

C & D Landfill
2 Landfill Rd
Happy Valley

17 December 2012

Attention: Christine Morgan

Dear Christine,

RE: Review of Slope Stability for Resource Consent, C & D Landfill, Happy Valley
Our Reference: 09870.000.000

1 INTRODUCTION AND SCOPE OF WORK

This letter report presents the results of our assessment of recommendations provided by Aurecon New Zealand Ltd (Aurecon) in regard to the future development of the C & D Landfill, Happy Valley, Wellington. The assessment was carried out by Geoscience Consulting (NZ) Ltd at the request of C & D Landfill Ltd as outlined in our proposal dated 23 November 2012 (ref: P2012.000.774)

We understand that C & D Landfill are currently seeking consent for the ongoing operation of the landfill. The proposed consent will allow for filling up to a maximum level of 240 masl (metres above sea level). The previous geotechnical report prepared by Aurecon was completed in 2009 essentially dealt with the proposed lateral expansion of the landfill and did not specifically consider increased heights much in excess of about 205 masl. Additionally, as part of their processing of a Resource Consent Application by C & D Landfill, Wellington City Council¹ requires confirmation of the currency of the Aurecon report conclusions, both in regard to the increase in the proposed fill height, as well as the other recommendations (drainage requirements, fill slope design etc).

The main purpose of this report is to provide a response to the request for further information issued by Wellington City Council.

The scope of work undertaken by Geoscience for this review has involved the following:

- Review of existing information provided to us, including
 - Aurecon's 2009 report;
 - A report prepared by URS (2009) on the stability of the landfill on behalf of Wellington City Council;
 - Drawings and cross sections of the proposed landfill provided by Opus;
 - The Application for Land-use Consent document prepared by Opus (2012), and;
 - WCC's RFI letter;

¹ WCC letter dated 24 October 2012; Section 1 'Geotechnical'.

- A half-day site assessment; this was undertaken on 4 December 2012 by a Principal Engineering Geologist from Geoscience;
- Assessment of the landfill stability to the proposed maximum fill height of 240masl;
- Review of the recommendations provided in the Aurecon report and confirmation of whether they are required to be adopted for the on-going development of the landfill; and
- Reporting (this letter).

We note that there are no plans available showing the specific geometry of the final structure for which consent is currently being applied. As such, we cannot provide definitive design drawings for the geotechnical aspects of the final consented structure. We have provided sketch diagrams where appropriate as Figures 1 to 3. A significantly greater level of engineering input will be required as part of detailed design of the landfill, should Resource Consent be granted.

2 REVIEW COMMENTS

Our review is focused primarily with the Aurecon 2009 report which is referred to specifically in WCC's RFI letter. In general, we agree on a geotechnical level with the findings of the Aurecon report.

Our report is constructed to reference specific sections of the Aurecon report and should be read in parallel with that report. Sections 1 to 5 of the Aurecon report provide background information and describe fill construction methodology practices which remain essentially unaltered at the time of our site visit in December 2012.

Our specific comments in regard to Sections 6.2 onwards in Aurecon's report are provided below:

Section 6.2 – Manmade Stability

Section 6.2.1 – Fillings

Aurecon consider that fill faces on the landfill should be constructed with the following geometry:

- Fill slope of 2H:1V (26.5°)
- 10m high batters, with
- 5m wide benches

Under these conditions, Aurecon have indicated that the faces will remain 'stable' (Factor of Safety greater than 1.0) even under large earthquake events.

Aurecon further note that fill faces in 2009 were typically constructed at angles of around 1.2H: 1V to 1.3H: 1V (38° to 39°), and further note that these face may undergo localised failure under static (ie non-seismic) conditions. Whilst for the majority of the landfill, Aurecon did not consider this to pose a significant level of risk, concern was raised in regard the affect that this would have should failure occur on the high face above the culvert intake (Refer Figure 1, attached).

Aurecon have identified (Section 7 of their letter report) that failure of the fill slope above the culvert may lead to blocking of intake and subsequent water ponding. Left uncontrolled, this could lead to breach of the fill embankment downslope and a subsequent debris flow into the populated valley below. Aurecon note that a "very sizeable event" [rainfall event] would be required to initiate such a failure and that C & D Landfill operational management plan has contingency within it to deal with this situation. We have not reviewed this plan as part of our brief.

We agree with Aurecon's assessment blockage of the existing culvert is a potential risk. Recommendations for suitable risk mitigation measures are provided in our comments on Section 8 below.

Section 7 – Discussion

The first part of this section of Aurecon’s report reiterates and expands on the risks associated with flooding of the culvert intake. We have provided comment on this above and additionally in our comments on Section 8, below.

The second part of Section 7 makes reference to the potential for fill height to proceed up to 250masl (‘or higher’) and suggests that this is feasible from a geotechnical point of view. See Section 8 below for further discussion.

Section 8 – Future Development Engineering Considerations

The first part of Aurecon’s Section 8 outlines aspects that were considered by Aurecon as requiring to be incorporated into future development of the landfill. Specific recommendations are provided in a numbered list (i) to (x). Table 1 below provides an outline of Aurecon’s recommendations and our considerations of the requirements for adoption of each recommendation. Direct quotations from Aurecon’s report are shown in italics in Table 1.

Table 1. General Recommendations for Landfill Development

Aurecon Recommendation	Requirement for Adoption	Geoscience Comments
<p>i) <i>Remediate existing fill slopes plus new fills to meet:</i></p> <p><i>(a) maximum fill height between benches of 10m</i></p> <p><i>(b) maximum fill slope 2H:1V</i></p> <p><i>(c) benches to be 5m minimum width</i></p>	<p>These recommendations should be adopted for final design slopes of the landfill and to the final height of 250masl. Temporary batter slopes can be constructed at up existing slope angles (38° to 39°)</p>	<p>Aurecon note that the recommended final design geometry will result in a Factor of Safety of 1.0 under large earthquake events. We consider that this is a conservative approach.</p>
<p>ii) and vii) <i>Incorporate a secondary flow path; preferably on natural down one margin of the fill and longitudinally slope the intermediate bench down towards the new drainage course</i></p>	<p>These recommendations should be adopted using the design drainage geometry outlined in vii) of Section 8 of Aurecon’s report and shown of Figure 3. (ie 3m wide x 1m deep channels excavated at ground surface). Sediment control measures (silt traps or similar; Refer Figure 3) -should be incorporated at the downstream edge of each bench prior to discharge from the surface of the landfill onto natural ground.</p>	<p>We note that in the RFI letter, WCC mention under Point 2 the requirement for a stormwater management system that would place no or limited reliance on the existing culvert. We do not consider this to be feasible given land boundary issues on the eastern side of the current landfill.</p>
<p>iii) <i>Permanent cut batters to be constructed no steeper than 70°, increments of not higher than 10m between benches of 5m width.</i></p>	<p>These recommendations should be adopted for final design slopes of the landfill.</p>	<p>Aurecon note some variation to this overall geometry could be undertaken subject to specific engineering design. We agree with this position.</p>

iv) Both cut and fills should be constructed to their finished face slope and revegetated at completion of their individual filling operation	This recommendation should be adopted.	
v) <i>Extension to main culvert up to the West Valley should have branch lines extending off the main at the junction with secondary valleys</i> <i>Each entry location... ..to have a proper permanent intake structure</i>	This recommendation should be adopted.	
vi) <i>.... Construction of a separate debris/trash screen some 10m upstream across the base of the gully to catch larger material...</i>	This recommendation should be adopted as shown on Figure 3	
viii) <i>Access tracks to the west valley may be achieved by use of the higher level fill benches....</i>	No comment – we consider this to be a design consideration; rather than a geotechnical consideration	
ix) This recommendation relates to infilling from the base of fill at the level of the culvert intake (132.5masl) to the 150m level. The recommendation discusses the requirement for a vertical manhole above the exiting culvert intake	We consider that filling should be undertaken up to a minimum level of 150masl as a matter of priority, and the culvert intake moved up valley to suit (Figure 2). We do not consider that a vertical manhole is required provided that adequate stormwater control is provided.	Infilling in the base of the valley and relocation of the culvert intake significantly reduces the risk of blockage due to slope failure within the area shown on Figure 1.
x) This recommendation relates to the lack of subsoil drainage within the existing fill and recommends that “any extension of the main culvert up the valley should be accompanied by subsoil drains” The remainder of the recommendation deals with design of an infiltration structure above the intake to the existing culvert	Subsoil drainage for new fillings should be considered as shown on Figure 3. We do not consider that an infiltration structure is required; rather appropriate sedimentation control measures (silt traps or similar) should be incorporated into the stormwater management design.	

3 RECOMMENDATIONS FOR DETAILED DESIGN

3.1 Overall Landfill Stability

Based on the stability analysis undertaken by both URS and Aurecon, we consider that filling of the landfill to a height of 240masl under the current proposed fill design is achievable. Aurecon indicate that they consider that with the proposed design, a Factor Safety (FOS) of approximately 1.0 (ie a state of marginal stability) is attained only under large scale seismic events.

3.2 Requirements for Detailed Design

We note in WCC's RFI letter their request for "relevant drawings, plans..." to support the recommendations above. We have attempted to do so for aspects of the design in Figures 1 to 3; however, it is difficult to provide comprehensive drawings at this stage, particularly in terms of stormwater design, as the final geometry of the landfill is uncertain. Assuming that Resource Consent is granted, the Aurecon recommendations outlined in Table 1 above should be incorporated into an engineered design for the finalised landfill scheme.

4 LIMITATIONS

- i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, C & D Landfill, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.
- ii. The recommendations in this report are based on the ground conditions indicated from published sources and site inspections described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgment and it must be appreciated that actual conditions could vary from the assumed model.
- iii. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.
- iv. This report is not to be reproduced either wholly or in part without our prior written permission.

Yours sincerely

For and on behalf of Geoscience Consulting (NZ) Limited



Richard Justice
Principal Engineering Geologist

Reviewed by

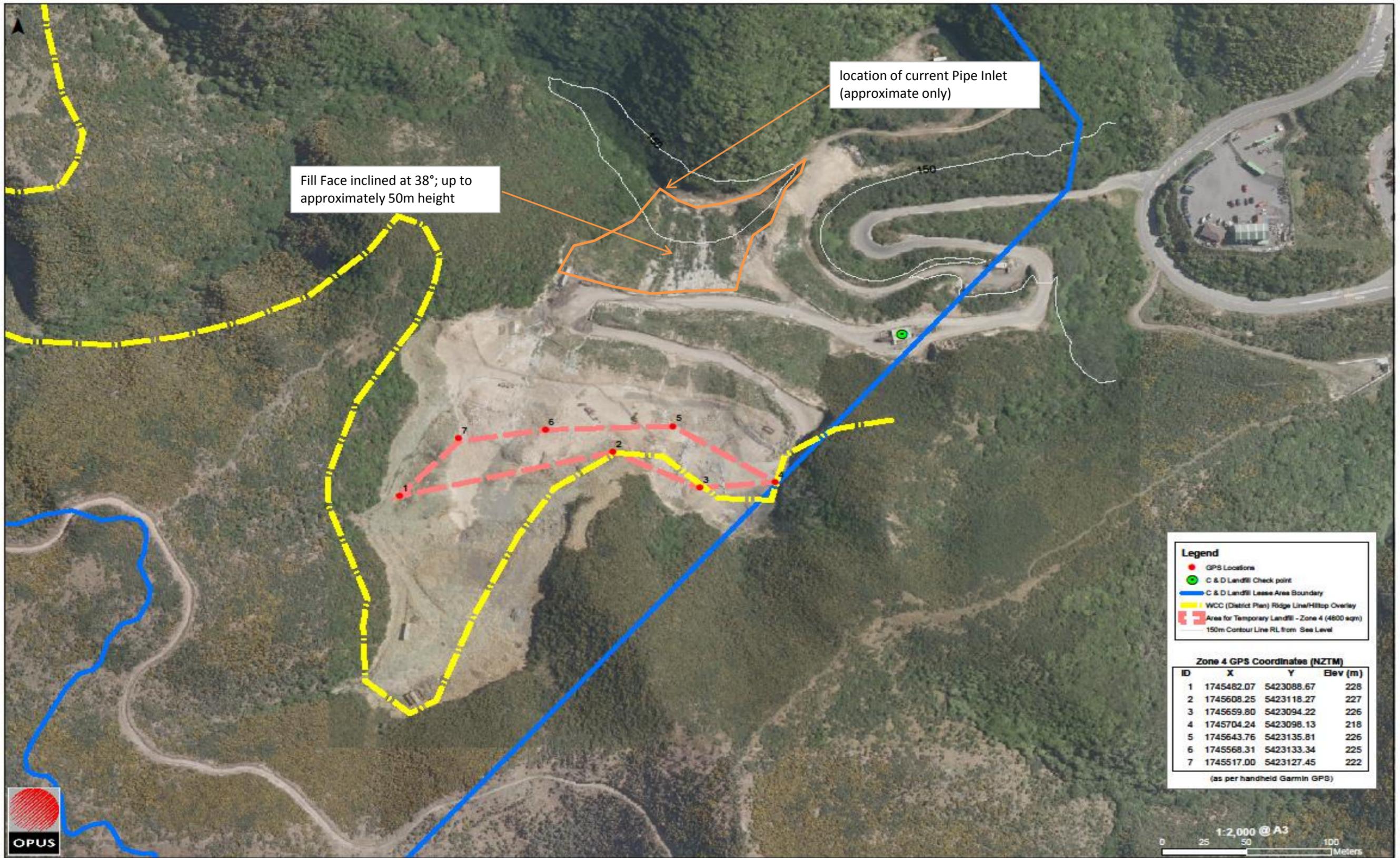


Guy Cassidy
Associate Engineering Geologist

5 REFERENCES

Aurecon New Zealand Ltd (2009) *Geotechnical Engineering Report – Stability C & D Landfill, Landfill Rd, Happy Valley, Wellington*. Letter report prepared for Burrell Demolition Ltd, 9 July 2009 ref 42373/001

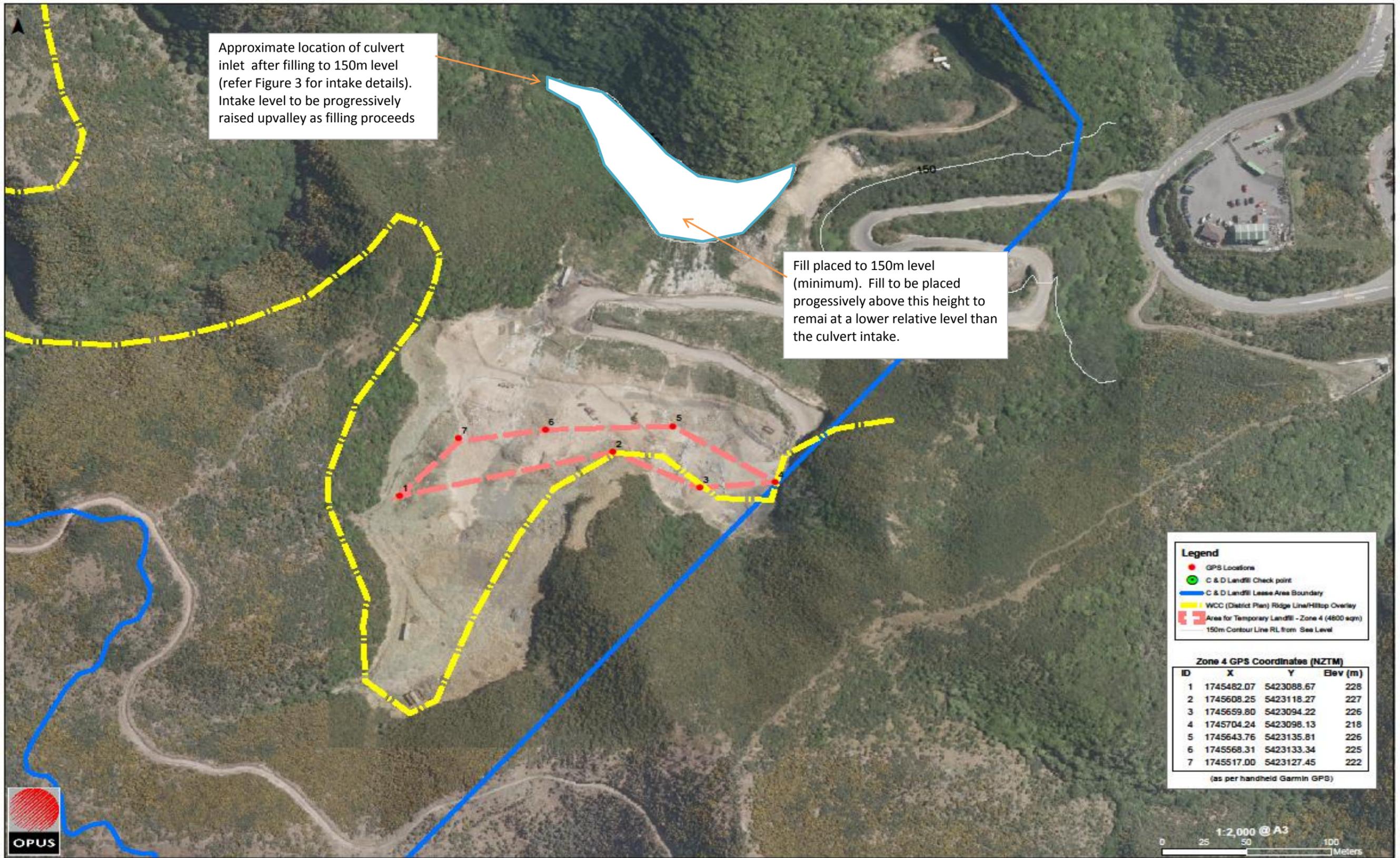
URS New Zealand Ltd (2009) *Geotechnical Assessment, Burrell's C & D Landfill, Happy Valley, Wellington*. Report prepared for Greater Wellington Regional Council and Wellington City Council, 27 July 2009. Ref 42091312/R001/E



Baseplan Source: Opus International Consultants: Application for Land use Consent



Date	14/12/12	Client	C & D Landfill	
Drawn by	RJ	Project	Review of Landfill Slope Stability for Resource Consent	
Approved by	GC	Description	Plan View	
Scale	NTS	Figure No.	1	Project Number 09870.000.000



Approximate location of culvert inlet after filling to 150m level (refer Figure 3 for intake details). Intake level to be progressively raised upvalley as filling proceeds

Fill placed to 150m level (minimum). Fill to be placed progressively above this height to remain at a lower relative level than the culvert intake.

Legend

- GPS Locations
- C & D Landfill Check point
- C & D Landfill Lease Area Boundary
- WCC (District Plan) Ridge Line/Hilltop Overlay
- Area for Temporary Landfill - Zone 4 (4800 sqm)
- 150m Contour Line RL from Sea Level

Zone 4 GPS Coordinates (NZTM)

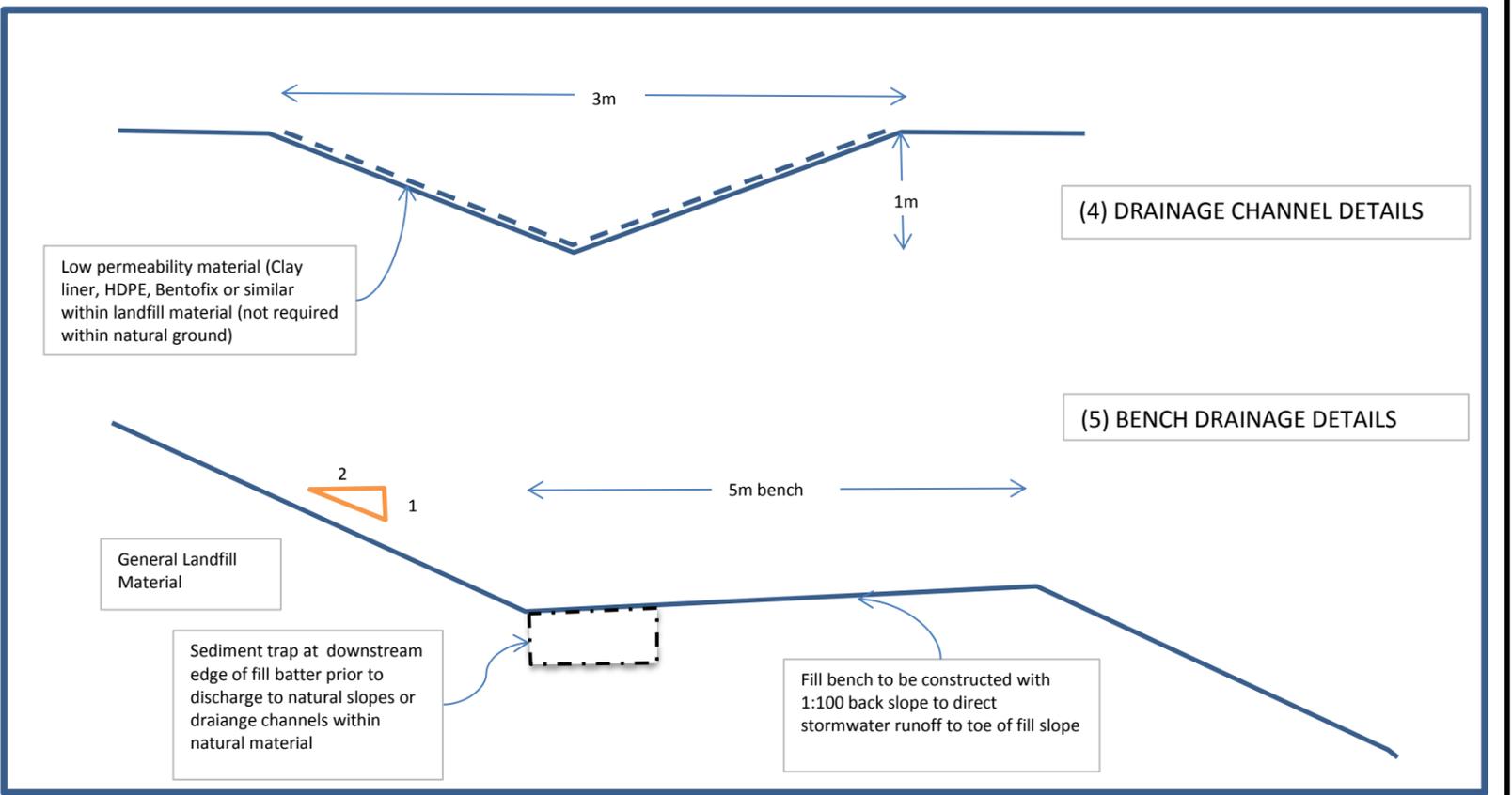
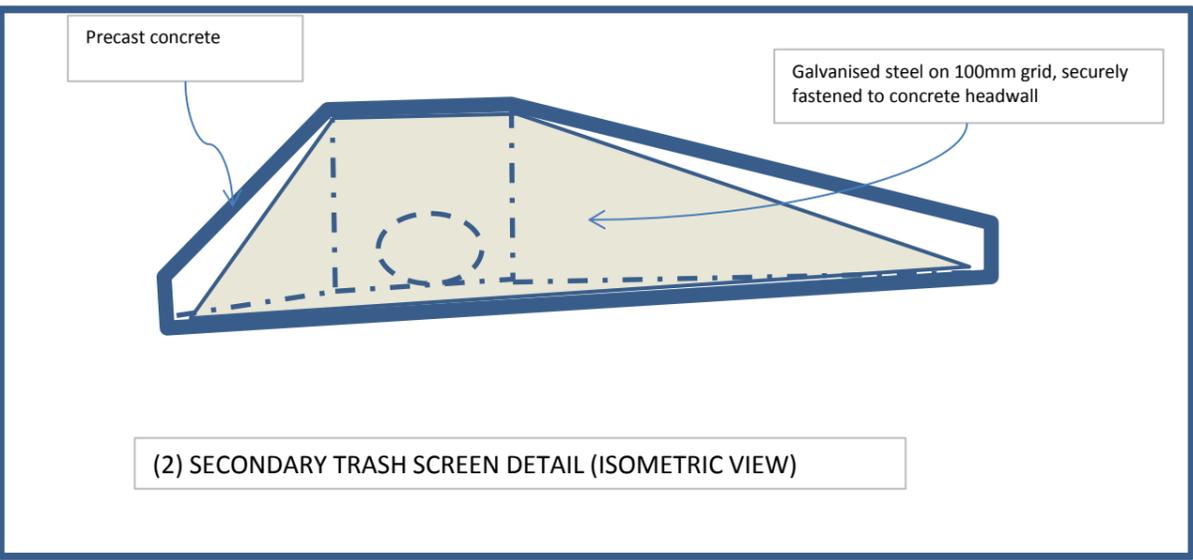
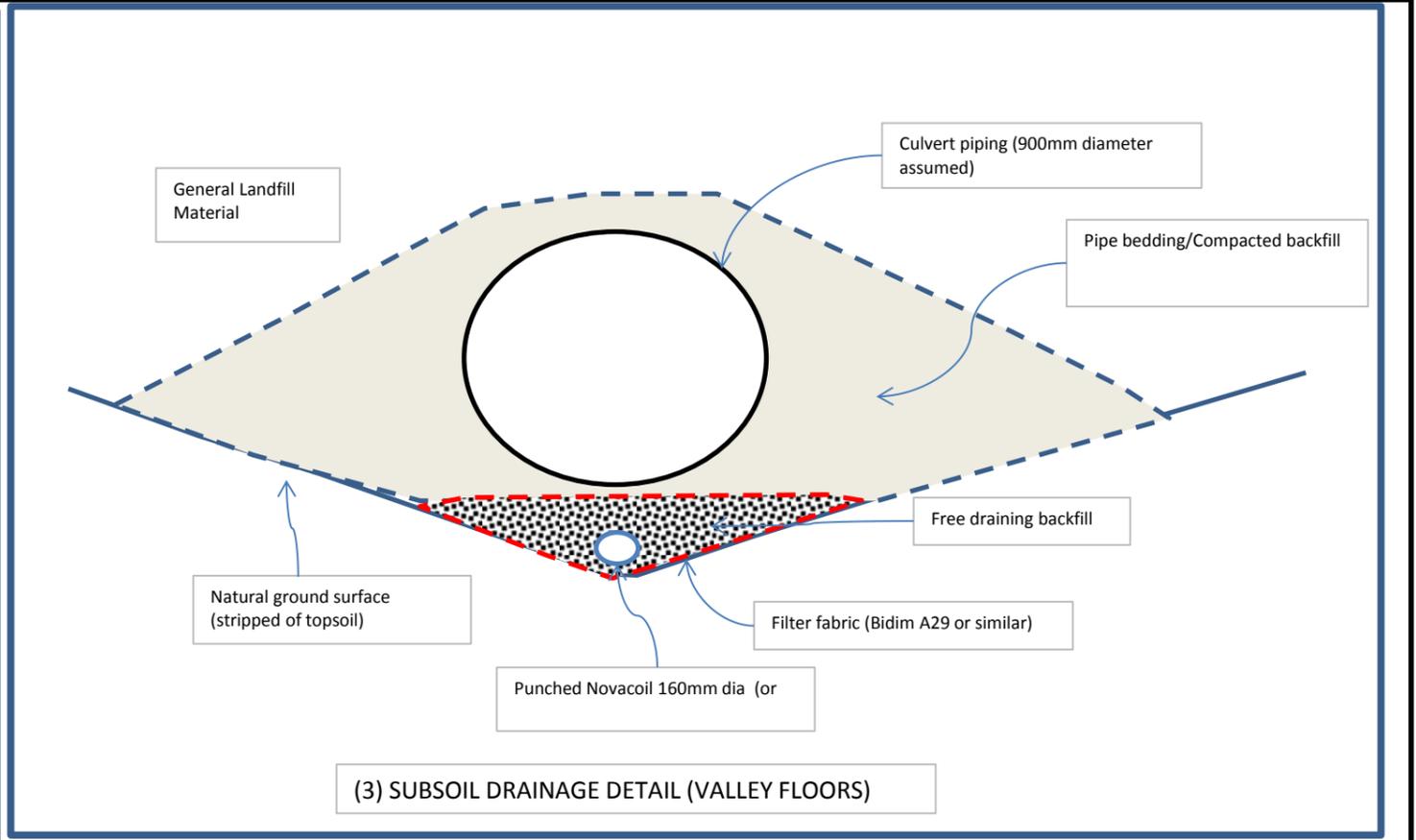
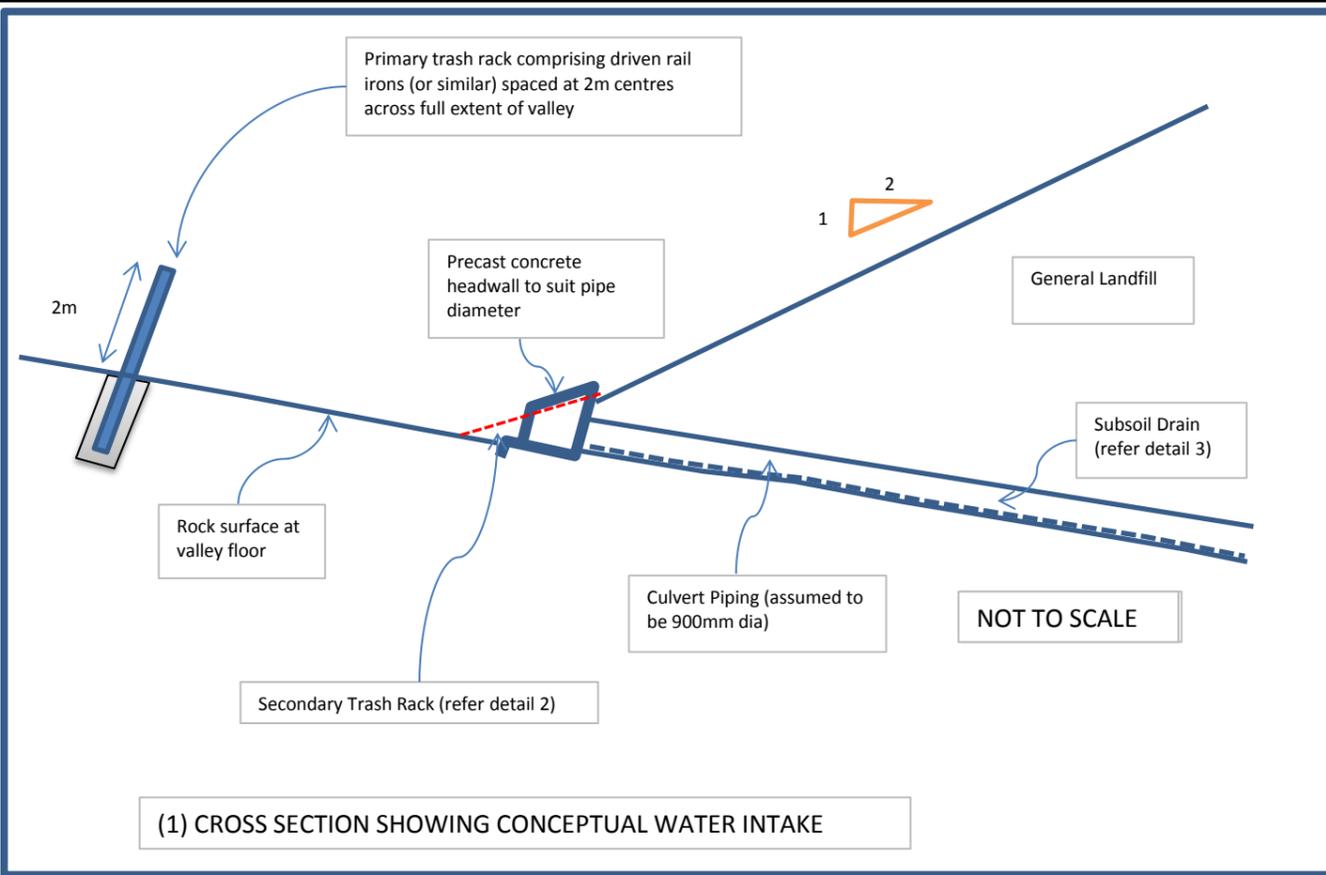
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1	1745482.07	5423088.67	228
2	1745608.25	5423118.27	227
3	1745659.80	5423094.22	226
4	1745704.24	5423098.13	218
5	1745643.76	5423135.81	226
6	1745568.31	5423133.34	225
7	1745517.00	5423127.45	222

(as per handheld Garmin GPS)

Baseplan Source: Opus International Consultants: Application for Land use Consent



Date	14/12/12	Client	C & D Landfill	
Drawn by	RJ	Project	Review of Landfill Slope Stability for Resource Consent	
Approved by	GC	Description	Requirements for Fill Placement to 150masl	
Scale	NTS	Figure No.	2	Project Number 09870.000.000



 GEOSCIENCE <small>A proud member of</small> ENGEO	Date	14/12/12	Client	C & D Landfill	
	Drawn by	RJ	Project	Review of Landfill Slope Stability for Resource Consent	
	Approved by	GC	Description	Conceptual Stormwater Management Details	
	Scale	NTS	Figure No.	3	Project Number