Purpose

This report presents the concept design for expansion of the PCCS containment cell to accommodate placement of contaminated material from the IFL site. The report addresses engineering and technical issues for proposed changes to the Consolidated PCCS Part 3A Approval. The report considers proposed specific changes to the cell landform with respect to the landform in the 2010 Approved Cell Design.

We understand that this concept design report will form part of a submission to the Department of Planning and Infrastructure (DoPI).



2.0 PROPOSED LANDFORM

2.1 Cell Volume Increase

The design for expansion of the PCCS containment cell provides increased cell storage volume¹, also referred to as ‘airspace.’ The increased airspace is achieved primarily through the following two modifications to the cell landform in the 2010 Approved Cell Design: (a) increasing the height of the cell; and (b) reducing the slope on the cell platform as approved in the August 2012 s75W Modification. Importantly, these modifications are achieved without changing the cell footprint or the slope angle of the cell batters (i.e., side slopes).

The increase in airspace proposed is approximately 450 000 cubic metre (cu.m.). The following table compares the airspace of the 2010 Approved Cell Design with the proposed design. Refer to Section 3.0 for discussion on the material from the IFL site.

Table 2: Cell Airspace

	2010 Approved Cell Design Airspace (cu.m.)	Proposed Design Airspace – rounded (cu.m.)	Airspace Gained (cu.m.)
Cell	1 143 300	1 593 100	449 800
Cell 2	26 300	26 300	0
Total	1 169 600	1 619 400	449 800

The containment cell footprint remains unchanged at approximately 19.4 ha.

2.2 Landform Features

A plan view of the proposed landform is shown in Figure 4 and cross-sections of the proposed landform are shown in Figure 6.

As shown in the figures, the proposed landform comprises cell batters with a slope of 5(H):1(V) and a cell platform with a surface slope of 2% (2 m fall over 100 m). The cell platform has an area of 8.4 ha. The peak of the landform is located in the eastern part of the cell platform. The cell batters occupy approximately 11.0 ha.

Table 3 below provides a comparison of the landform features of the Consolidated PCCS Part 3A Approval Design and the proposed design. It can be seen from the table that the proposed design has a platform area that is approximately 3.5 ha smaller than the platform area of the 2010 Approved Cell Design. The change in cell platform area is shown on Figure 4.

Table 3: Cell Areas and Slopes

	Consolidated PCCS Part 3A Approval Design	Proposed Cell Expansion Design
Platform slope	2%	2%
Batter slope	5(H):1(V)	5(H):1(V)
Batter area (Ha)	7.5 ¹	11.0
Platform area (Ha)	11.9 ¹	8.4
Total area (Ha)	19.4	19.4

¹ As per the 2010 Approved Design as no landform in accordance with the Consolidated PCCS Part 3A Approval has been designed.

¹ The containment cell airspace is measured as the volume between the leachate floor (the bottom of the leachate collection layer) and the bottom of the capping system.



The batters are highest on the western side of the cell, with heights varying from 12 m to 24 m above proposed surrounding ground levels. The eastern batter is generally smaller than the western batter, with the batter height ranging from 9 m to 12 m above proposed surrounding ground levels.

Two benches have been designed for the western batter of the cell. The horizontal distance between the two benches is generally 50 m, approximately equivalent to 10 m vertically on the batter, and the maximum horizontal distance is 65 m, approximately equivalent to 13 m vertically on the batter. The primary purpose of the benches is to provide additional slope stability for the high western batter and to interrupt the flow of surface water down the batter slope, thus reducing flow velocity and erosion potential.

Surface water management on the cell platform is achieved by collection and diversion of water flowing from the landform peak towards surface water 'drop structures' as indicated in Figure 5. The detailed layout of the surface water diversion structures on the platform and the drop structures will be developed during the detailed design stage, but is likely to comprise berms.

Water management on the cell batters is generally as follows:

- stormwater on the eastern batter will flow towards the surface water perimeter drains surrounding the cell;
- stormwater on the western batter will be partially collected in the benches and diverted towards either the drop structure on the western batter or the perimeter drains; and
- stormwater falling on the western batter below the lowest bench will flow directly into the perimeter drains.

A provision for vehicular access to the cell platform has been provided along the eastern batter of the cell. This has been achieved by flattening the cell batter along a 16 m wide corridor at a gradient of 16%, which should provide an acceptable grade and width for road access.

2.3 Cell Filling Sequence

The filling sequence outlined in the Consolidated PCCS Part 3A Approval Design has been followed to date. Filling has been completed and the cell capping system installed in the eastern portion of the cell identified as Stage A and Stage B1 (comprising approximately 6.3 Ha). In addition, the portion of the cell containing higher-risk materials, referred to as Cell 2, has been filled and covered with an interim cap (refer Section 3.2). Filling is ongoing in the remainder of the PCCS cell.

It is expected that by the time the first material from the IFL site can be accepted in the PCCS cell, the cell would be filled to levels close to the 2010 Approved Design. Therefore, placement of IFL material in the PCCS cell would occur almost exclusively on sections of the PCCS cell that have already received PCCS material.

It is proposed that IFL material placement would first occur in the western and central sections of the PCCS cell as these are currently uncapped. Once the western and central sections of the expanded cell are nearing completion, the existing capping system materials in the eastern portion of the cell would be removed and stockpiled for reuse.

It should be noted that the cell filling sequence will be flexible to allow for changes in the volume of contaminated material received from the IFL site. Any changes to the proposed final landform resulting from less than 450 000 cu.m. of contaminated materials being received from the IFL site would be consistent with the design parameters and slope angles outlined in this report.

2.4 Land Use

The proposed land use for the containment cell remains the same as for the Consolidated PCCS Part 3A Approval Design, being passive recreation/open space use.



CONTAINMENT CELL CONCEPT DESIGN

The concept design of the containment cell landform has been developed, however, such that additional land uses are feasible from an engineering standpoint. Specifically, the landform is considered suitable for development of playing fields and associated amenities. The potential for a playing field land use was recognised in the Aug 2012 s75W Modification, but any actual land use will need to be the subject of any further planning applications as required by applicable planning controls at the relevant time. The landform incorporates a provision for vehicular access to the cell platform (refer Figure 4).



3.0 MATERIAL FROM INCITEC SITE

3.1 Acceptable Material Types

Materials from the IFL site, as identified below, are considered acceptable for placement in the PCCS containment cell. Soil with slag contamination will comprise approximately 95% of the materials.

- **Soil Materials:** Much of the soil fill present the IFL site contains slag from the PCCS smelter and has elevated metal levels similar to those at the PCCS site. Fertiliser production at the IFL site has resulted in local areas of impact to soil with elevated nitrate, phosphate, sulphate and fluoride concentrations. Refer: URS, 2004; Soil & Groundwater Consulting, 2008a, 2008b, 2008c, 2010a. The specification for placement of soils from the IFL site into the PCCS cell will be the same as for the PCCS site materials. This includes particle size restrictions, organic content restrictions, and compaction requirements
- **Concrete:** Some concrete slabs and retaining walls on the IFL site may have elevated metal levels from the incorporation of slag aggregate. Placement into the PCCS cell will require similar methods to those employed for concrete from the PCCS site.
- **Water Treatment Plant Filter Media:** Spent filter media from an on-site water treatment plant is contained within geotextile filter tubes on the IFL site. The media is understood to comprise inert material with absorbed/trapped contaminants from site water, with these contaminants being those present in the site soils. The media will be incorporated within the PCCS cell by mixing with soil, followed by soil placement and compaction as indicated above.

3.2 Chemical Compatibility

PCCS Site Materials: Golder (2006, 2007) carried out material characterisation and compatibility studies for the Pasminco containment cell. The PCCS site materials were assessed for leaching potential, aggressivity, fouling potential, flammability and potential for chemical reaction between materials. These studies concluded that contaminated soils, as well as most other site materials, are acceptable for placement into the main portion (Cell 1) of the PCCS containment cell. Some process wastes at the PCCS site were found to be unsuitable for Cell 1 and were designated for placement into Cell 2, a small portion of the cell with enhanced containment measures. The IFL site materials are proposed to be comingled with PCCS Cell 1 materials only.

IFL Site Materials: Golder (2010a) performed a compatibility assessment for IFL site materials for placement in a then proposed IFL on-site containment cell. The IFL site materials were assessed against criteria including corrosivity, fouling, reactivity, ignitability, and toxicity, noting that the materials have not been found to be contaminated with significant strong acids, bases, oxidisers or flammable materials. The assessment concluded that the materials were suitable for placement within the proposed IFL cell. This conclusion is also considered applicable for placement of IFL materials into the PCCS containment cell.

Compatibility: The IFL site materials are substantially similar to the PCCS site materials. It is considered unlikely that comingling these materials will result in detrimental effects within the PCCS containment cell.



4.0 ENGINEERING CONSIDERATIONS FOR PROPOSED LANDFORM

4.1 Cell Platform Settlement

The proposed increased cell height for the concept design will result in increased stresses within cell materials and underlying soil. The effect of these increased stresses has been considered with respect to cell platform settlement, as discussed in this Section, and also with respect to landform slope stability (refer Section 4.2) and leachate collection system pipe stability (refer Section 5.3).

The increased stresses will likely result in increased differential settlement of the cell platform surface and an increased risk of poor surface drainage or local surface grade reversal (i.e., ponding). Therefore, the concept design included a settlement assessment based on the platform design slope of 2%. The assessment (Appendix A) concludes that the anticipated performance is acceptable. Specifically, the assessment concludes that the calculated maximum long-term surface settlement is less than 600 mm and that the calculated surface slope remains greater than 0.5% in all areas, indicating low risk of unacceptable drainage performance or ponding. This issue will also be managed through an inspection, monitoring and maintenance program after construction (refer Section 4.5).

4.2 Slope Stability

Slope stability of the containment cell is governed primarily by the cell landform geometry, seismic loading parameters, and site geotechnical conditions. Compared to the 2010 Approved Cell Design, the concept design for the cell expansion is based on the same seismic loading parameters but includes changes to the cell landform geometry and to certain geotechnical strength values, as described below. Therefore, a slope stability assessment has been conducted for the proposed cell expansion design.

The assessment considered both static and seismic loading conditions using the same analysis methodology as for the 2008 and 2010 Approved Cell Design and focussing on the stability of the highest cell batter, i.e., along the western edge of the cell. Compared to the Consolidated PCCS Part 3A Approval Design, the maximum cell batter height is greater by 5 m (24 m vs. 19 m), which will generally result in smaller slope stability factors of safety. The analyses used an increased the shear strength of emplaced cell materials based on the results of the ongoing compaction density testing during cell filling, which indicate that an average density of 103% of standard maximum dry density has been achieved (Golder 2011), and on results of recent in situ testing.

The slope stability assessment (Appendix B) concludes that acceptable levels of overall slope stability are achieved for the proposed cell expansion design.

4.3 Surface Water Management on Cell

The surface water management approach and design features for the proposed cell expansion are substantially the same as those in the Consolidated PCCS Part 3A Approval Design. Required changes are summarised in the points below.

- Some features, such as the drop structures that convey water down the cell batter, will require realignment and lengthening during detailed design to suit the new landform.
- Features to assist in directing water on the cell platform surface toward the drop structures will require modification to suit the 2% slope of the cell platform. The design of these features will be developed during detailed design and may comprise small surface berms.
- An additional bench has been designed on the western cell batter to manage surface water flow given the increased batter height.

These changes are considered feasible, and relatively minor, and will be further developed during detailed design.



4.4 Mine Subsidence

The concept design for the cell expansion does not affect the ability of the cell to tolerate deformations from mine subsidence. This is discussed below for the key components at the cell base and cap.

- The severity of deformation that could occur due to potential mine subsidence beneath the cell is related primarily to the dimension and location of the mining voids that could potentially collapse, and not to the overall ground stress conditions. Therefore, stress changes related to the cell height increase are not anticipated have a significant effect on the risk of deformation from mine subsidence.
- The cell expansion design does not alter the design or specification of the soil materials and pipes in the cell base and leachate collection system from that in the Consolidated PCCS Part 3A Approval Design. Therefore, the ability of these materials to tolerate deformations from mining subsidence is unchanged and remains acceptable.
- The cell expansion design does not change the design or specification of the capping system materials from that in the Consolidated PCCS Part 3A Approval Design. Therefore, the ability of these materials to tolerate deformations from mining subsidence is unchanged and remains acceptable.

In summary, cell performance with respect to potential mine subsidence will not be significantly affected by the cell expansion design because there are no significant changes likely to occur in the magnitude of mine subsidence-induced deformations and the deformation resistance of the key cell components.

4.5 Post-Construction Operation and Maintenance

After the construction of the containment cell is complete, a program of inspection, monitoring and maintenance will be conducted. This program will provide additional management of design issues associated with the cell landform such as settlement, slope stability, surface water drainage, and capping system stability, as discussed in the preceding sections.

The existing Cell Operation and Maintenance Plan (COMP) (Golder, 2008) will be updated at an appropriate time prior to cell expansion construction in order to suit the features of the cell expansion design. This update should also include certain features of the capping system as identified in the August 2012 s75W Modification.



5.0 EFFECT ON EXISTING CELL INFRASTRUCTURE

5.1 Surface Water Management

Management of surface water around the containment cell perimeter will not be affected significantly by the proposed cell expansion. Specifically, no significant changes to the alignment and flow capacity of perimeter drains will be required because the containment cell footprint remains the same. Overall runoff volumes internal and external to the cell footprint will remain the same.

The philosophy of cell surface water management as outlined in Section 2.2 is not altered by the cell expansion. Surface water management features on the cell will require relatively minor changes as indicated in Section 4.3.

5.2 Groundwater Management (Cutoff Drains)

The design of the upgradient and downgradient groundwater cutoff drains remains the same as in the Consolidated PCCS Part 3A Approval Design. The drains comprise 600 mm wide gravel-filled trenches with 160 mm HDPE collection pipes at the trench base. Groundwater is collected in five sumps (sumps A through E) from where the water is pumped to a treatment system. The alignment of the drains is along the edge of the cell footprint, as shown in Figure 5. Construction of the upgradient drain and the majority of the downgradient drain is already complete.

The downgradient cutoff drain is designed to capture potentially impacted groundwater from below the cell within the shallow aquifer. The cutoff drain includes a filter geotextile on both sides of the aggregate drainage layer, as seepage into the trench may occur from both sides. The upgradient cutoff drain is intended to lower groundwater levels underneath the containment cell footprint.

The alignment, depth and design details of the cutoff drains are not affected by the proposed cell expansion design. This is because the cell footprint remains the same and therefore stresses and strains imposed on the drains are unchanged. In addition, no changes are required to drain inspection and monitoring points.

The overall amount of groundwater expected to be collected in the cutoff drains is not significantly affected by the proposed cell expansion design. This is because the drain alignment and depth remains the same and because the proposed design does not include any features expected to change overall groundwater levels.

5.3 Leachate Collection System

The design of the leachate collection system remains the same as in the Consolidated PCCS Part 3A Approval Design. The leachate collection system consists of a continuous 150 mm thick layer of drainage material, incorporating a network of high density polyethylene (HDPE) leachate drainage pipes with drainage aggregate surrounds. Construction of the leachate collection system is already complete for the majority of the cell.

The cell expansion design results in increased stresses acting on some leachate collection pipes due to the increased cell height. Compared to the Consolidated PCCS Part 3A Approval Design, the maximum height of cell material overlying the pipes is increased from 16 m to 20.7 m. Therefore, the concept design includes pipe stress analysis to assess the effect of the increased loading. The analysis indicates that the leachate collection pipes remain suitable to withstand the loadings imposed by the proposed cell expansion (Appendix C).

The leachate collection system includes pipe inspection and clean out points. No changes are required in these points as a result of the cell expansion design. This is due to the fact that they are located along the edge of the cell footprint and will remain accessible because the cell footprint remains the same.

The maximum flow rate expected for leachate collected in the leachate collection system is not significantly affected by the proposed cell expansion design. This is because leachate is generated principally from rainwater infiltrating through the containment cell cap and the area of the cap remains the same.



5.4 Groundwater and Leachate Treatment

The design and management approach for collected groundwater and leachate remains the same as in the Consolidated PCCS Part 3A Approval Design. Groundwater extracted from the cutoff drains as well as leachate collected from the leachate collection is delivered to an Effluent Treatment Plant (ETP).

The ability of the ETP to treat contaminated leachate and groundwater from the cell may be affected generally by two factors: (a) an increase in average or peak flow rate of water requiring treatment, if above the plant capacity; or (b) a change in inflow water quality, if outside the specified treatment range. With respect to the first factor, required treatment flow rates are not expected to be significantly affected by the cell expansion design as discussed in Sections 5.2 and 5.3. With respect to the second factor, IFL site materials to be placed in the cell are expected to be of similar composition to PCCS site materials (refer Section 3.2) and therefore the composition of water to be treated in the ETP is not expected to be affected significantly by the proposed cell expansion.

In summary, no changes are required to the water treatment approach and ETP design as a result of the cell expansion.

5.5 Landfill Gas Collection System

The landfill gas collection approach and design features for the proposed cell expansion are substantially the same as those in the Consolidated PCCS Part 3A Approval Design. The system comprises a number of gravel-filled trenches and gravel blanket collection areas, incorporating gas collection pipes, beneath the capping system in the cell platform area. A riser pipe in each gravel blanket area vents any captured gas. Large portions of the landfill gas collection system have been constructed in the eastern portion of the cell where the capping system is already installed (refer Section 2.3).

Required changes for the cell expansion design are summarised in the points below.

- The already constructed landfill gas collection system will be removed and subsequently reinstalled underneath the capping system for the cell expansion.
- Some blanket collection areas and riser pipes will require relocation to suit the cell platform area of the proposed landform.
- Some collection trenches will require realignment to suit the cell platform area of the proposed landform.

These changes are considered feasible, and relatively minor, and will be further developed during detailed design.



6.0 LIMITATIONS

Please refer to Appendix D for limitations relating to this report.



Report Signature Page

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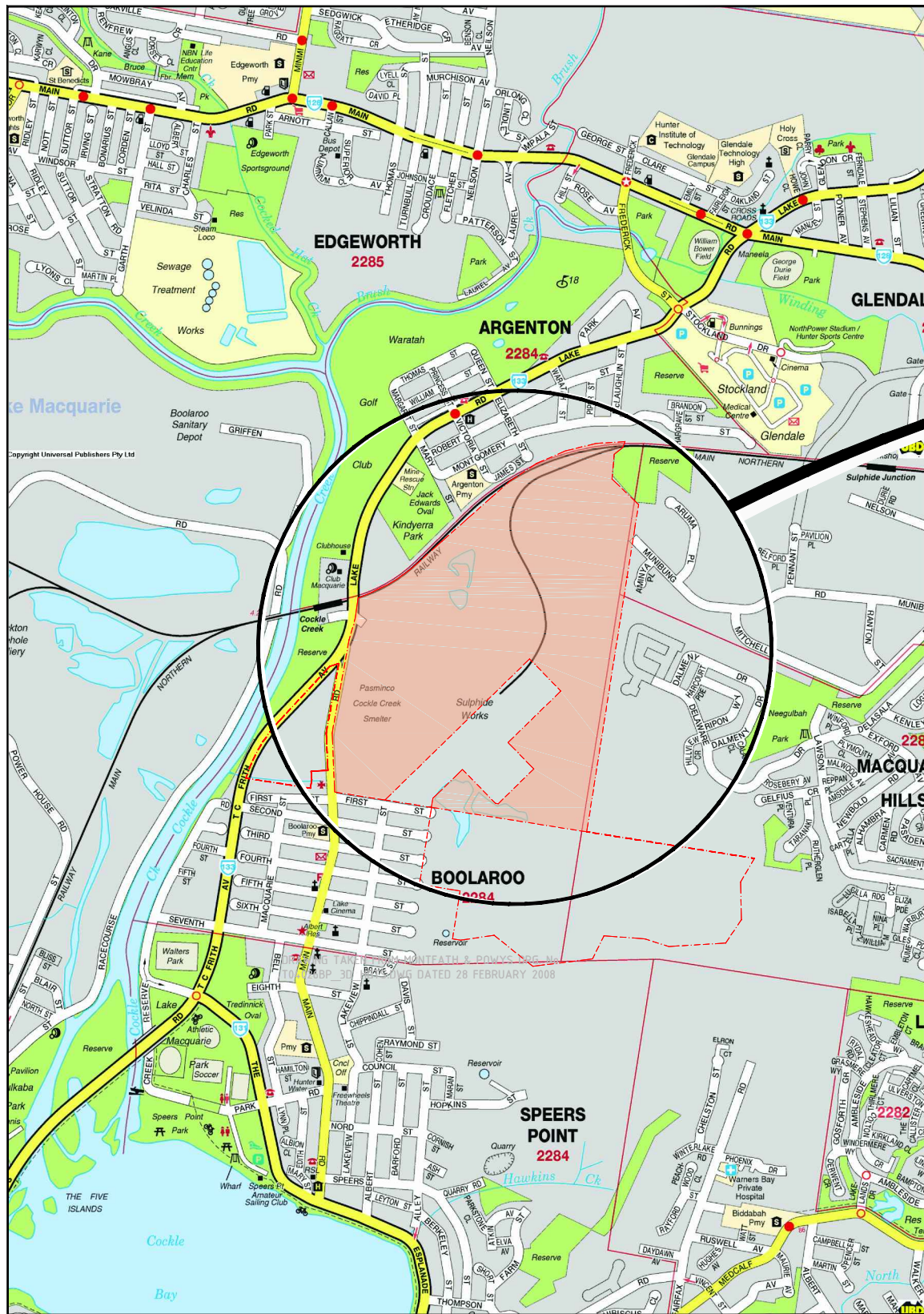
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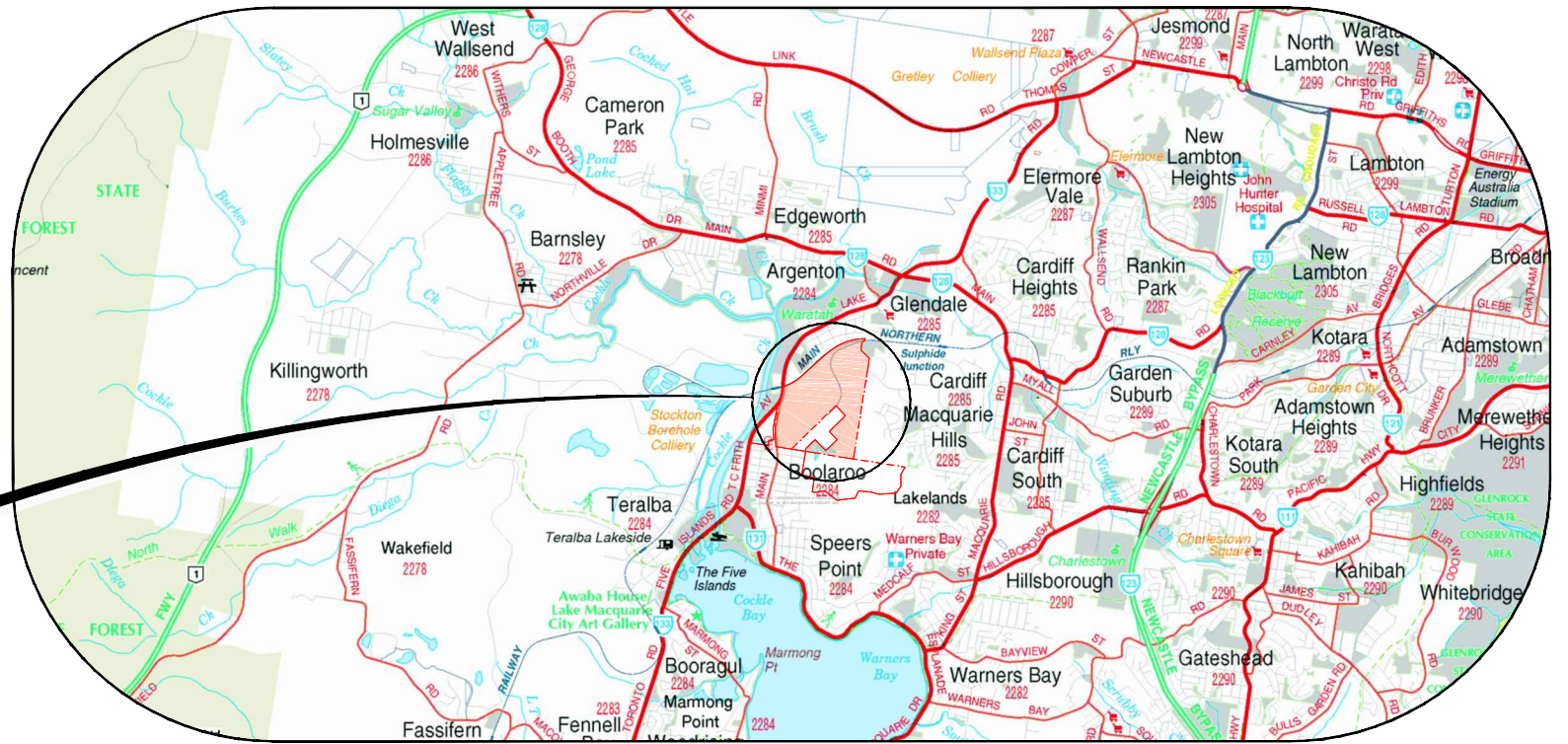
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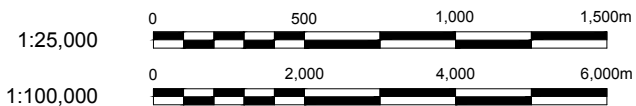


SITE LOCALITY PLAN
SCALE 1:100,000 (approx)

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- FIGURE 6 F006 REV0 CROSS SECTIONS

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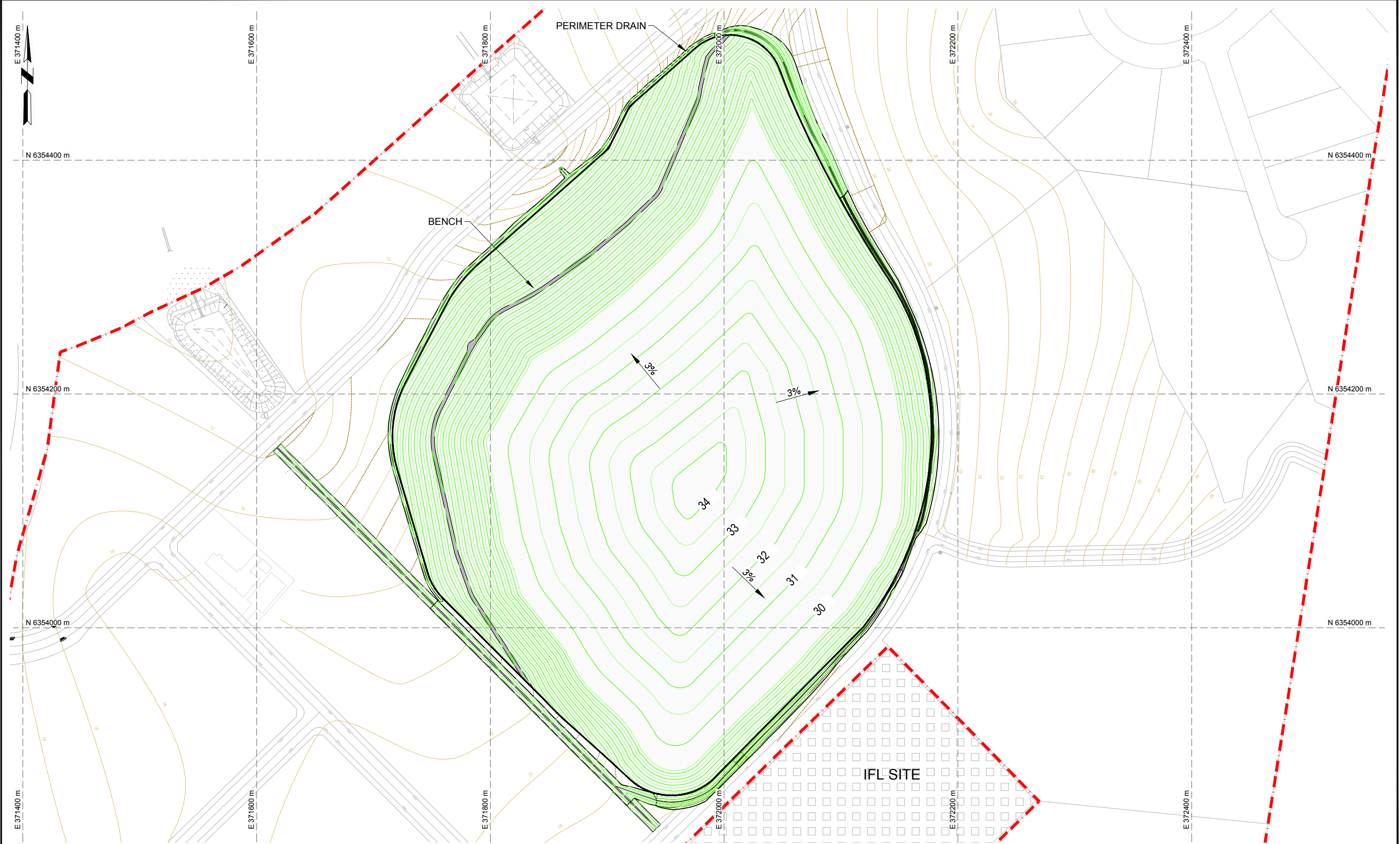
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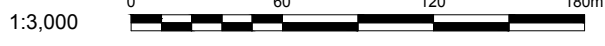
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GRS	28.09.2012			06623099	780	R	F002	0	FIGURE 2				
SCALE		1:7,500		SHEET SIZE	A3								

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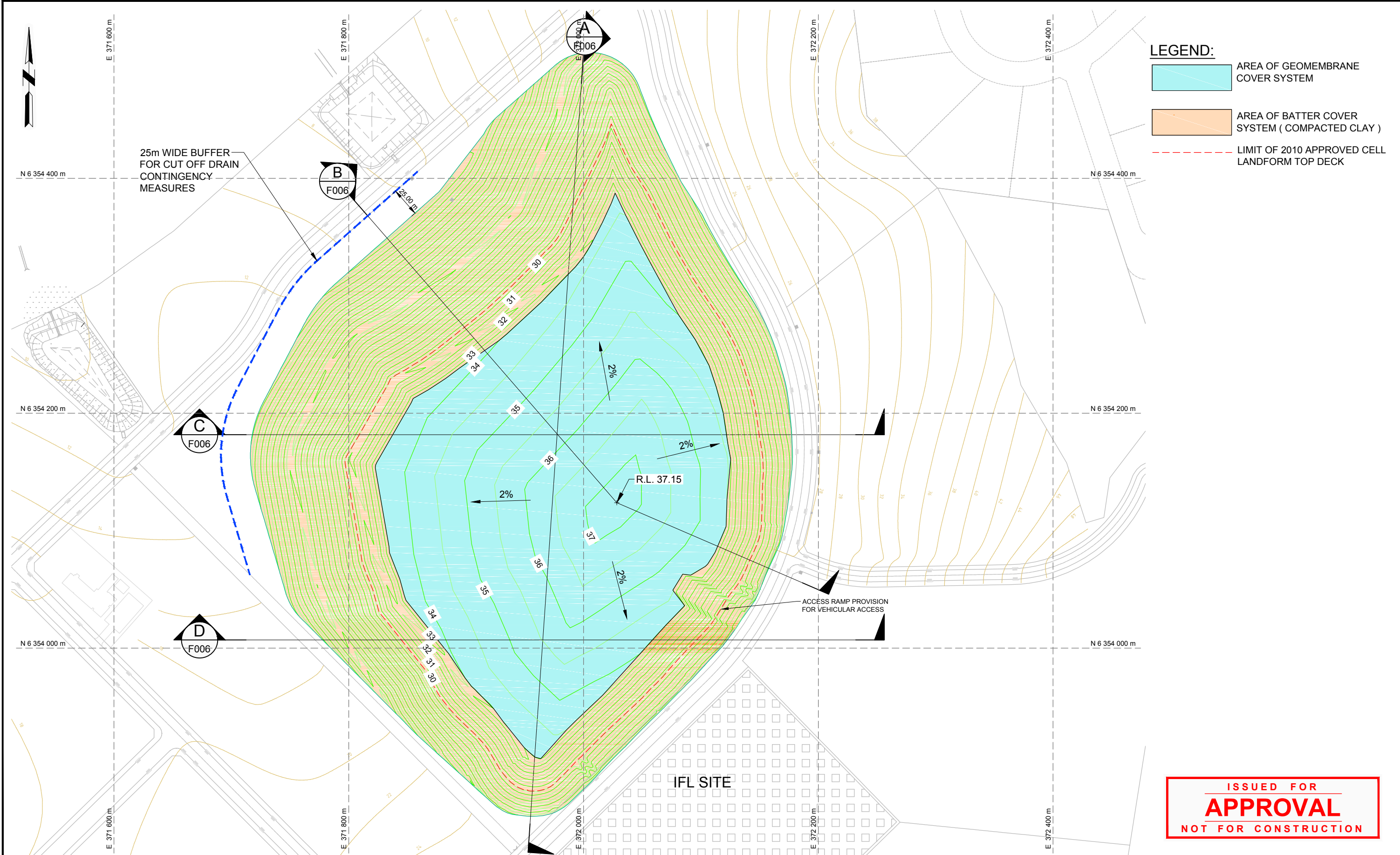
- LEGEND**
- - - SITE BOUNDARY
 - EXISTING MINOR CONTOUR
 - EXISTING MAJOR CONTOUR
 - DESIGN MINOR CONTOUR
 - DESIGN MAJOR CONTOUR

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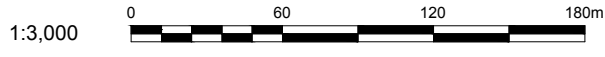
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		DRAWN BY HC	DATE 28.08.2012	DRAWING TITLE 2010 APPROVED CONTAINMENT CELL LANDFORM					
		CHECKED BY GRS	DATE 30.08.2012						
		SCALE 1:3,000	SHEET SIZE A3	PROJECT No 06623099	DOC No 780	DOC TYPE R	FIGURE No 003	REVISION 0	FIGURE 3

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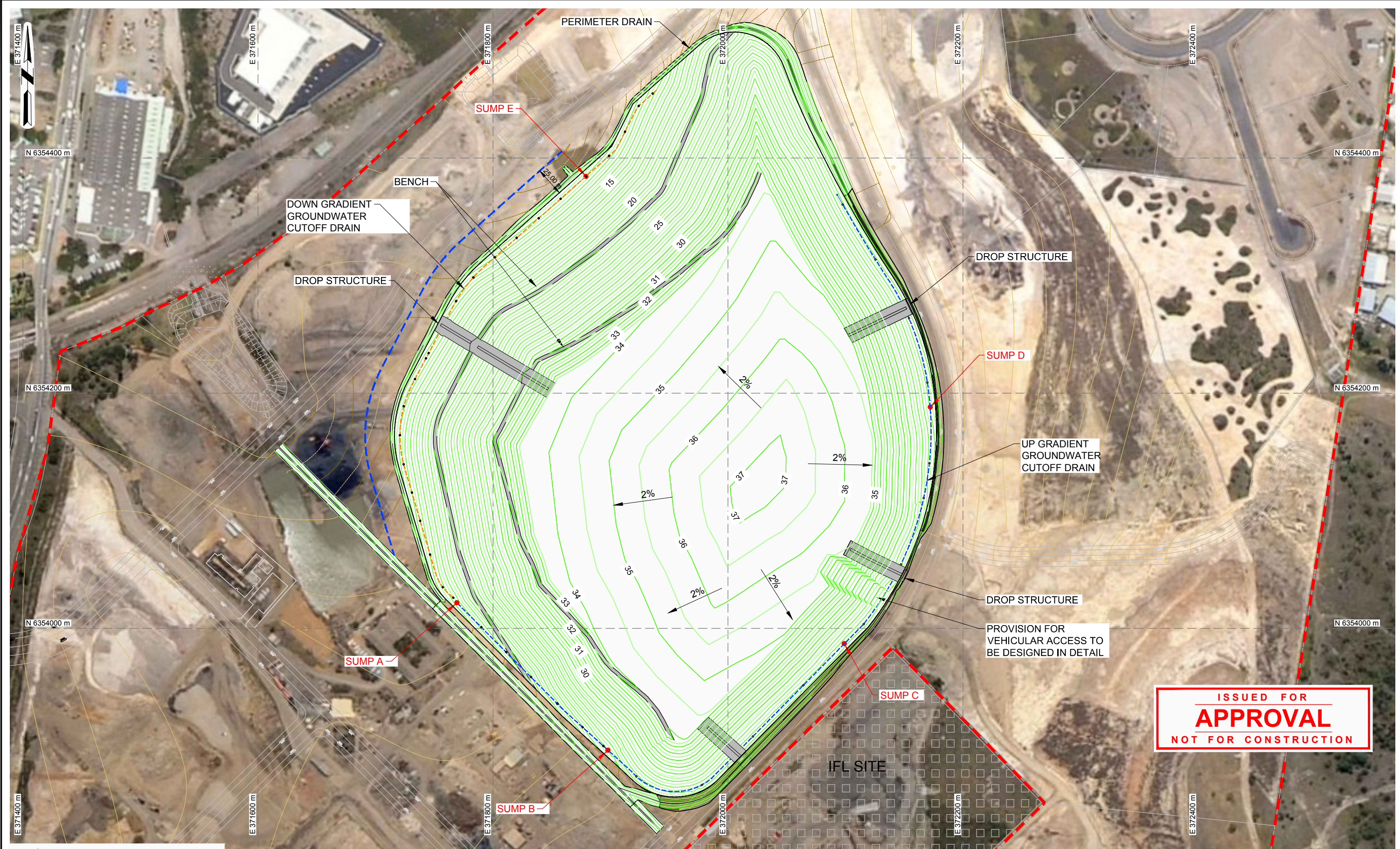
- LEGEND:**
- AREA OF GEOMEMBRANE COVER SYSTEM
 - AREA OF BATTER COVER SYSTEM (COMPACTED CLAY)
 - LIMIT OF 2010 APPROVED CELL LANDFORM TOP DECK

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	DRAWN BY MMC	DATE 29.08.2012	DRAWING TITLE PROPOSED CONTAINMENT CELL LANDFORM			
CHECKED BY GRS	DATE 29.08.2012					
SCALE 1:3,000	SHEET SIZE A3	PROJECT No 06623099	DOC No 780	DOC TYPE R	FIGURE No F004	REVISION 0
FIGURE 4						

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LEGEND

- - - - -	SITE BOUNDARY
- - - - -	EXISTING MINOR CONTOUR
- - - - -	EXISTING MAJOR CONTOUR
- - - - -	DESIGN MINOR CONTOUR
- - - - -	DESIGN MAJOR CONTOUR

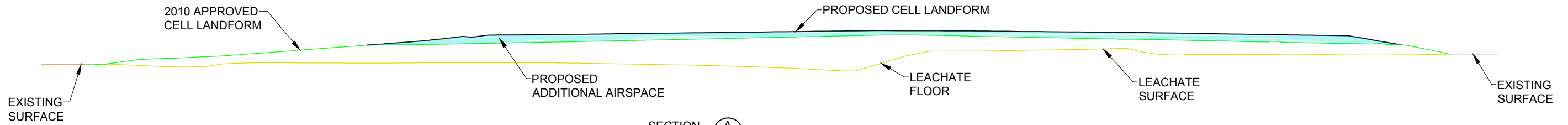
NOTE:

- LAYOUT OF SURFACE WATER MANAGEMENT SYSTEMS ON TOP DECK OF CELL TO BE DESIGNED IN DETAIL

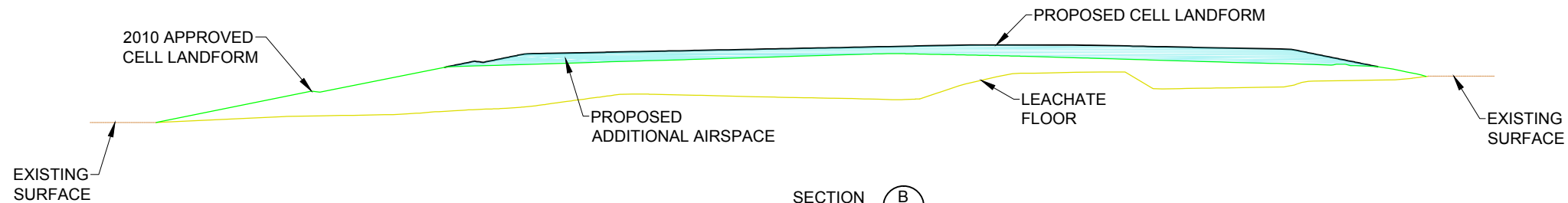
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CHECKED BY GRS	DATE 28.09.2012					
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FIGURE 5						

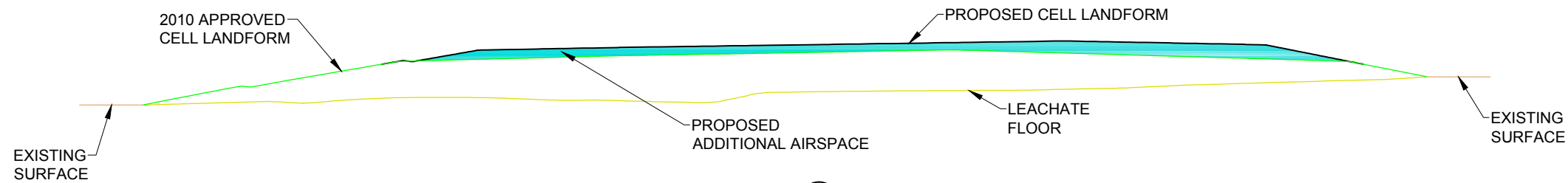
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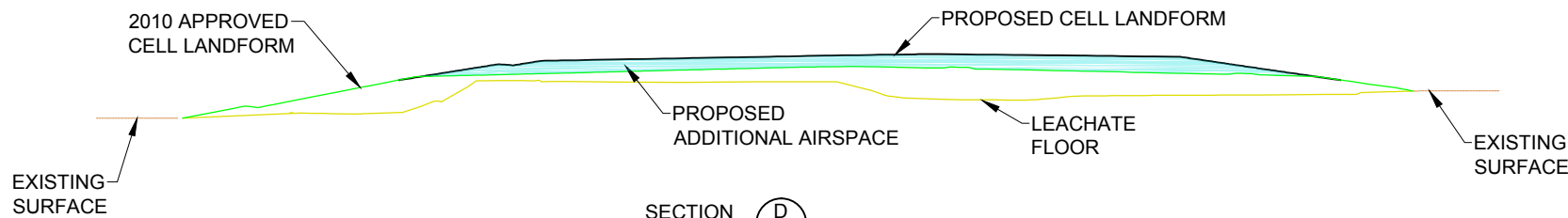
SECTION A
HOR SCALE 1:2000
VER SCALE 1:2000



SECTION B
HOR SCALE 1:2000
VER SCALE 1:2000

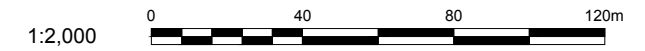



SECTION C
HOR SCALE 1:2000
VER SCALE 1:2000



SECTION D
HOR SCALE 1:2000
VER SCALE 1:2000

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	CHECKED BY GRS	DATE 28.09.2012							
	SCALE 1:2,000	SHEET SIZE A3	PROJECT No 06623099	DOC No 780	DOC TYPE R	FIGURE No F006	REVISION 0	FIGURE 6	



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APPENDIX A

Cell Settlement Calculations

28 September 2012

Project No. 06623099-801-L-Rev0

Mr Wayne Woodward
Ferrier Hodgson
PO Box 42
Boolaroo NSW 2284

PROPOSED EXPANSION OF PASMINCO CONTAINMENT CELL – ASSESSMENT OF CELL PLATFORM SETTLEMENT
**PROPOSED EXPANSION OF PASMINCO CONTAINMENT CELL:
ASSESSMENT OF CELL PLATFORM SETTLEMENT**

Dear Wayne

This letter concerns the proposed expansion of the Pasmenco Cockle Creek Smelter (PCCS) containment cell to accommodate materials from the adjacent Incitec site. This letter presents an assessment of potential settlements on the cell platform of the proposed expanded cell.

1.0 BACKGROUND AND PURPOSE

The relatively flat portion of the top of the PCCS cell landform is referred to as the 'cell platform'. The currently approved slope of the cell platform is 2% as per the August 2012 s75W Modification. Golder previously performed a feasibility assessment and concluded that there was low risk of surface ponding due to settlement of the cell platform if sloped at 2% (Golder letter 06623099-674-L-Rev0 dated 5 Sept 2011). The previous assessment was used as supporting information for the August 2012 s75W Modification.

The currently proposed expansion of the PCCS cell comprises changing the cell landform by raising the cell height but maintaining the 2% slope of the cell platform. The increased cell height will result in increased compression of cell materials and underlying foundation soils and increased settlement potential for the cell platform surface.

The purpose of this letter is to present the results of an updated settlement assessment that reflects the proposed cell expansion landform.

As with the previous assessment, the updated assessment has been undertaken to assess likely settlements and risk implications for the cell platform surface. The main performance issue associated with the cell platform slope is the potential for localised grade reversal and associated ponding on the cell surface. Very small gradients and/or ponding on the cell platform could increase maintenance costs and/or affect the future potential use of the cell. Sustained ponding could also result in increased water infiltration into the containment cell and increased leachate generation.

2.0 ASSESSMENT METHODOLOGY

The updated assessment has been performed using the same methodology as in the previous assessment (Golder, 5 Sept 2011). The methodology is described below in text sourced from the previous assessment with relevant revisions.

Settlement predictions for the PCCS containment cell have been assessed using simplified methods based on estimated material compressibility input parameters. The reliability of these input parameters is relatively low given there is limited investigation and testing data which can be used to correlate against material



compressibility. Also, the spatial distribution of boreholes is limited, the intrinsic variability of site materials, including fill materials, is relatively high and localised soft materials could exist along narrow relic drainage channels that may be potentially present within foundation soils.

The uncertainties in material compressibility are partly mitigated because we understand that the site preparation process undertaken by PCCS involves treating known unsuitable cell foundation areas. This involves removing areas of known near-surface soft soil and sludge materials within the cell footprint and replacing these with controlled fill, including crushed concrete. Other areas of existing fill underlying the proposed waste cell materials have been improved using High Energy Impact Compaction (HEIC). These preparation processes have been documented in milestone submissions by PCCS and other project stakeholders.

Considering the input uncertainties, the reliability of the settlement calculations should be regarded as approximate and some contingency for settlement-related maintenance should be allowed for when making planning decisions about the future site use.

The following tasks have been undertaken to provide estimates of future cell surface settlements:

- Review existing data to understand the type and distribution of materials and potential for buried compressible channel features, and to select cross sections for analysis;
- Estimate engineering properties of site materials based on available geotechnical and construction quality control data (laboratory compaction and grading tests, geotechnical investigation data);
- Base Case: Calculate one-dimensional cell surface settlements using proprietary spreadsheet software 'PCON' at representative locations, due to cell fill self-weight and compression of underlying materials; and
- Sensitivity Case: Estimate the local surface settlement profile that could potentially develop above a compressible foundation zone, e.g. softened natural materials representative of a soft clay channel underlying the cell fill. Superimpose the local settlement profile on the one-dimensional settlement results from the Base Case. We note that the risk of unsuitable compressible material occurring within the future cell fill is low due to the specification and testing regime applied to the cell material during placement.

We consider this simplified approach is appropriate for this assessment, taking into consideration the input uncertainty.

3.0 INPUTS AND ASSUMPTIONS

The updated assessment has been performed using the same inputs and assumptions as in the previous assessment (Golder, 5 Sept 2011), with updated cell landform geometry for the proposed cell expansion. The inputs and assumptions are described below.

Based on our review of site investigation data and published correlations and technical papers, a geotechnical model has been developed, incorporating material compressibility values as shown in Table 1 below.

Table 1: Geotechnical Model and Input Parameters

Unit No.	Description	Stiffness E' (MPa)	Coeff. of Compressibility, Mv (m ² /MN)	Coeff. of Consolidation Cv (m ² /Yr)	Compression Index, Cc/(1+e0)	Creep Index, C _α (%)	Unit Weight (Saturated), kN/m ³
1	New Cell Fill (Silty Clay)	20	0.037	-	-	0.3	17
2	In-Situ Fill (Mainly granular)	30	0.025	-	-	0.2	19
3	Existing Landfill (former plant refuse)	-	-	2	0.058	1.0	11
4	Residual Soil	30	0.025	-	-	0.15	18
5	Bedrock	Assumed incompressible					

Note: Some materials such as those previously referred to as ISF and LBF stockpiles and sludge have been omitted due to them either having been removed as part of the cell filling process, or not inferred to occur at analysed locations.

Key analysis assumptions are as follows:

- Waste cell fill is placed rapidly, and is homogeneous;
- In previously filled areas of in-situ fill and existing landfill, the effects of historic preloading are conservatively ignored;
- No live load is applied to the new cell fill surface; and
- Groundwater level is assumed constant at RL-15m AHD.

Two cross sections (A and B) were selected for settlement analysis, as shown on Figures 1 and 2. Please note that the cell landform geometry shown in Figures 1 and 2 is the pre-expansion geometry and has been updated for this assessment to reflect the proposed cell expansion landform shown in Figure 3, including the 2% cell platform slopes. Along both of these sections, points at borehole locations were selected for one-dimensional settlement analysis, with results projected onto the nearest relevant cross section. The analysis locations have been selected to target relatively 'hard' and 'soft' profiles to enable assessment of locations having the greatest potential for differential settlement. Each location analysed along the respective cross sections is shown highlighted in yellow on Figure 2, attached.

A graphical representation of the subsurface profile at each analysed location along the sections is provided in Figure 4.

Settlement at the cell landform peak, which lies between borehole locations A10 and A11 on cross section B (Figure 2), has been interpolated between the calculated settlements at locations A10 and A11. This assumption is conservative in that the peak of the proposed expanded landform is positioned near the crest of the batter of the underlying LBF monolith (refer Figure 2) and is therefore expected to undergo relatively small settlement. It is generally conservative to overestimate settlement at the landform peak when considering the risk of ponding on the cell platform.

Settlement at borehole location A10 on cross section B (Figure 2) has been assumed to be zero. This assumption is conservative because the actual settlement of the fill at this location will be greater than zero. It is generally conservative to underestimate settlement to the east of the landform peak when considering the risk of ponding due to poor eastward drainage on the cell platform.

4.0 RESULTS AND DISCUSSION

Analyses were undertaken to quantify settlements along sections A and B at future time intervals after full-height cell filling for the Base Case and the Sensitivity (soft spot) Case. To capture settlement at future time intervals due to on-going creep and consolidation, settlements have been calculated at nominal time intervals of 1, 10, 20 and 50 years. Overall settlement-induced changes in slope of the cell platform are calculated by comparing the difference in settlement between adjacent locations to the horizontal distance between the locations.

Base Case

A summary of tabulated and graphical settlement and platform slopes for the Base Case is given in Figure 5. Calculated long-term one-dimensional settlements at various locations are in the general range of 200 mm to 600 mm. Calculated long-term overall slope changes on the cell platform range from 0.2% steeper to 0.5% flatter, which can be compared to the design grades of 2%.

Sensitivity Case

We note that the calculations done to explore how local surface settlement profiles are influenced by ground movements at depth involved adapting empirical methods which predict settlement troughs above tunnels of various sizes, as described by CIRIA Report No. 30¹.

To estimate the influence of various sizes of possible buried soft spots on surface settlements, the CIRIA method was then used to reproduce the predicted soft layer settlements to estimate the resulting surface settlement depression. Soft zones of varying width were then assessed to explore the sensitivity of surface settlements to soft zone size (Refer Figure A, below).

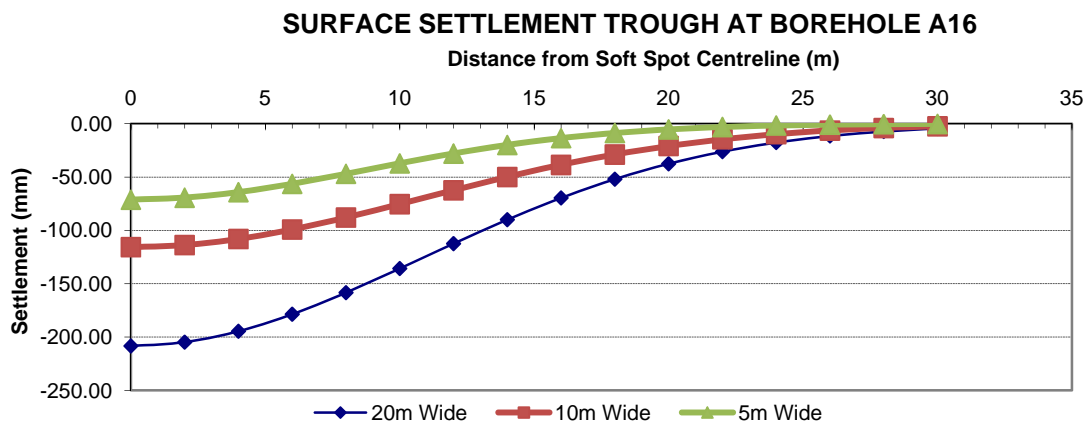


Figure A: Estimates Surface Settlements for Soft Zones of Varying Width

On the assumption that it is reasonable to allow for a 2m thick softened zone in natural materials underlying the cell with a thickness of 2m and a maximum width of 10 m, the shape of the resulting settlement trough at the surface is shown in the central line in Figure A, above. The maximum slope of this trough profile is approximately 0.6%.

Superimposing the calculated maximum overall slope change from the Base Case, 0.5%, on the calculated maximum local slope from soft spot settlement, 0.6%, results in a maximum slope change of 1.1%. Applying this slope change to a 2% design slope of the cell platform indicates that the residual gradient would remain satisfactory at approximately 1%.

Consideration of Ponding Risk

Although these calculations provide a basis for estimating the magnitude and extent of settlements, to make rational management decisions it is necessary to consider the impact of settlement in terms of a risk

¹ CIRIA Report 30 (1996) Prediction and effects of ground movements caused by tunnelling in soft ground beneath urban areas

management framework. Given the uncertainty of input variables and simplified nature of this study, it is appropriate to consider risk in terms of qualitative rather than quantitative terms.

Qualitative risk can be expressed using the widely accepted approach and terminology presented in the AGS landslide risk management framework². Table 2, below provides a guide to the risk of ponding on the cell platform considering the estimated likelihood of the calculated settlements occurring, and the potential consequences of these settlements in the event that they occur.

Table 2: Risk Summary

Initial Slope of Cell Platform	Likelihood of ponding ¹	Consequence ²	Risk (=Consequence x Likelihood)
2%	Unlikely	Minor	Low – Usually acceptable, ongoing maintenance may be required.

Notes: 1. Likelihood: Rare: The event is conceivable but only under exceptional circumstances over the design life
 Unlikely: The event might occur under very adverse circumstances over the design life
 Possible: The event could occur under adverse circumstances over the design life
 2. Consequence is assumed to be 'minor' (i.e. limited damage to part of the site requiring some reinstatement works).
 Note: If loss of potential future land use amenity is considered then these risk levels may increase.

This qualitative risk assessment indicates that use of a slope of 2% for the cell platform is a reasonable design approach, associated with a low risk of ponding. This approach implicitly accepts the potential need for cell inspection and maintenance to address ponding risk.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This report contains a basic quantitative assessment of predicted surface settlements for the platform of the proposed PCCS cell expansion, including sensitivity to localised soft zones in underlying materials. To assist decision making, we have also provided qualitative risk assessment that considers the likelihood and consequence of predicted settlements.

Key outcomes are as follows:

- Calculations using the assumed input parameters indicate that long-term surface settlements on the cell platform after completion of filling to the proposed cell expansion landform are likely to be typically in the range of 200 mm to 600 mm. Settlements could potentially increase by about 100 mm if the cell is underlain by a hypothetical 10m wide, 2m thick soft clay zone.
- In terms of qualitative risk, the simplistic calculations indicate that there is a low risk of grade reversal causing widespread ponding following cell completion for the cell platform slope constructed with an initial 2% surface slope.
- To help manage this risk, we recommend maintaining current quality control requirements during construction to remove unsuitable natural materials at the cell foundation level. We also recommend monitoring of surface settlements by surface survey as per the Cell Operations and Maintenance Plan (COMP, Golder 2008), for a period of at least 5 years immediately following cell completion, or until it can be demonstrated that on-going settlements are within acceptable limits. The (COMP) should be updated appropriately to reflect the cell expansion landform geometry.
- In the event that structures, road/footpath infrastructure or utilities are constructed on the containment cell, we would recommend additional settlement studies are undertaken to assess potential settlement effects.

² Practice Note Guidelines for landslide risk Management 2007, Australian Geomechanics Society Landslide Taskforce, Landslide Practice Note Working Group, Australian Geomechanics Vol 42 No 1 March 2007

6.0 REFERENCES

Golder 2008 Golder Associates, *Cell Operation and Maintenance Plan, Containment Cell Construction, Former Pasmaenco Cockle Creek Smelter, Consultants Ref.: 06623099_081_R14*, December 2008

Please contact the undersigned if you have any questions regarding this document.

GOLDER ASSOCIATES PTY LTD



Daniel Dohle
Senior Engineer

PD/GRS/gl

CC:

Attachments: Figure 1 – Site Plan and Location of Analysis Cross Sections
Figure 2 – Cross Sections
Figure 3 – Proposed Containment Cell Landform
Figure 4 – Subsurface Design Profiles
Figure 5 – Settlement Calculations
Limitations



Phil Davies
Principal Geotechnical Engineer

j:\06proj\051-100\06623099_pasminco_remediation_cockle_creek\deliverables\06623099_801_l_rev0 cell platform settlement for cell expansion.docx

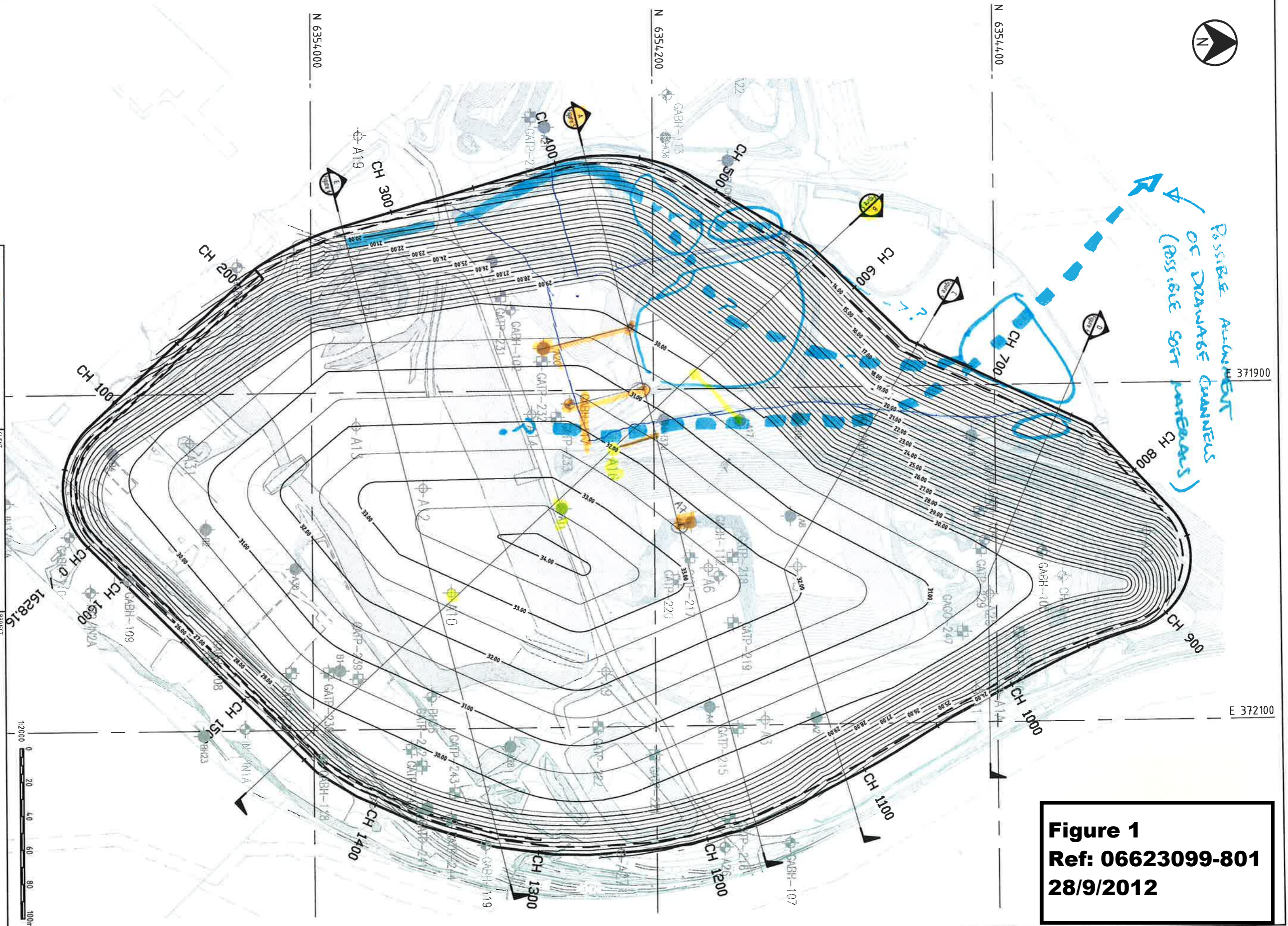


Figure 1
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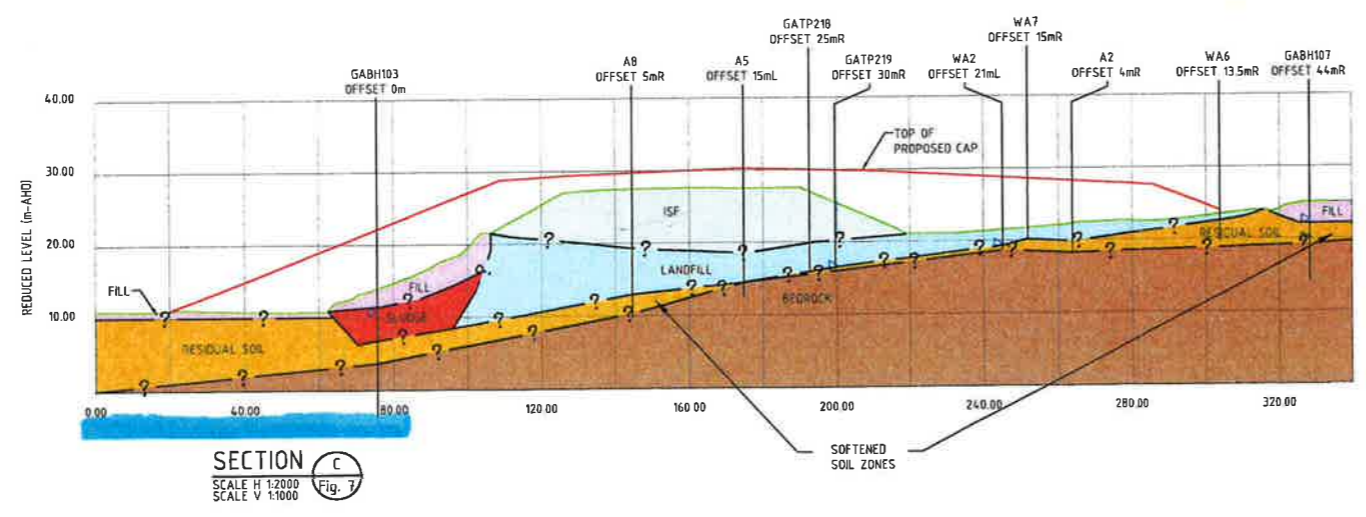
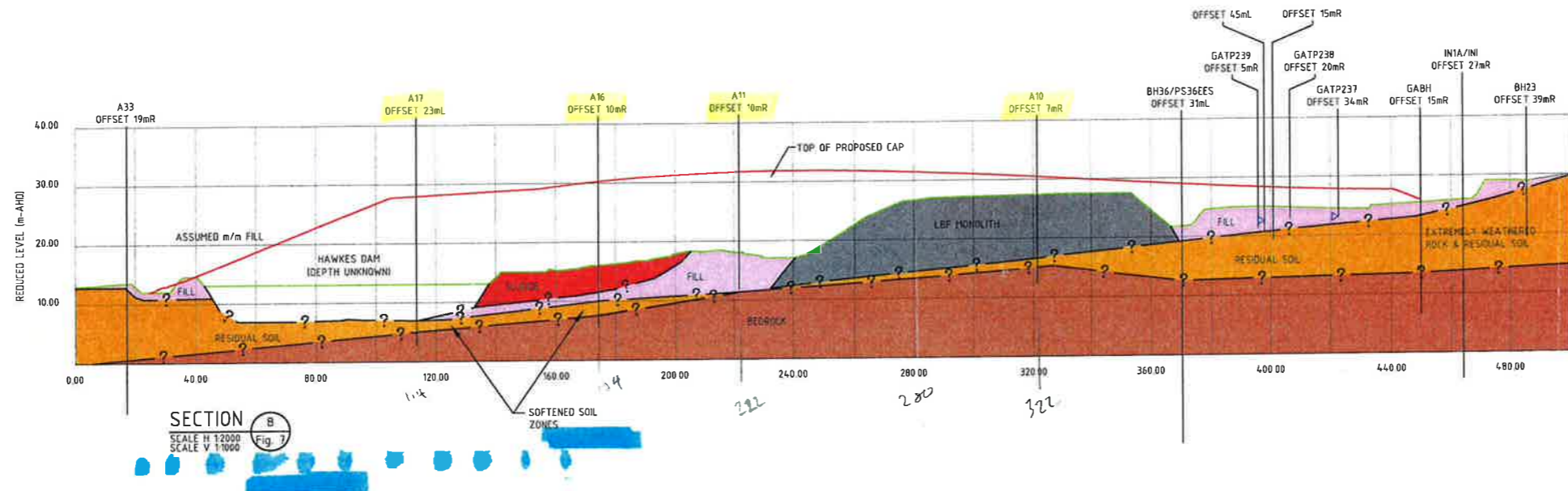
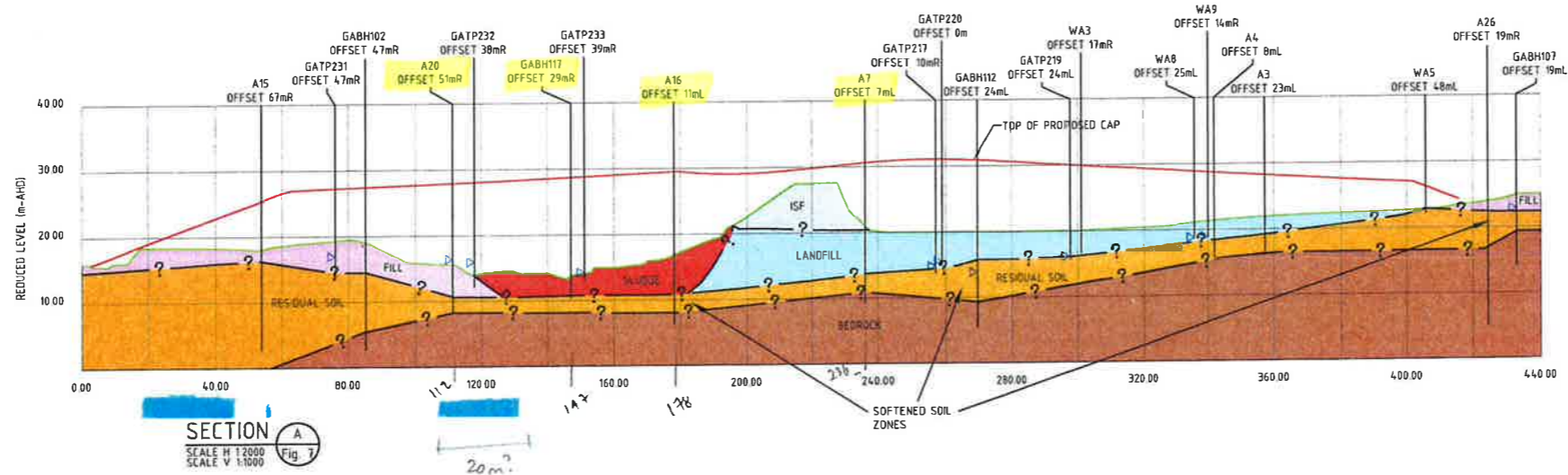


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			FIGURE No FIGURE 7

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LEGEND:

- STRATUM LAYERS**
- FILL/LANDFILL
 - ISF STOCKPILE
 - LBF MONOLITH
 - SLUDGE
 - LANDFILL
 - RESIDUAL SOIL
 - BEDROCK
- WATER INFLOW OBSERVED DURING FIELD INVESTIGATION
 - COAL SEAMS
 - BOREHOLE/TESTPIT IDENTIFICATION (REFER TO GOLDR REPORT 06623099/016 DATED 26 OCT. 2006)
 - OFFSET FROM SECTION LINE
 - APPROXIMATE BOREHOLE/TESTPIT END DEPTH
 - INFERRED MATERIAL BOUNDARY



PRELIMINARY

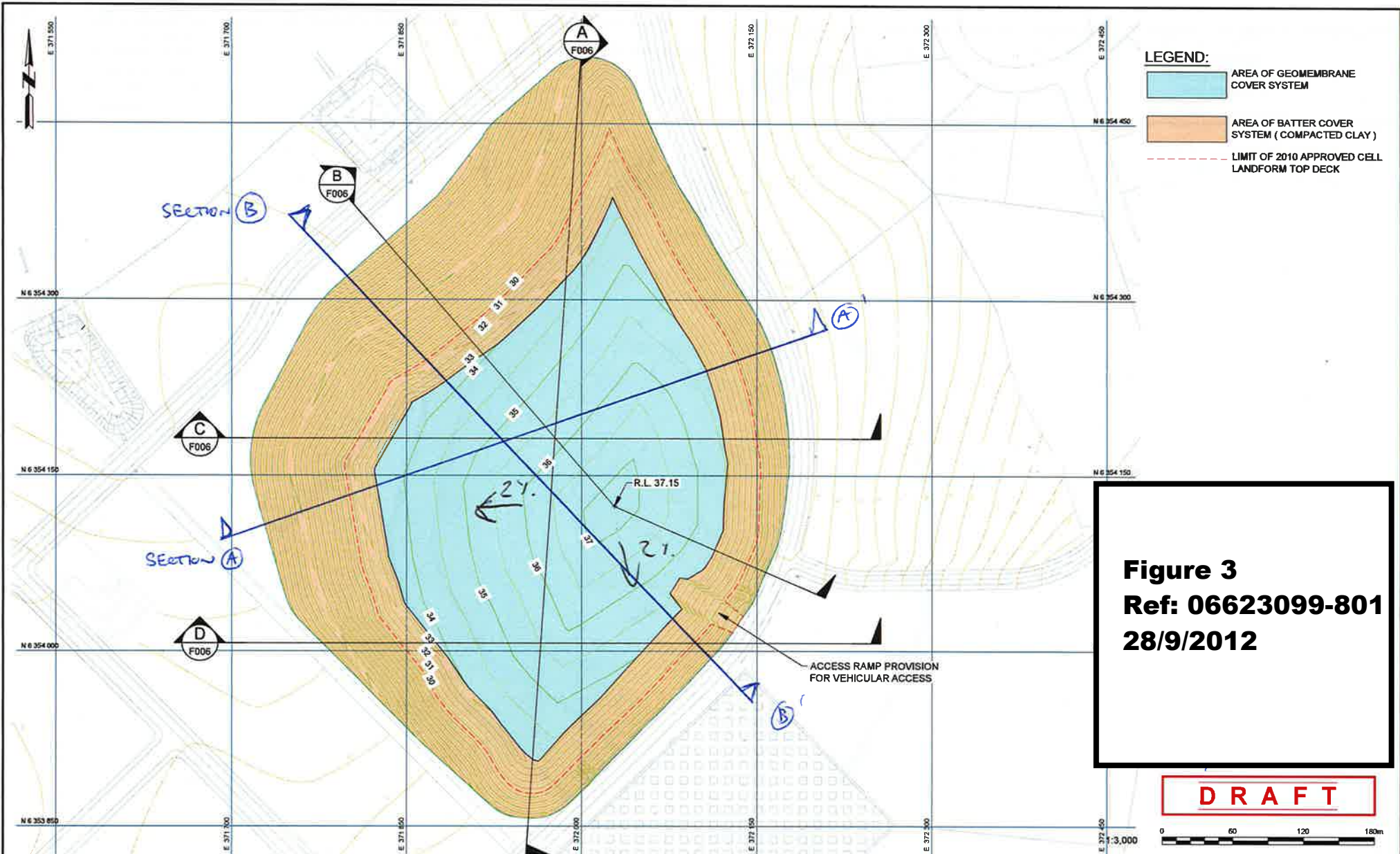
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LEGEND:

- AREA OF GEOMEMBRANE COVER SYSTEM
- AREA OF BATTER COVER SYSTEM (COMPACTED CLAY)
- LIMIT OF 2010 APPROVED CELL LANDFORM TOP DECK

Figure 3
Ref: 06623099-801
28/9/2012

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0 60 120 180m
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 Golder Associates <small>www.golder.com GOLDBER ASSOCIATES PTY. LTD.</small>	CLIENT: FERRIER HODGSON		PROJECT: PCCS - CELL EXPANSION			
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	DRAWN BY: GRS	DATE: 29.08.2012				
	SCALE: 1:3,000	SHEET NO: A3	PROJECT NO: 06623099	DOC NO: 779	DOC TYPE: L	FIGURE NO: F004
FIGURE 4						

Depth below Finished Surface Level (m)	Borehole Profile / Cross Section Location						
	Section A			Section A+B	Section B		
	A7	A20	GABH117	A16	A10 ¹	A11	A17
1	Unit 1 New Fill (13m)	Unit 1 New Fill (15m)	Unit 1 New Fill (17.5m)	Unit 1 New Fill (17.5m)	Unit 1 New Fill (7m)	Unit 1 New Fill (15.75m)	Unit 1 New Fill (24m)
2							
3							
4							
5							
6							
7							
8	Unit 3 Existing Landfill (6m)	Unit 2 In-Situ Fill (4m)	Unit 1 New Fill (3m) – Replacing sludge	Unit 1 New Fill (4m) – Replacing sludge	LBF Monolith	Unit 2 In-Situ Fill (5m)	
9							
10	Unit 4 Residual (2m)	Unit 4 Residual (2m)	Unit 4 Residual (2m)	Unit 2 In-Situ Fill (1m)	Unit 4 Residual (1m)	Unit 5 Bedrock	
11							
12	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 4 Residual (2m)	Unit 5 Bedrock	Unit 4 Residual (2m)	
13							
14	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
15							
16	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
17							
18	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
19							
20	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
21							
22	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
23							
24	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
25							
26	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	Unit 5 Bedrock	
27							

Note:
 1. All materials at A10 are considered as incompressible, which results in a conservative differential settlement outcome relative to this hard spot. Predicted settlements at the waste cell crest between A10 and A11 are interpolated between these locations.


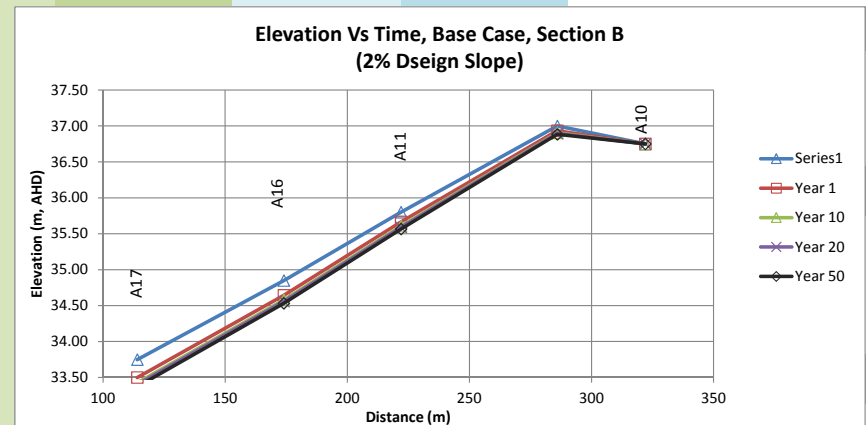
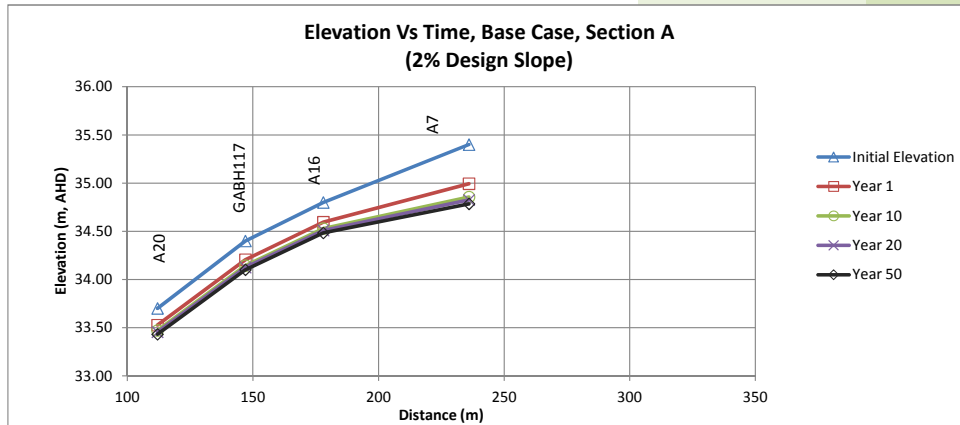
	CLIENT Ferrier Hodgson		PROJECT Pasminco Cockle Creek Smelter Waste Cell	
	DRAWN PD	DATE 26/09/12	TITLE Feasibility Assessment for Revised Platform Design Profiles for One Dimensional Settlement Assessment	
	CHECKED GS	DATE 26/09/12		
	SCALE NTS	A4	PROJECT No 06623099-801	FIGURE No 4

Figure 5
Surface Settlement Assessment - Base Case
Proposed Cell Expansion (landform peak RL 37.15 m)

Section A	Chainage	Settlement at year (mm)				Elevation	grade check (%)	grade check (%)		grade check (%)	grade check (%)		grade check (%)		
		1	10	20	50			Year 1	Year 10		Year 20	Year 50			
A20	112	173	229	246	268	33.70	2.00	33.52671	1.94	33.47076	1.92	33.4539	1.92	33.43162	1.91
GABH117	147	195	256	275	299	34.40	1.29	34.20536	1.26	34.14391	1.24	34.12539	1.24	34.10092	1.23
A16	178	205	271	291	317	34.80	1.03	34.59451	0.69	34.52906	0.56	34.50935	0.54	34.48328	0.52
A7	236	406	544	575	615 reference	35.40		34.99404		34.85601		34.82526		34.78468	

Section B	Chainage	Settlement at year (mm)				Elevation	grade check (%)	grade check (%)		grade check (%)	grade check (%)		grade check (%)		
		1	10	20	50			Year 1	Year 10		Year 20	Year 50			
A17	114	249	324	346	376	33.75	1.83	33.50105	1.91	33.42611	1.92	33.40353	1.93	33.37369	1.93
A16	174	205	271	291	317	34.85	1.98	34.64451	2.13	34.57906	2.14	34.55935	2.15	34.53328	2.15
A11	222	133	193	211	234 reference	35.80	1.88	35.66652	1.98	35.60732	2.03	35.58948	2.04	35.56591	2.06
Crest	286	67	96	105	117	37.00	0.69	36.93326	0.51	36.90366	0.43	36.89474	0.40	36.88295	0.37
A10	322	0	0	0	0	36.75		36.75		36.75		36.75		36.75	





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APPENDIX B

Slope Stability Calculations

28 September 2012

Reference No. 06623099-756-L-Rev0

Mr Richard Bastow
Ferrier Hodgson
Level 29
600 Bourke Street
Melbourne VIC 3000

PROPOSED PASMINCO CONTAINMENT CELL EXPANSION DESIGN – SLOPE STABILITY MODELLING

Dear Richard

1.0 INTRODUCTION

This letter provides the results of additional slope stability analyses carried out for the proposed expansion design of the containment cell at the former Pasmenco site.

This letter was prepared in accordance with our proposal 06623099-774-P-Rev1, dated 01 August 2012 and your acceptance via email, dated 01 August 2012.

2.0 BACKGROUND

Golder developed a geotechnical model for the containment cell as part of the 2008 Approved Design (Golder 2007). We carried out slope stability modelling on selected cross sections of the geotechnical model using the SLOPE/W software package, and reported outcomes in our letter report dated 08 March 2007 (Golder 2007).

Additional site knowledge was gained through geotechnical site investigations of areas for the potential occurrence of soft soils and through the remediation works carried out, which led to Golder refining the model in 2010 (Golder 2010).

This letter should be read in conjunction with the above documents.

We understand that Pasmenco Cockle Creek Smelter Pty Ltd (PCCS) and Incitec Fertiliser Limited (IFL), may come to an arrangement to place contaminated material from the IFL site in the PCCS containment cell. Up to 450 000 cubic metre (cu.m.) of material from the IFL site will be placed in the PCCS cell.

The expansion design (Golder 2012a) provides a cell with a maximum final elevation of less than RL 38 m AHD (reduced level in Australian Height Datum) compared to a maximum final elevation of RL 34 m AHD in the 2010 Approved Cell Design. Slope stability modelling is required to demonstrate that adequate design performance is achievable for the cell expansion design.

The cross sections used in this updated geotechnical model reflect the changes in the landform as outlined in Figure 4 and Figure 6 of the Expansion Design Report (Golder 2012a). We have further amended the geotechnical model based on additional knowledge gained from in situ geotechnical testing of the contaminated material placed (refer Section 5.3 below).



3.0 SCOPE OF SERVICES

We carried out the following tasks for this assessment:

- Slope stability analyses using the proposed design reduced levels (RLs) as per Figure 4 'Proposed Containment Cell Landform' as presented in Golder (2012a). Note: Figure 4 is provided as Attachment 1 to this letter.
- Sensitivity analyses for variation in undrained shear strength of subgrade materials such as sludge; and
- Interpretation and discussion of the slope stability results.

4.0 PREVIOUS SLOPE STABILITY ASSESSMENT

Previous stability assessments were carried out in January 2007 for five geotechnical cross sections along the cell, Sections A to E (refer Attachment 2 for location of sections which have been sketched on to the Robert Carr and Associates (RCA) site investigation plan). The assessment assumed a compaction of material placed in the cell achieved 90% of the Standard Maximum Dry Density Ratio (SMDD). The results of these previous stability assessments were presented in Golder (2007).

Additional stability analyses were carried out in March 2010 which took account of the site investigation information obtained by RCA regarding the extent of sludge material in the cell subgrade. The analyses were carried out for two critical sections, Section A and Section C, where the greatest sludge extents were inferred based on the RCA site investigation. The results of the assessments were presented in Golder memorandum 476 Rev0.

The results of the March 2010 stability analyses indicated that an acceptable factor of safety for slope instability during a seismic event could be achieved within three years following construction of the cell. This assessment estimated that there is an improvement of sludge shear strength over a 3 year period to an undrained shear strength of at least 40 kPa due to cell fill loading. However, if a seismic event occurs within three years of cell construction, there would be an increased risk of slope instability on the basis that the shear strength of the sludge material may be lower than the estimated shear strength of 40 kPa.

Based on our site supervision and information provided by you, we understand that the sludge material has been excavated by PCCS Services, the cell construction contractor, from the majority of the cell footprint and replaced with crushed concrete as part of the cell subgrade preparation works. No survey information of this was provided apart from completion reports for high energy impact compaction.

5.0 REVISED SLOPE STABILITY ASSESSMENT

5.1 Landform

The slope stability analyses presented in this letter have been carried out for the critical sections (Section A and Section C) as shown in Attachments 3 and 4 to this report. The cell surface is modelled as per the design surface levels presented in figure F004 'Proposed Containment Cell Landform' as presented in Golder (2012a).

5.2 Parameters

Parameters and general assumptions for the assessment (soil parameters and seismic acceleration) are generally as discussed in Golder document 055 Rev0 and Golder memo 476 Rev0 (Golder 2010), with the exception that the inferred shear strength of the material placed in the containment cell has been increased from 50 kPa to 75 kPa as a result of additional site knowledge and recent testing data described below.

Due to uncertainty as to the extent over which the sludge has been removed and replaced with crushed concrete, we have assumed the extent of the sludge material below the cell is as described in our memorandum 476 Rev0 (Golder 2010).

Drained shear strength parameters were used to assess the long term stability of the proposed containment cell batter slope. Undrained shear strength parameters were used to assess the short-term stability of the containment cell batter slope during a seismic event, under 50% of an un-factored peak site ground acceleration of 0.375g. Where existing landfill material and fill material above sludge is predominantly granular (gravel and sand), drained shear strength values were used in the seismic analyses.

5.3 Rationale for Increase in Shear Strength of Cell Material

We have amended the shear strength for the contaminated material placed in the containment cell based on additional knowledge gained from in situ geotechnical testing of the placed contaminated material. Specifically, we have increased the undrained shear strength for the contaminated material from 50 kPa to 75 kPa.

The original slope stability model as presented in Golder (2007) assumed a compaction of cell material to 90% of the Standard Maximum Dry Density Ratio (SMDD) with no compaction testing specified. However, the actual compaction density achieved during cell construction was measured at a specific frequency by the geotechnical inspection and testing authority (GITA) for the project. The GITA is engaged to independently monitor compliance with the specification (Level 1, AS 3798). As per December 2011, approximately 750 compaction density tests had been conducted by the GITA in the contaminated material that had been placed in the cell, with the average density achieved being approximately 103% SMDD.

The compaction test data indicates that the contaminated fill material has generally been placed at a significantly higher density than assumed by the design. This means that the cell material is expected to be stronger, stiffer, and less compressible than anticipated at the time of the original slope stability model.

To substantiate this expectation, Golder carried out in-situ testing of contaminated material placed in the containment cell, using dynamic cone penetration (DCP) testing. Strength correlations by Look (2007) have been used to assess soil strengths based on DCP results. It should be noted that these correlations are approximate and that measurements made with a DCP are indicative only. Refer to Attachment 5 for detailed information relating to the DCP investigation (Golder 2012b).

Graph 1 within the DCP investigation report provides a summary of the DCP results in contaminated material placed in stages B2-1, B2-3 and C of the containment cell. The investigation was carried out by Golder on 14 August 2012.

Graph 1 indicates a mean and median number of DCP results below a 300 mm depth, providing an indication that the shear strength of the soil is 75 kPa or higher. Our review of compaction results also supports this inferred strength value.

6.0 RESULTS OF STABILITY ASSESSMENT

A summary of the results of the updated stability analyses is presented in Table 1, below. Figures are provided in Attachments 3 and 4.

Table 1: Summary of Results of Stability Analyses

Section ID	Conditions of Analysis		Seismic Ground Acceleration	Undrained Cohesion of Sludge	Calculated FOS value	Target FOS value**	Figure No.*
Section A	Long Term	Drained***	Nil	N/A	2.0	1.5	-
	Short Term	Undrained	Nil	15 kPa	2.7	1.3	1
	Short Term	Undrained	0.1875g	15 kPa	1.1	1.0	2
	Short Term	Undrained	0.1875g	40 kPa	1.1	1.0	3
Section C	Long Term	Drained***	Nil	N/A	1.8	1.5	-
	Short Term	Undrained	Nil	15 kPa	1.9	1.3	7
	Short Term	Undrained	0.1875g	15 kPa	0.9	1.0	8
	Short Term	Undrained	0.1875g	40 kPa	1.0	1.0	9

Note: FOS = factor of safety

Numbers in bold italics have lower FOS than target FOS

*Figures are attached to this letter

**FOS has been calculated using optimised slip surfaces

***Drained sludge parameters are based on an effective friction angle of 15 degrees

Based on this stability assessment, the stability of the cell batters is expected to be lowest during an earthquake event. The calculated FOS values for long term and short term stability (without earthquake loads) were greater than commonly accepted target factor of safety values.

For short-term earthquake stability case of Section C, the factor of safety is less than the target factor of safety of 1.0 when the unimproved strength of the sludge is modelled as 15 kPa. When the sludge has undrained shear strength of 40 kPa, the calculated factor of safety increases and the target factor of safety of 1 is achieved.

7.0 DISCUSSION OF STABILITY ASSESSMENT RESULTS

7.1 Section A

We consider that an acceptable factor of safety for slope instability under static (i.e. non-earthquake) conditions can be achieved. We consider that an acceptable factor of safety for slope instability during a seismic event can be achieved. For the seismic case this relies on improvement of sludge shear strength to an undrained shear strength of at least 15 kPa due to cell fill loading (as assumed in our initial assessment (Golder 2010)) or due to excavation and replacement of sludge.

7.2 Section C

We consider that an acceptable factor of safety for slope instability under static (i.e. non-earthquake) conditions can be achieved. We consider that an acceptable factor of safety for slope instability during a seismic event should be achieved within three years following construction of the cell. For the seismic case, this relies on improvement of sludge shear strength to an undrained shear strength of at least 40 kPa due to cell fill loading (as estimated in our previous assessment (Golder 2010)) or due to excavation and replacement of sludge. This is considered to be an acceptable situation given that in the three years prior to the sludge achieving the assumed undrained shear strength of 40 kPa, there is a 1 in 167 chance (0.6% of the design earthquake occurring. The design earthquake has an intensity of ground shaking that has a 10% chance of being exceeded within 50 years, which generally corresponds to an earthquake with a 500-year return period.

8.0 SUMMARY

The results of this slope stability assessment indicates that the proposed cell expansion design achieves acceptable levels of slope stability.

9.0 REFERENCES

Burt Look 2007, *Handbook of Geotechnical Investigation and Design Tables*, Taylor & Francis Group, London, UK,

Golder 2012a, *Concept Design Report, Expansion of Pasminco Cockle Creek Smelter Containment Cell*, Consultant's Reference 06623099-780-R-Rev0, September 2012

Golder 2012b, *DCP Investigation of Contaminated Fill in Pasminco Cell*, Consultant's Reference 06623099-786-L-Rev0, September 2012

Golder 2010, *Slope Stability and Settlement Assessment*, Consultant's Reference: 06623099-476-M-Rev0, March 2010.

Golder 2007, *Containment Cell Detailed Design and Management Plan, Pasminco Cockle Creek Smelter, Boolaroo, NSW, Appendix D Rationale for Seismicity study and stability assessment*, Consultant's Reference 06623099-055, dated, March 2007.

Please contact us should you have any questions about this letter.

GOLDER ASSOCIATES PTY LTD



Daniel Dohle
Senior Waste Management Engineer

MK,DD,GRS/PRED/km



Phil Davies
Principal Geotechnical Engineer

Attachments:

- Attachment 1 – Proposed Containment Cell Land Form, Figure 4
- Attachment 2 – Marked up RCA Figure – Plan showing location of geotechnical cross-sections
- Attachment 3 – Results of Stability Analyses for Section A
- Attachment 4 – Results of Stability Analyses for Section C
- Attachment 5 – DCP investigation of Contaminated Fill in Pasminco Cell
- Attachment 6 – Limitations

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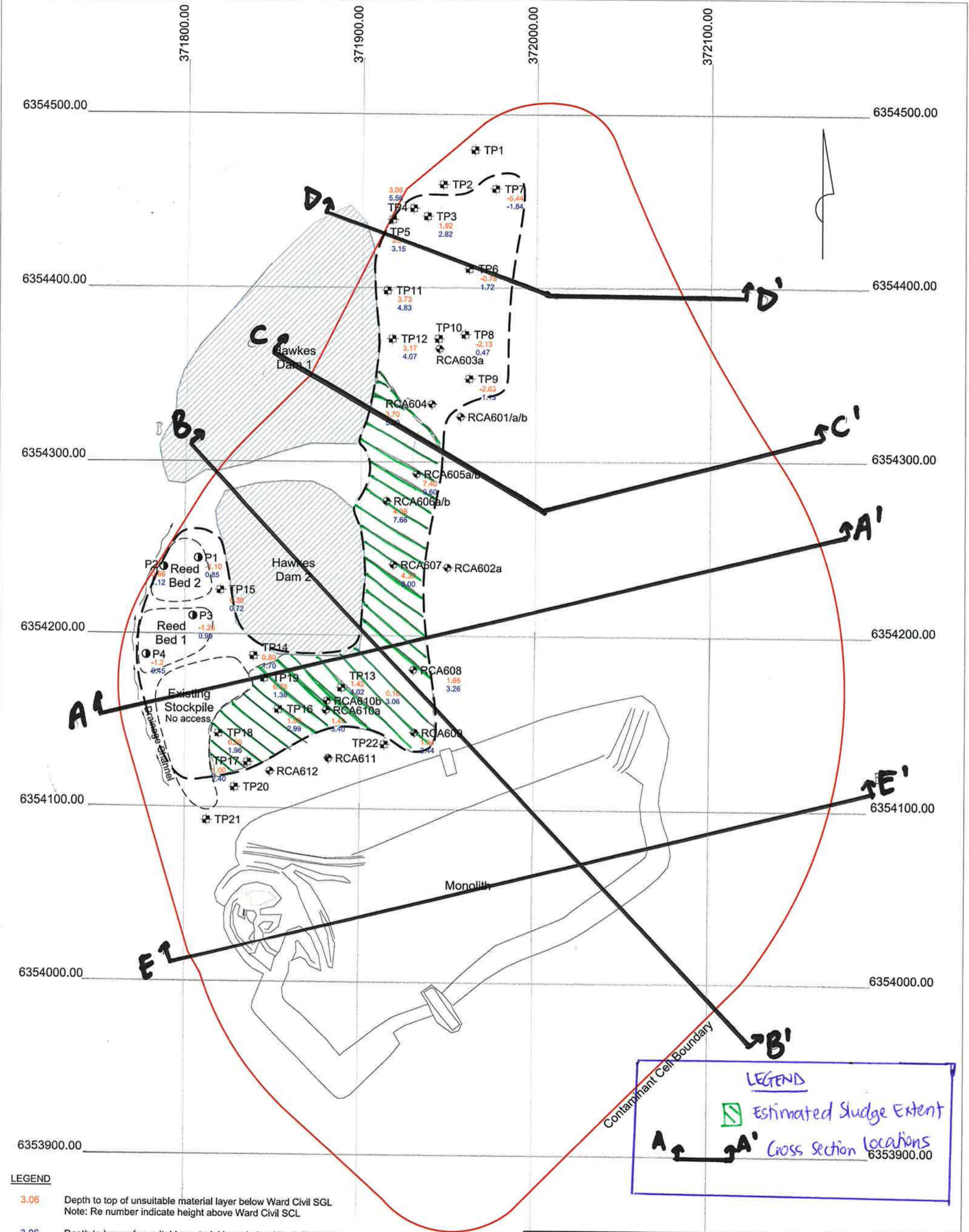
ATTACHMENT 1

Proposed Containment Cell Land Form, Figure 4

ATTACHMENT 2

Marked up RCA Figure – Plan showing location of geotechnical cross-sections

CDT-DWG-A3V-001/1



- LEGEND**
- 3.06 Depth to top of unsuitable material layer below Ward Civil SGL
Note: Re number indicate height above Ward Civil SGL
 - 3.06 Depth to base of unsuitable material layer below Ward Civil SGL
Note: Re number indicate height above Ward Civil SGL
 - (---) Inferred extent of unsuitable material layer
 - DCP test in reed bed
 - ⊕ RCA test pit location, July 2009
 - ⊕ RCA borehole location, August 2009

NOTE: Drawing adapted from plan supplied by Ward Civil Engineering Ref No 543123a, Dated 7/8/2009

LEGEND

- Estimated Sludge Extent
- Cross section locations

A-A' B-B' C-C' D-D' E-E'

		INFERRED EXTENT OF UNSUITABLE MATERIALS BASED ON RCA INVESTIGATION AUGUST 2009 BUNDERRA REDEVELOPMENT PSSC, COCKLE CREEK	
CLIENT	Ward Civil Engineering	PROJECT No	7014-600
DRAWN BY	JE	SCALE	1 : 2000 (A3)
APPROVED BY	RJC	DATE	1/9/2009
		DRAWING No	3
		REV	0
		OFFICE	NEWCASTLE

ATTACHMENT 3

Results of Stability Analyses for Section A

Name: Drained

Pasminco Stability Analysis - SECTION A

Date: 9/13/2012

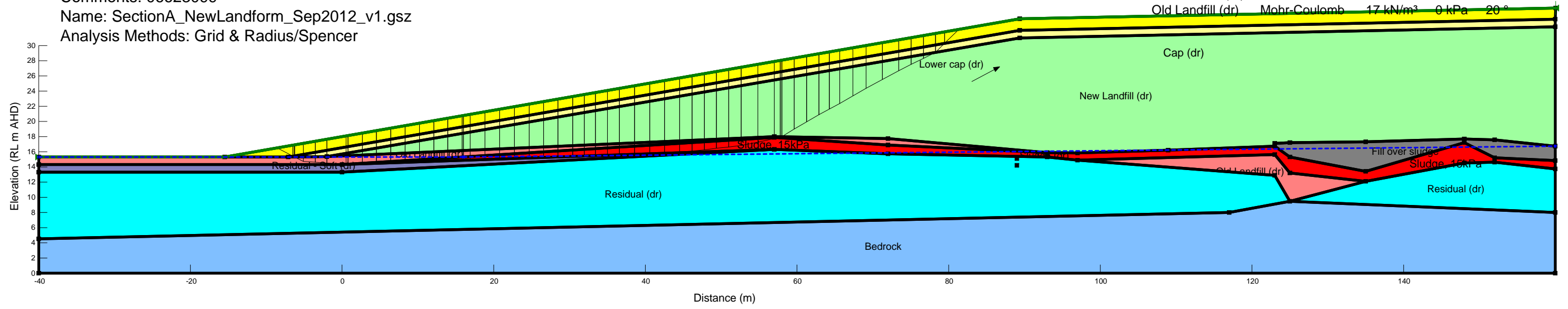
Comments: 06623099

Name: SectionA_NewLandform_Sep2012_v1.gsz

Analysis Methods: Grid & Radius/Spencer

Factor of Safety: FOS: 2.00
Seismic Ground Acceleration = 0 g

Bedrock	Bedrock (Impenetrable)			
Fill over sludge	Mohr-Coulomb	18 kN/m ³	0 kPa	32 °
Sludge (dr)	Mohr-Coulomb	15 kN/m ³	0 kPa	15 °
Residual (dr)	Mohr-Coulomb	18 kN/m ³	10 kPa	30 °
Residual - Soft (dr)	Mohr-Coulomb	18 kN/m ³	5 kPa	20 °
Cap (dr)	Mohr-Coulomb	18 kN/m ³	10 kPa	30 °
Lower cap (dr)	Mohr-Coulomb	18 kN/m ³	10 kPa	30 °
New Landfill (dr)	Mohr-Coulomb	18 kN/m ³	0 kPa	25 °
Old Landfill (dr)	Mohr-Coulomb	17 kN/m ³	0 kPa	20 °



Name: Undrained, with earthquake, sludge = 15kPa

Pasminco Stability Analysis - SECTION A

Date: 9/14/2012

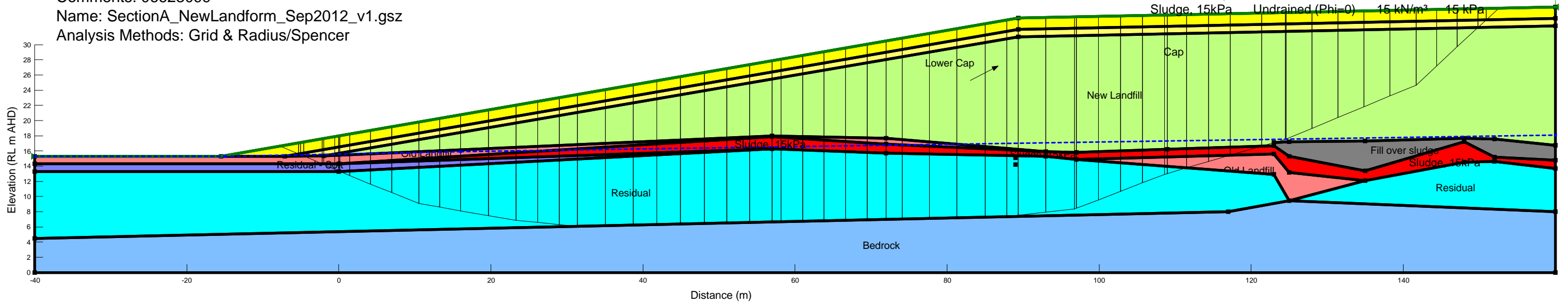
Comments: 06623099

Name: SectionA_NewLandform_Sep2012_v1.gsz

Analysis Methods: Grid & Radius/Spencer

Factor of Safety: FOS: 1.12
Seismic Ground Acceleration = 0.1875 g

Cap	Undrained (Phi=0)	18 kN/m ³	100 kPa
New Landfill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Old Landfill	Undrained (Phi=0)	17 kN/m ³	30 kPa
Residual	Undrained (Phi=0)	18 kN/m ³	100 kPa
Residual - Soft	Undrained (Phi=0)	18 kN/m ³	30 kPa
Bedrock	Bedrock (Impenetrable)		
Lower Cap	Undrained (Phi=0)	18 kN/m ³	75 kPa
Fill over sludge	Mohr-Coulomb	18 kN/m ³	0 kPa 32°
Sludge, 15kPa	Undrained (Phi=0)	15 kN/m ³	15 kPa



Name: Undrained, sludge = 15kPa

Pasminco Stability Analysis - SECTION A

Date: 9/14/2012

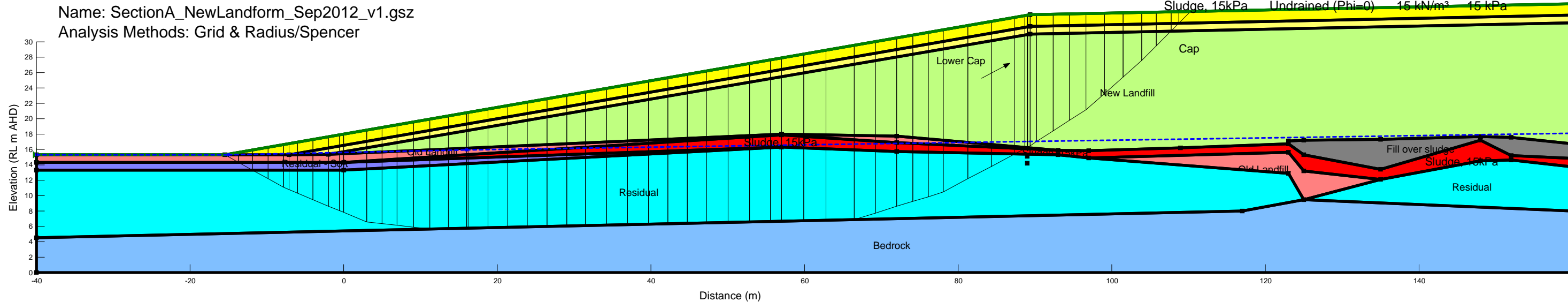
Comments: 06623099

Name: SectionA_NewLandform_Sep2012_v1.gsz

Analysis Methods: Grid & Radius/Spencer

Factor of Safety: FOS: 2.68
Seismic Ground Acceleration = 0 g

Cap	Undrained (Phi=0)	18 kN/m ³	100 kPa
New Landfill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Old Landfill	Undrained (Phi=0)	17 kN/m ³	30 kPa
Residual	Undrained (Phi=0)	18 kN/m ³	100 kPa
Residual - Soft	Undrained (Phi=0)	18 kN/m ³	30 kPa
Bedrock	Bedrock (Impenetrable)		
Lower Cap	Undrained (Phi=0)	18 kN/m ³	75 kPa
Fill over sludge	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °
Sludge, 15kPa	Undrained (Phi=0)	15 kN/m ³	15 kPa



Name: Undrained, with earthquake, sludge = 40kPa

Pasminco Stability Analysis - SECTION A

Date: 9/14/2012

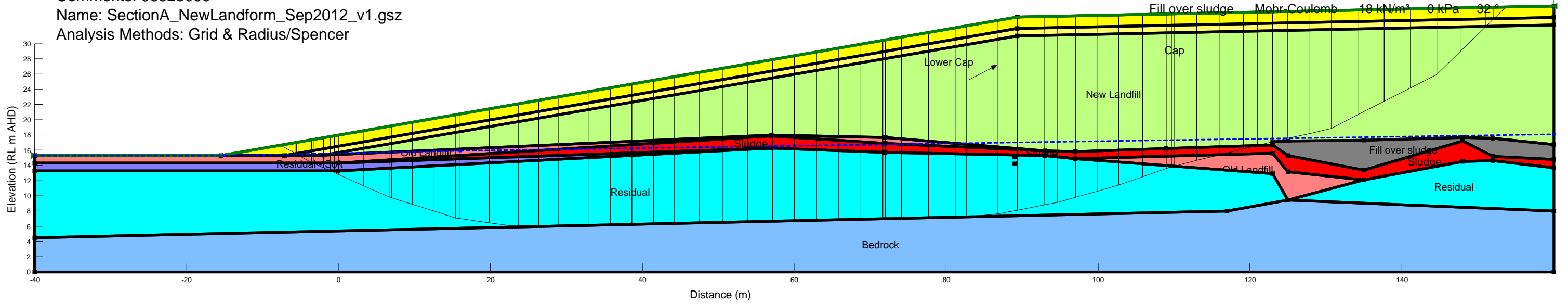
Comments: 06623099

Name: SectionA_NewLandform_Sep2012_v1.gsz

Analysis Methods: Grid & Radius/Spencer

Factor of Safety: FOS: 1.12
Seismic Ground Acceleration = 0.1875 g

Cap	Undrained (Phi=0)	18 kN/m ³	100 kPa
New Landfill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Old Landfill	Undrained (Phi=0)	17 kN/m ³	30 kPa
Residual	Undrained (Phi=0)	18 kN/m ³	100 kPa
Residual - Soft	Undrained (Phi=0)	18 kN/m ³	30 kPa
Bedrock	Bedrock (Impenetrable)		
Sludge	Undrained (Phi=0)	15 kN/m ³	40 kPa
Lower Cap	Undrained (Phi=0)	18 kN/m ³	75 kPa
Fill over sludge	Mohr-Coulomb	18 kN/m ³	0 kPa 32°



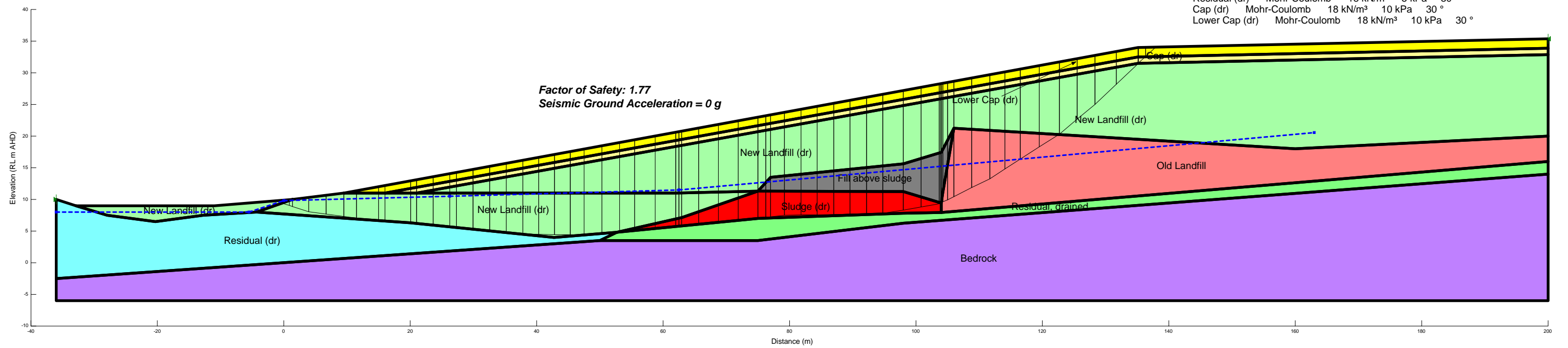
ATTACHMENT 4

Results of Stability Analyses for Section C

Analysis name: Drained

Pasminco Stability Analysis - SECTION C
Date: 9/14/2012
Comments: 06623099
Name: SectionC_NewLandform_Sep2012_v1.gsz
Analysis Methods: Grid & Radius/Spencer

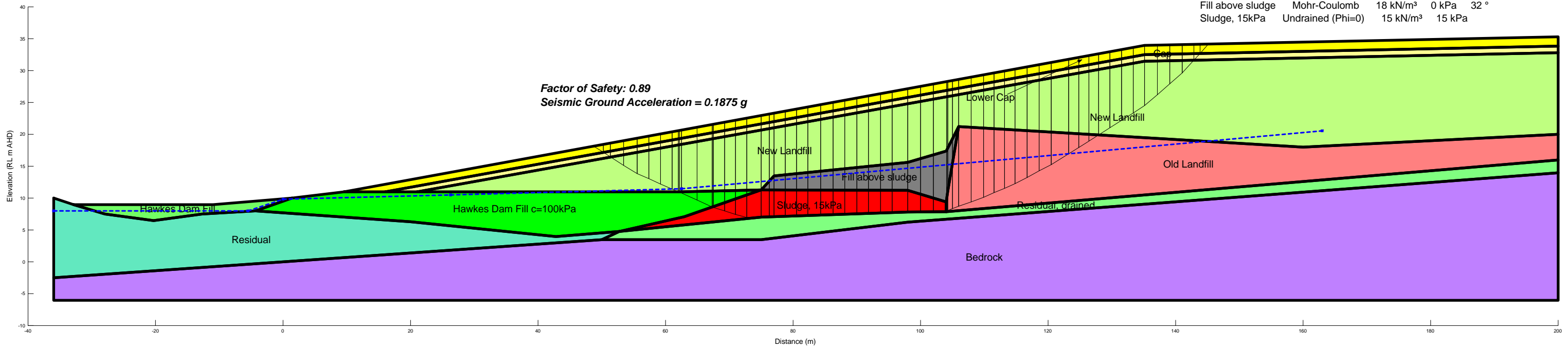
Old Landfill	Mohr-Coulomb	17 kN/m ³	0 kPa	20 °
Bedrock	Bedrock (Impenetrable)			
Residual, drained	Mohr-Coulomb	18 kN/m ³	0 kPa	32 °
Fill above sludge	Mohr-Coulomb	18 kN/m ³	0 kPa	32 °
New Landfill (dr)	Mohr-Coulomb	18 kN/m ³	0 kPa	25 °
Sludge (dr)	Mohr-Coulomb	15 kN/m ³	0 kPa	15 °
Residual (dr)	Mohr-Coulomb	18 kN/m ³	5 kPa	30 °
Cap (dr)	Mohr-Coulomb	18 kN/m ³	10 kPa	30 °
Lower Cap (dr)	Mohr-Coulomb	18 kN/m ³	10 kPa	30 °



Analysis name: Undrained, with Earthquake, Sludge = 15kPa

Pasminco Stability Analysis - SECTION C
 Date: 9/14/2012
 Comments: 06623099
 Name: SectionC_NewLandform_Sep2012_v1.gsz
 Analysis Methods: Grid & Radius/Spencer

CAP	Undrained (Phi=0)	18 kN/m ³	100 kPa
New Landfill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Old Landfill	Mohr-Coulomb	17 kN/m ³	0 kPa 20 °
Residual	Undrained (Phi=0)	18 kN/m ³	100 kPa
Bedrock	Bedrock (Impenetrable)		
Lower Cap	Undrained (Phi=0)	18 kN/m ³	75 kPa
Hawkes Dam Fill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Hawkes Dam Fill c=100kPa	Undrained (Phi=0)	18 kN/m ³	100 kPa
Residual, drained	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °
Fill above sludge	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °
Sludge, 15kPa	Undrained (Phi=0)	15 kN/m ³	15 kPa



Analysis name: Undrained

Pasminco Stability Analysis - SECTION C

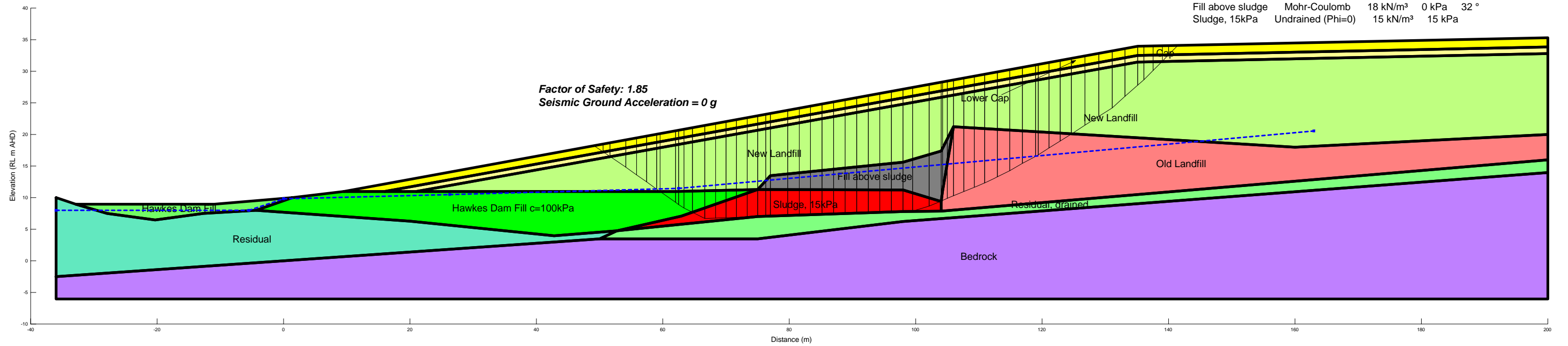
Date: 9/14/2012

Comments: 06623099

Name: SectionC_NewLandform_Sep2012_v1.gsz

Analysis Methods: Grid & Radius/Spencer

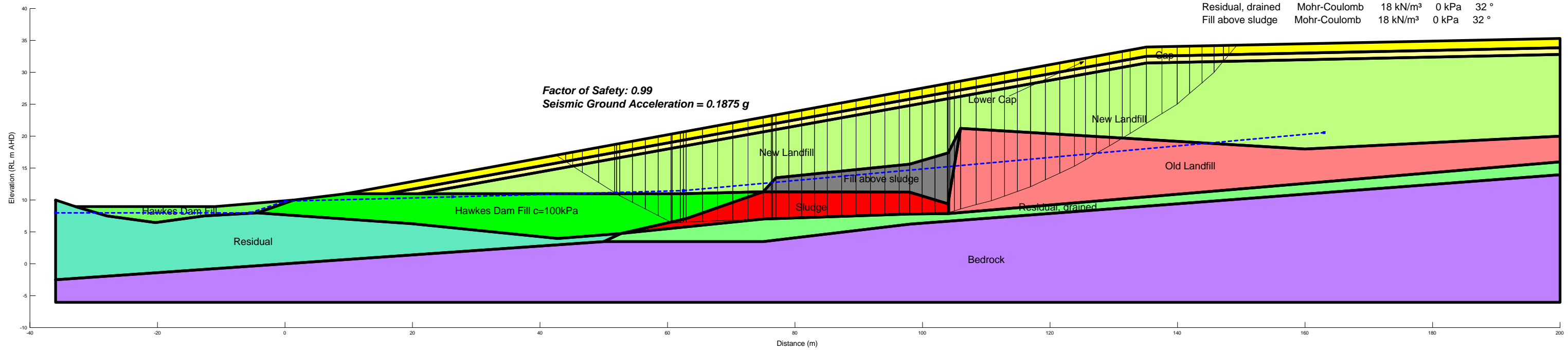
CAP	Undrained (Phi=0)	18 kN/m ³	100 kPa
New Landfill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Old Landfill	Mohr-Coulomb	17 kN/m ³	0 kPa 20 °
Residual	Undrained (Phi=0)	18 kN/m ³	100 kPa
Bedrock	Bedrock (Impenetrable)		
Lower Cap	Undrained (Phi=0)	18 kN/m ³	75 kPa
Hawkes Dam Fill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Hawkes Dam Fill c=100kPa	Undrained (Phi=0)	18 kN/m ³	100 kPa
Residual, drained	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °
Fill above sludge	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °
Sludge, 15kPa	Undrained (Phi=0)	15 kN/m ³	15 kPa



Analysis name: Undrained, with Earthquake, Sludge = 40kPa

Pasminco Stability Analysis - SECTION C
 Date: 9/14/2012
 Comments: 06623099
 Name: SectionC_NewLandform_Sep2012_v1.gsz
 Analysis Methods: Grid & Radius/Spencer

CAP	Undrained (Phi=0)	18 kN/m ³	100 kPa
New Landfill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Old Landfill	Mohr-Coulomb	17 kN/m ³	0 kPa 20 °
Residual	Undrained (Phi=0)	18 kN/m ³	100 kPa
Sludge	Undrained (Phi=0)	15 kN/m ³	40 kPa
Bedrock	Bedrock (Impenetrable)		
Lower Cap	Undrained (Phi=0)	18 kN/m ³	75 kPa
Hawkes Dam Fill	Undrained (Phi=0)	18 kN/m ³	75 kPa
Hawkes Dam Fill c=100kPa	Undrained (Phi=0)	18 kN/m ³	100 kPa
Residual, drained	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °
Fill above sludge	Mohr-Coulomb	18 kN/m ³	0 kPa 32 °



ATTACHMENT 5

DCP investigation of Contaminated Fill in Pasminco Cell

24 September 2012

Reference No. 06623099-786-L-Rev0

Mr Richard Bastow
Ferrier Hodgson
Level 29
600 Bourke Street
Melbourne VIC 3000

DCP INVESTIGATION OF CONTAMINATED FILL IN PASMINGO CELL

Dear Richard

1.0 INTRODUCTION

This memorandum summarises the findings from a series of Dynamic Cone Penetrometer (DCP) tests carried out at the Pasmingo Cockle Creek Smelter on the 14 August 2012. This letter was prepared in accordance with our proposal 06623099-774-P-Rev1, dated 01 August 2012 and your acceptance via email, dated 01 August 2012.

We understand that the purpose of the DCP investigation was to provide further justification for revision of the geotechnical site model with respect to shear strength of the Unit 21 Contaminated Material placed in the containment cell. It is proposed to revise the shear strength of the Unit 21 from 50 KPa as assumed in the original design report (Golder 2007).

The DCP tests were carried out in Stage B2-3, Stage B2-1 and Stage C. The stage layout and DCP testing locations can be found in Figure 1.

Results of the DCP tests are described in Section 2.0 of this memorandum.

2.0 DCP TEST RESULTS

We located and carried out the DCP tests at 16 locations across the investigation area, 11 in Stage B2-3, 4 in Stage B2-1 and 1 in Stage C.

DCP tests were targeted to a 2 m depth and testing was stopped if there were either no penetrations occurred or over 25 blows were encountered in a single 100 mm interval.

In cases where the hammer was bouncing in the early stage of the test, a second attempt was carried out in the nearby vicinity.

Tests were carried out outside the extent of haulage roads so that the test results were representative of the body of compacted waste material



2.1 Stage B2-3

14 DCP tests were carried out at 11 locations in Stage B2-3. We understand that this area is more representative a conservative median for the overall site as the waste placement is in progress in the area. We therefore carried out more DCP tests in this area.

As the filling of Unit 21 in this area was still in progress, the thickness of fill in some area was less than 2.0 m. The DCP testing therefore was terminated when we assumed hitting the black sand layer.

Due to a breakage in the DCP rods when carrying out DCP 8 and 9, the DCP's for 8, 9, 15 and 16 could not be completed to the 2 m target depth.

The results of the DCP tests in Stage B2-3 are shown in **Error! Reference source not found.** at the end of this report.

2.2 Stage B2-1 and Stage C

6 DCP tests were carried out at 4 locations in Stage B2-1 from sub base surface which has been recently constructed.

Only 1 DCP test carried out in Stage C which was completed to sub base surface for approximately a year. We note that the DCP rod was broken at the join between 2 rods in the test while pulling the rod out of the ground (lost 1 rod).

The results of the DCP tests in Stage B2-1 and Stage C are shown in **Error! Reference source not found.** at the end of this report.

3.0 RESULT INTERPRETATION

A visual representation of all DCP test results is given in Graphs 1 through to 3 at the end of this report. This includes a presentation of the mean and median values of all investigation results (Graph 1).

Table 1 below shows a rule of thumb conversion from DCP blows per 100 mm versus indicative undrained shear strength (kPa).

Table 1: Rule of thumb Shear Strength Conversion (Burt Look, 2007)

DCP Blows per 100 mm interval	Indicative Undrained Shear (kPa)	Term
0 to 1	0 to 12	Very Soft
0 to 1	12 to 25	Soft
1 to 3	25 to 50	Firm
3 to 5	50 to 100	Stiff
5 to 10	100 to 200	Very Stiff
Above 10	Above 200	Hard

Further discussion and a consideration of compaction test results is provided in our letter 06623099-756-L-Rev0.

4.0 CLOSURE

Please do not hesitate to contact the undersigned, should you have any queries.

5.0 REFERENCES

Golder 2007, *Containment Cell Detailed Design and Management Plan, Pasminco Cockle Creek Smelter, Boolaroo, NSW, Appendix D Rationale for Seismicity study and stability assessment*, Consultant's Reference: 06623099-055, dated 8 March 2007.

Burt Look 2007, *Handbook of Geotechnical Investigation and Design Tables*, Taylor & Francis Group, London, UK.

GOLDER ASSOCIATES PTY LTD



Ryan Huynh
Civil Engineer

RH/DD,GRS/df



Phil Davies
Associate

Attachments:

Figures - Figure 1, Plan of investigation locations
Tables - DCP results tables for Stages B2-3, B2-1 and C
Graphs - Graphs 1, 2 and 3
Limitations

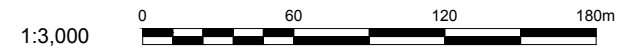
j:\06proj\051-100\06623099_pasminco_remediation_cockle_creek\deliverables\06623099_786_l_rev0_dcp_testing_on_unit_21_cell_1.docx

ATTACHMENT: FIGURES

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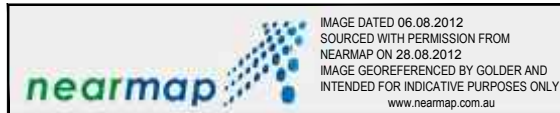


- MGA 94, ZONE 56 COORDINATE GRID
- DEPARTMENT OF LANDS 2004 CADASTRE



LEGEND

- DCP15 APPROXIMATE LOCATION OF DYNAMIC CONE PENETROMETER TESTS (15.08.2012)
- SITE BOUNDARY



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CLIENT FERRIER HODGSON		PROJECT PCCS - CELL EXPANSION			
DRAWN BY HC	DATE 06.09.2012	DRAWING TITLE DYNAMIC CONE PENETROMETER TEST LOCATIONS - CELL 1 (15.08.2012)			
CHECKED BY MN	DATE 06.09.2012				
SCALE 1:3000	SHEET SIZE A3	PROJECT No 06623099	DOC No 786	DOC TYPE M	FIGURE No F001
					REVISION A
					FIGURE 1

ATTACHMENT: DCP TABLES

Table 2: DCP results for Stage B2-3 (14/08/2012)

DCP test No.	01 (1)	01 (2)	02 (1)	02 (2)	03	04	05	06	07	08	09	15 (1)	15 (2)	16
Latitude														
Longitude														
0.0 - 0.1m	3	3	3	4	2	2	2	1	2	-	-	1	1	-
0.1 - 0.2m	2	5	3	6	1	1	2	2	3	1	1	7	1	3
0.2 - 0.3m	4	5	3	3	2	1	3	2	3	1	1	9	1	3
0.3 - 0.4m	5	3	5	5	3	1	2	5	6	1	1	7	4	6
0.4 - 0.5m	4	2	10/80 HB	6	7	3	3	5	7	4	3	3/50 HB	7	14
0.5 - 0.6m	5	3		7	11	3	3	8	5	3	4		3/50 HB	10
0.6 - 0.7m	4	7		5	9	3	4	6	7	12	6			4
0.7 - 0.8m	5	8		3	3	9	6	4	8	10	6			4
0.8 - 0.9m	5	8		3	4	5	6	3	6	6	7			4
0.9 - 1.0m	5	6		5	4	4	3	7	6	3	4			5
1.0 - 1.1m	3/ HB	6		5	6	5	4	9	10	4				
1.1 - 1.2m		6		13	6	6	4	5	12					
1.2 - 1.3m		7		8	14	20	6	15	12					
1.3 - 1.4m		13		7	20	BS	5	10	22					
1.4 - 1.5m		5		7	BS		10	7	17					
1.5 - 1.6m		5		7			20	13	8					
1.6 - 1.7m		5		8			20	10	8					
1.7 - 1.8m		8		7			BS	6	7					
1.8 - 1.9m		17		6				5	7					
1.9 - 2.0m		BS		7				9	16					

Notes : () Bracketed number indicates the attempt number at each DCP location

(-) Dashed results indicates very soft ground where the first 100 mm interval was pushed in by hand

BS: Black Sand

HB: Hammer Bouncing

Table 3: DCP results for Stage B2-1 and Stage C (14/08/2012)

DCP test No.	10 (1)	10 (2)	11	12	13 (1)	13 (2)	14 (Stage C)
Latitude							
Longitude							
0.0 - 0.1m	6	4	2	3	3	2	7
0.1 - 0.2m	3	6	2	9	2	1	11
0.2 - 0.3m	4	5	3	4	1	1	13
0.3 - 0.4m	2	9	9	5	1/HB	3	5
0.4 - 0.5m	1	3	13	4		3	7
0.5 - 0.6m	3	2	7	2		3	7
0.6 - 0.7m	4	13	8	1		3	16
0.7 - 0.8m	8	9	8	3		4	20
0.8 - 0.9m	9	14	8	8		15	16
0.9 - 1.0m	14	9	8	7		15	19
1.0 - 1.1m	20	15	14	5		14	21
1.1 - 1.2m	10/H B	>25	17	5		15	18
1.2 - 1.3m			18	9		16	15
1.3 - 1.4m			18	13		23	12
1.4 - 1.5m			17	27		24	11
1.5 - 1.6m			15				15
1.6 - 1.7m			23				19
1.7 - 1.8m			21				>26
1.8 - 1.9m			22				
1.9 - 2.0m			25				

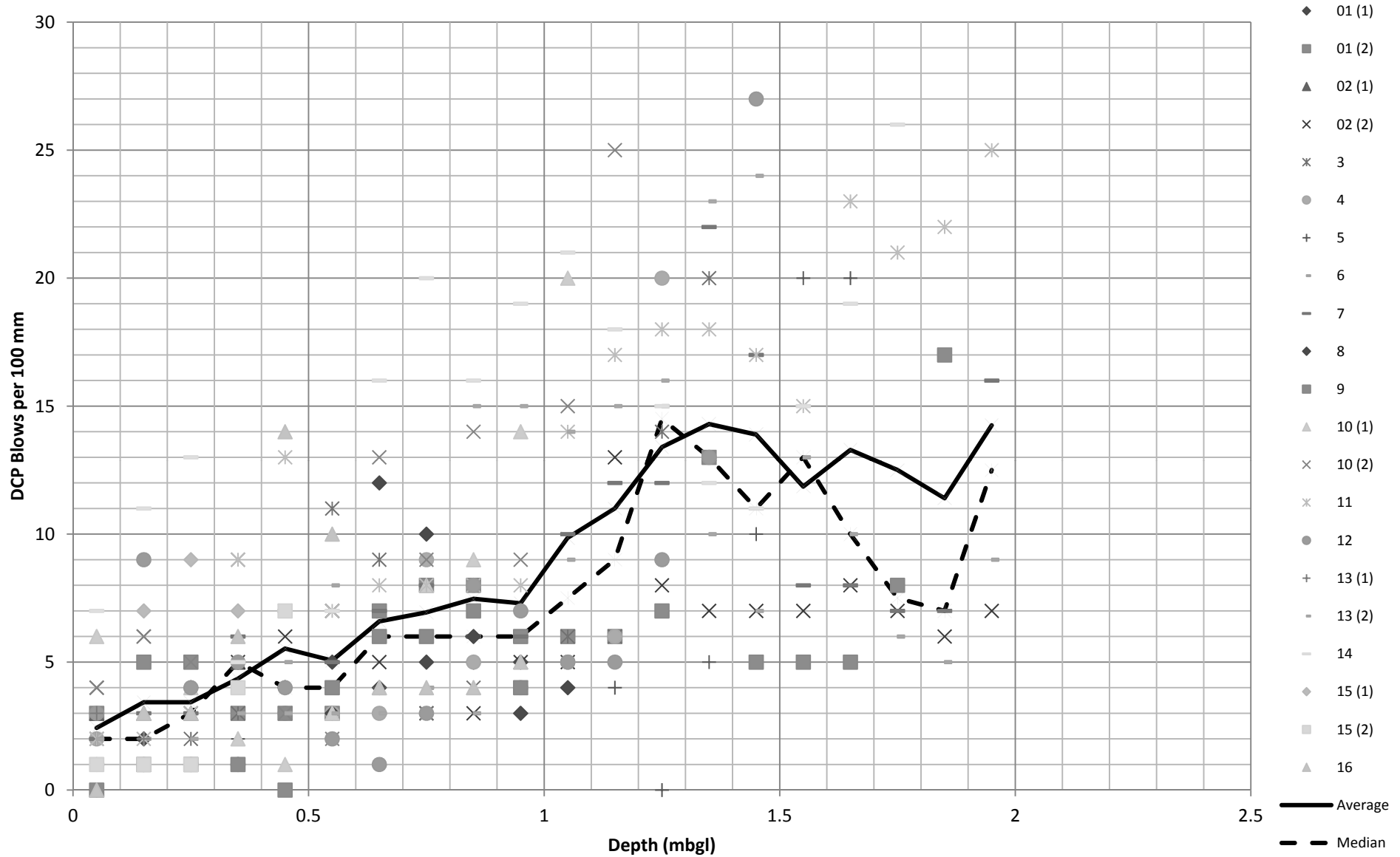
Notes : () Bracketed number indicates the attempt number at each DCP location

BS: Black Sand

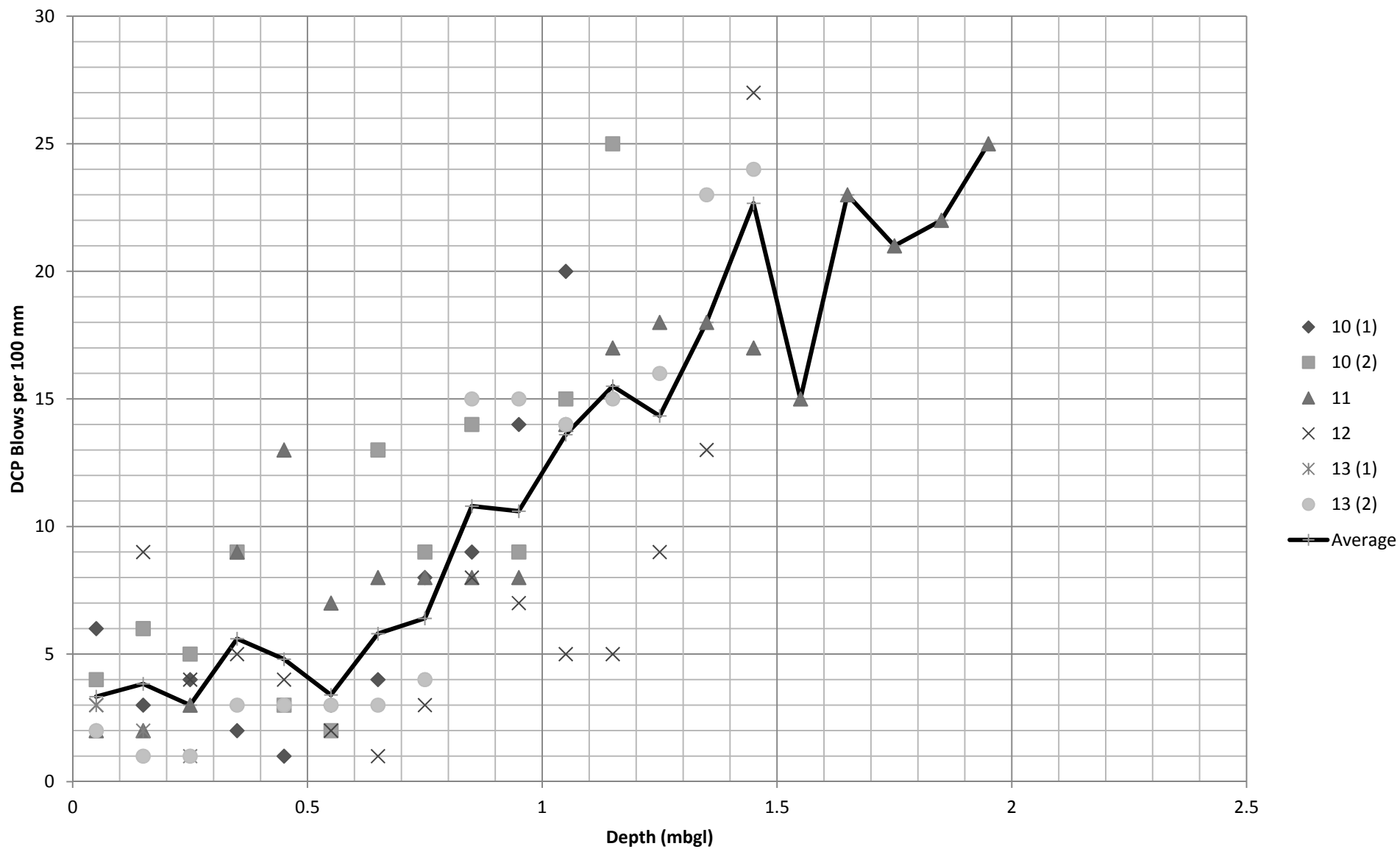
HB: Hammer Bouncing

ATTACHMENT: GRAPHS

Graph 1: Pasminco Fill DCP Investigation, All Data



Graph 2: DCP Investigation, Stage B2-1



ATTACHMENT: LIMITATIONS



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APPENDIX C

Pipe Stress Analysis for Proposed Landfill Expansion Design



APPENDIX C

PCCS Concept Design Report - Pipe Stress Analysis for Proposed Landfill Expansion Design

LEACHATE COLLECTION SYSTEM – PIPE STRESS ANALYSIS FOR PROPOSED LANDFILL EXPANSION DESIGN

The attached spreadsheet provides a calculation for stresses and deflections for the most highly loaded leachate pipe segment within the proposed landfill expansion. The pipe segment of interest is located near the crest of the western cell batter where the thickness of overlying cell materials is at a maximum for the proposed landfill expansion, i.e. 20.7 m. The calculation considers pipe loading, pipe bedding material type, pipe material and dimensions, and the effect of the holes drilled in the pipe to allow leachate collection. Key calculation results are as follows:

- the factor of safety against pipe buckling is calculated to be 11.25 and significantly exceeds the recommended minimum acceptable value of 2; and
- the pipe deflection ratio, which indicates pipe 'out-of-roundness', is calculated to be 3.15% and is less than the recommended maximum acceptable value of 3.4%.

These results indicate that the leachate collection pipes are suitable to withstand the loadings imposed by the proposed cell expansion.

Attachments: Spreadsheet 'Pipe Stress Analysis for Proposed Landfill Expansion Design'

j:\06proj\051-100\06623099_pasminco_remediation_cockle creek\deliverables\06623099_780 concept design\appendix c\06623099_780_r_rev0 appendix c.docx

as per Qian, Koerner, Gray, *Geotechnical Aspects of Landfill Design and Construction*, 2002, Section 9.4

$$\Delta X = \frac{D_L \cdot K \cdot W_c \cdot r^3}{E \cdot I + 0.061 \cdot E' \cdot r^3}$$

$$W_c = \frac{(\sum \gamma_i \cdot H_i) \cdot D_o}{(1 - n \cdot d / 12)}$$

$$P_{cr} = 2 \cdot \left\{ [E' / (1 - \mu^2)] \cdot (E \cdot I / r^3) \right\}^{1/2}$$

Pipe Specification:
SDR 13.6, PN12.5, PE 100 HDPE, 160 mm

	Description	Unit	Value	Source*	Rationale
ΔX	horizontal deflection	m	0.0043	F9.16	
K	Bedding constant	-	0.11	T9.1	
D_L	Deflection lag factor	-	1	T9.2	
W_c	vertical load per unit length	kN/m	51.30	F9.18	
r	mean pipe radius	m	0.07705	F9.20	1/2 D
D	mean diameter pipe	m	0.1541	F9.20	(D _o -D _i)/2
E	elastic modulus pipe material	kN/m ²	194000	E9.2	
I	moment of inertia pipe	m ⁴ /m	1.4E-07	P305	I=t ³ /12
t	pipe wall thickness	m	0.0118	From Iplex pipelines specification	
E'	soil reaction modulus	kN/m ²	20700	T9.3 Crushed rock, moderate compaction (Unit 8 - Drainage Aggregate)	
γ_i	unit weight of material on pipe	kN/m ³	20	Assumed density of compacted clay rich soils	
H_i	thickness of material on pipe	m	16	Approximate maximum from leachate pipe invert to top of cell	
D_o	outside diameter of pipe	m	0.16	Spec	
d	diameter perforated hole/slot on pipe	m	0.006	P300	
n	number of holes/slots per row per foot	-	4	Very low leachate flow, so not many holes needed	
P_{cr}	critical pipe buckling pressure	kN/m ²	2298.63	F9.30	
μ	Poisson's ratio pipe material	-	0.3	E9.2	
P_{tp}	vertical pressure on pipe	kN/m ²	320.64	F9.23	
FS	Factor of Safety pipe buckling	-	7.17	F9.33 P _{cr} /P _{tp} (recommended to be larger than 2)	
D_R	Deflection Ratio	%	2.77%	T9.4 To be <3.4 % for pipes with SDR=13.5 as per Table 9.4	

Input Values
Calculated Values
Output

***Notes:** 'T' denotes 'Table'
 'F' denotes 'Figure'
 'E' denotes 'Equation'
 'P' denotes 'Page'
 'Spec' denotes 'Golder Technical Specification (2008)'



APPENDIX D

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