Department of Environment

Report for Waste Measurement Model

Report

July 2006

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Executive Summary

GHD Pty Ltd (GHD) was commissioned by the Government of Western Australia - Department of Environment (DoE) to perform an investigation in support of the development of a conversion factor to assist in estimating the weight of landfilled waste disposed at licensed landfill sites operating in Western Australia (WA). The investigation was performed in order to accommodate existing regulations regarding waste data reporting and recommendations for development of a volumetric conversion factor for landfilled inert waste. The results of the investigation were based on the analysis of field data collected at select inert landfills. This report presents the findings of these field investigations and associated calculations performed in support of the development of a waste measurement model appropriate for conversion of volumetric waste measurements to tonnes.

Development of the waste measurement model occurred through the investigation of landfilled waste at three (3) inert landfills located within the Perth metropolitan area. Waste types permitted for disposal at inert landfills, typically referred to as Class I Landfills, includes clean fill, non-hazardous, non-biodegradable wastes, asbestos and asbestos cement products, and certain other approved inert wastes. The investigation included field measurements of landfilled waste collected from twenty (20) test pits excavated over the three (3) test sites. Selection of test pit locations was based on specific criteria intended to replicate typical landfill conditions throughout the State. The measurement methodology employed during the tests was maintained throughout the investigation without any significant deviation. The field measurements were used to determine the in-place unit weight of the investigated landfilled waste. Inert waste unit weights calculated at each test site were used to develop the conversion factor of **1.55-tonnes/cubic metre** for translating volume measurements to tonnes.

Although the measurement methodology was maintained throughout the investigation, it should be noted that the developed model is based on an investigation of a finite number of sites. The investigation sites may be representative of most inert landfills within WA, however, alterations in (among other things) waste streams, waste moisture content, landfill operations, climate, and age of waste will influence the material characteristics of the landfilled waste. It is recommended that the model be applied for waste data reporting purposes only as the actual unit weight of landfilled waste may vary from one landfill to another.

1. Introduction

1.1 Background

Following a review of Landfill Levy (Levy) collection from inert landfills operating throughout Western Australia, the Government of Western Australia - Department of Environment (DoE) determined the need to undertake a volumetric conversion investigation of inert waste at certain active landfill sites within Western Australia (WA). As the vast majority of the 300-plus landfills currently in operation within the state possess no on site weighbridge, currently the Levy regulations provide for licensed landfill operators to report waste disposal data on the basis of in-place volume.

The provision to allow volume based waste reporting was also borne out of recommendations of a review of data requirements for Western Australia, commissioned by the Government of Western Australia - Waste Management Board (WMB). Recommendation 5 of the "Department of Environment – Program for the Collection, Analysis and Reporting of Major Waste Streams in Western Australia – Draft Report", prepared by Nolan-ITU Pty Ltd (Nolan), and dated November 2004, stated that:

> "*If assessment of the Levy payable at inert landfills was conducted on the basis of quarterly volumetric survey information, as recommended by WMB; the Department of Environment develop a conversion factor for landfilled inert wastes to convert volume-based estimates of landfilled waste to weight-based estimates.*"

Despite the current provisions for landfill operators to provide volume-based inert waste data, the State must still report its quantity of all waste going to landfill in tonnes. Thus, DoE recognised the need to develop a system to provide a reasonably accurate method for conversion of volumetric waste measurements to tonnes.

Reporting of waste disposal quantities only occurs within the Perth metropolitan region, with licensed metropolitan landfill operators data reporting based on weighbridge records and most licensed metropolitan inert landfill operators reporting based on volumetric estimates. To date, these inert landfill estimates have used a load-based volume (such as the estimated volume in a truck) converted to tonnes.

As follow-up to the Nolan Report, DoE commissioned GHD to perform an investigation in support of the development of a conversion factor to assist in estimating the weight of landfilled waste disposed based on the analysis of field data collected at inert landfills. The outcomes of such an investigation could assist with:

» Providing a practical methodology for conversion of volumetric measurements to weight;

» Developing a method that allows the waste disposal at landfills away from Perth to be estimated accurately at relatively low cost; and

» Contributing to the collection of accurate data for WMB and DoE to develop and measure the success of future waste management policies and strategies.

1.2 Objective

The objective of the project was to develop a conversion factor for translating volume measurements of landfilled inert waste to tonnage estimates of inert landfilled waste for the purposes of reporting WA landfill data in a consistent format. A secondary objective of the project was to increase agency/industry confidence in the accuracy of waste data collected and reported at sites that possess no weighbridges.

1.3 Scope of Works

As the objective of the project was to develop a conversion factor that may be used by DoE for the purposes of reporting State landfill data, it was recommended that the methodology and associated calculations be relatively transparent and that input from GHD and participating landfill operators be considered as relevant to the investigation.

The following scope of works was developed with consideration to the objectives identified above, and included:

- Selection of test sites and coordination of landfill operators and subcontractors/suppliers to conduct site investigations;
- Conducting site investigations, including excavation of test pits, collection of weight and dimension measurements;
- Reviewing waste handling techniques employed at the test sites;
- Developing a conversion factor for translating volumetric measurements to weight measurements; and
- Preparation of this Report.

2. Methodology

2.1 Site Selection

In consultation with DoE, it was decided initially, to select sites based on their proximity to the Perth metropolitan area. This decision was based on the logistics and associated costs involved in transporting excavation machinery and trucks, one fully loaded with pea gravel, significant distances to test sites on a daily basis. Given the lack of weighbridge facilities at most landfills throughout the state, it was determined that organisation of the use of weighbridges on and off site was more practical and efficient within the Perth metropolitan area as opposed to rural regions within the state.

The lack of weighbridge facilities, particularly at inert landfills, also led to landfill sites that accept putrescible and inert waste being contacted. Whilst the preference was to investigate landfill sites that only accepted inert waste; the allowance was made to contact putrescible and inert landfill operators, as a pre-determined number of sites was required to generate sufficient data to develop robust volumetric calculations.

Although putrescible landfills were contacted to participate in this investigation, it should be noted that investigations took place at inert landfills only, which resulted in the elimination of non-inert waste fill influences, as no allowance had to be made for any percentage of putrescible waste within the test pits or holes.

Table 1 below provides a list of the test sites, including locations for each test site and corresponding dates when the site investigation was performed.

Table 1 Investigation Facilities

Facility Name (Operator)/Location	Weighbridge Location	Investigation Date
9 Mile Quarry (RCG Pty)/ Lot 9 Rockingham Road	Henderson Landfill Rockingham Road	21 March 2006
Driver Road (Non-Organic Disposals)/ 50 Driver Road	On site	22 March 2006
Quinns Road (RCG Pty)/ Lot 70 / 717 Quinns Road	City of Wanneroo	23 March 2006
9 Mile Quarry (RCG Pty)/ Lot 9 Rockingham Road	Henderson Landfill Rockingham Road	31 March 2006

2.2 Measurement Location Selection

To develop a comprehensive data set, five (5) test pit locations per test site were selected. Test pit locations were selected based on the following criteria:

- Areas not designated for disposal of asbestos containing materials (ACM);
- Areas landfilled at least five (5) months prior to performance of the field investigations;

» Areas that had received predominantly building and demolition waste.

It is noted that the above criteria were met for each test site. The criteria identified below were more difficult to meet, for either the test site, or the particular test pit location.

» Areas with some separation from waste disposal activities; and

» Areas that are regularly trafficked by vehicles delivering waste.

Table 2 below delineates those test pit locations where the above criteria could or could not be satisfied.

Table 2 Test Pit Location Characteristics

Test Site	Location	Separated from Waste Disposal	Trafficked
9 Mile Quarry	1 to 3 (Figure 1)	x	ü
	4 and 5 (Figure 1)	ü	ü
Driver Road	1 to 5 (Figure 2)	ü	ü
Quinns Road	1 (Figure 3)	x	ü
	2 to 5 (Figure 3)	ü	x
9 Mile Quarry	1 and 2 (Figure 4)	x	ü
	3 to 5 (Figure 4)	ü	ü

A complete set of Figures is provided in Appendix A.

2.3 Measurement Methodology

Field measurements were collected by excavating a pre-determined volume of waste; weighing the excavated waste; and backfilling the test pit (hole) with pea gravel to assist in measuring the volume of waste excavated. Photographic documentation of typical investigation activities is provided as Plates 1 through 10 included in Appendix B. Methods for determining the unit weight of the pea gravel and collection of data from test pits are described in detail below.

2.3.1 Pea Gravel

The pea gravel employed during the investigation was single-sourced and no deviation to the type of gravel used to backfill the test pits occurred during the tests.

The method employed to determine the unit weight of the pea gravel utilised in this investigation was performed as follows:

1. On the initial day of site investigations, 21 March 2006, the designated pea gravel transport truck (Truck A) loaded with a known weight of pea gravel arrived at 9 Mile Quarry.
2. The pea gravel was manually distributed within the truck bed and spread evenly and levelled to determine the corresponding depth of gravel within the truck bed (Plate 1). Truck bed dimensions were measured to calculate the unit weight of the test gravel utilising the weight of gravel provided by the gravel supplier.

The Truck A bed contained a hoist apparatus which required that the associated volume of truck bed space consumed by the hoist be subtracted from the Gross truck bed volume to determine the corrected pea gravel volume, which in turn was used to calculate the pea gravel's corresponding unit weight. The unit weight calculations for the pea gravel are provided in Table 3 below.

Table 3 Pea Gravel Unit Weight Calculations

	Truck A Bed Struck Capacity (Level w/Top of Truck Bed Sidewalls) (m)	**Freeboard Capacity (Top of Truck A Bed Sidewalls to minus 140 mm) (m)**	**Truck A Hoist Dimensions (m)**	**Corrected Pea Gravel Volume (m^3)**
Length	4.27	4.27	0.76	
Width	2.30	2.30	0.51	
Depth	0.95	0.14	0.95	
Volume (m^3)	9.33	1.37	0.37	7.59

Initial weight pea gravel (t)	13.80
Pea Gravel Unit Weight (t/m^3)	**1.82**

2.3.2 Inert Waste

The detailed methodology typically employed for each test pit location is described as follows:

1. Truck A delivered a load of pea gravel and stockpiled this load at each test site,
2. Truck A imported an additional load of pea gravel, which was weighed to determine the combined weight of the truck and pea gravel.
3. An additional truck (Truck B) was weighed at the weighbridge to determine its initial tare weight.
4. An area approximately 2 m x 2 m was marked out at each test pit location (Plates 2 and 3), excavated by backhoe with corresponding excavated waste placed into Truck B bed (Plate 4). The test pit was measured (Plate 5) periodically during excavation to assist the backhoe operator in maintaining the pre-determined excavation dimensions (2 m x 2 m x 1 m - deep) and corresponding volume ($4m^3$).

   As a means of maintaining quality assurance to ensure that a minimum of 4 m^3 of waste was being excavated at each test pit location, Truck B was marked along the interior truck bed sidewalls to a level corresponding to a volume representing 4 m^3. It is noted that Truck B was not intentionally filled to this level, as it was used only as a secondary check against periodic measurements of the test pit excavation to maintain the target volume of 4 m^3.
5. Following excavation and waste loading at each test pit location, the loaded Truck B was weighed (Plate 6). The initial tare weight of Truck B was then subtracted from the loaded Truck B weight to

calculate the weight of excavated waste from each test pit. The calculations for each test pit location are provided in Appendix C.

6. The excavation was backfilled with pea gravel deposited by Truck A (Plate 7). It should be noted that only sufficient pea gravel was placed to backfill the excavation to the level of the pre-excavation surface and that no compactive effort was provided to the gravel backfill.
7. Truck A was then weighed to determine the amount of pea gravel deposited within the backfilled excavation. The associated excavation volume was then calculated utilising the calculated test pea gravel unit weight of 1.82 m^3/t. The Average Unit Weight calculations for each test site are provided in Appendix C.
8. Pea gravel was then removed from each test pit to the extent practical, and replaced in to the bed of Truck A. Care was taken to avoid contaminating the pea gravel with waste and the truck was topped up from the onsite pea gravel stockpile as necessary to re-establish the designated pea gravel volume.
9. The re-filled Truck A was then weighed (Plate 8).
10. Excavated waste was replaced in each test pit (Plate 9), and site operators agreed to compact/cover the waste and / or transport excavated waste to the landfill's active tip face.

A summary of truck movements is provided as Figure 5 in Appendix A.

Site operators advised that cover materials used at each landfill were essentially soils and finer inert materials taken from the landfill waste stream. As is the case at most putrescible landfills, site operators advised there is no specific engineering specifications for cover materials, other than all cover material must be comprised of clean soils or fine inert building rubble. Based on this information and lack of observation of distinct cover material layers within the test pit excavations (Plate 5), consideration of cover material was deemed irrelevant and was not undertaken as part of this investigation.

2.4 Authenticity of Sites and Test Pit Locations

As the results of this investigation will assist in determining applicable landfill levy payments for sites at which the data is collected, it may be suggested that participating site operators could have pre-selected test locations to manipulate results in an effort to reduce estimates of waste disposed for an equivalent volume, thus resulting in lower landfill levy payments.

This suggestion does not appear to be valid to this investigation, as it was noted that:

» Test sites participating in the study noted their interest in receiving results from the investigation to correlate test results to their own compaction estimations;

» Participating site operators indicated their full willingness to participate in the study and expressed sincere interest in prolonging the life of their respective landfills and a desire to achieve and maintain higher compaction rates;

» Participating site operators were completely cooperative and assisted both GHD and DoE staff with site access and, where possible, weighbridge use;

» Participating site operators identified a variety of areas where excavations could be undertaken (refer to Figures 1 to 4 in Appendix A; and

» Areas measured appeared typical of wastes received, as observed from materials excavated (refer Plates 4, 5, and 9 in Appendix B).

Based on observations of each participating test site, the four (4) test sites are typical inert landfills and are representative of other similar sites operating in Western Australia. GHD found no evidence of landfill operation methods, equipment or waste encountered that are unique to the sites investigated.

2.5 Test Data Evaluation

GHD identified various factors that could affect the development of the waste measurement model used to determine the inert waste conversion factor. These factors included the following:

1. Variances in Test Activities;
2. Variances in Landfilled Waste; and
3. Technical Variances.

Variances in test activities include weight variations (gravel moisture content, Truck fuel levels, quantities of excavated waste). The moisture content of the gravel was relatively consistent throughout the tests. Although no moisture content testing was performed, investigation staff noted little or no visual difference in the amount of moisture in the gravel or the amount of dust generated when handling the gravel. To the extent possible, all test activities followed the methodology detailed above.

Although specific waste streams can vary from one landfill to the next, inert waste landfills are generally less heterogenous than putrescible waste landfills which by their very nature includes most types of waste materials. The moisture content of putrescible wastes typically exhibits a higher level of variety than inert wastes. Although no moisture content testing was performed, investigation staff noted little or no visual difference in the amount of moisture in the wastes from one site to another.

Technical variances within the investigation should be limited to equipment only, which would be restricted further to the weighbridges. Although degree of accuracy from one weighbridge to another may vary, it is expected that these variances were significantly limited as calibrated scales were dedicated to each site investigation.

3. Inert Waste Measurement Model

Development of the conversion factor for landfilled inert wastes to convert volume-based estimates of landfilled waste to weight-based estimates was completed through the collection and application of field measurements at selected inert waste landfills. A summary of the development of the waste measurement model is provided below:

1. Weight of pea gravel backfill was calculated by subtracting the gross truck weights before and after backfill activities.
2. Volume of each test pit was calculated using two methods:
   a) Multiplying the weight of the pea gravel backfill by the calculated pea gravel unit weight; and
   b) Measuring the length, width and depth of each test pit excavation.
3. Unit Weight of Excavated Wastes was calculated using two methods:
   a) Dividing the weight of excavated waste by the measured test pit excavation volume; and
   b) Dividing the weight of excavated waste by the calculated pea gravel volume.
4. Corresponding Average Test Pit Unit Weights was calculated by adding the calculated unit weights and dividing by the number of test pits.
5. Site-specific waste unit weights were calculated by averaging the two calculated average unit weights.
6. The conversion factor was derived by averaging the calculated site-specific unit weights.

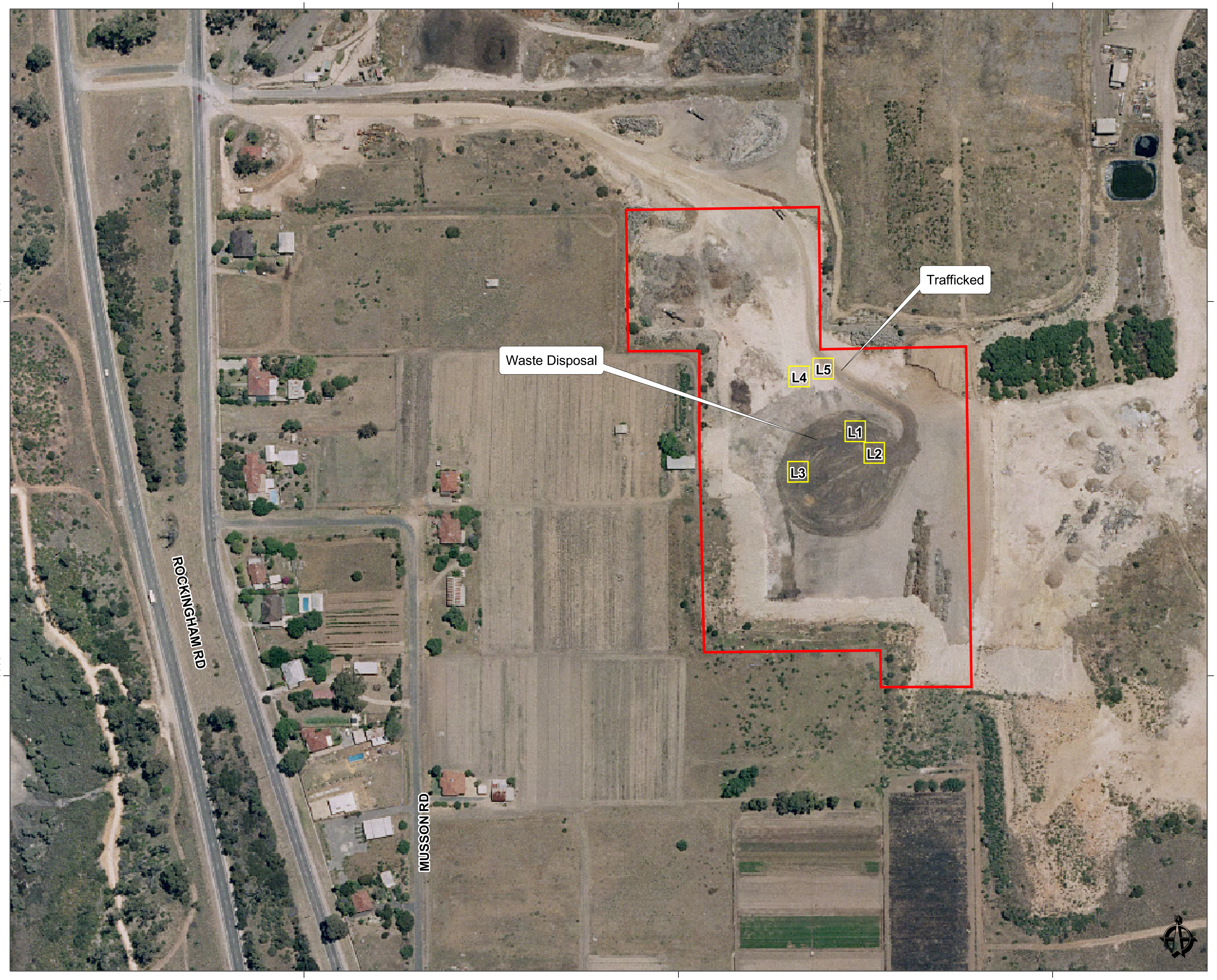
A copy of the inert waste unit weight calculations is provided in Appendix C. A summary of the conversion factor data is provided in Table 4 below.

Table 4 Conversion Factor Data

Facility	**Test Date**	**Inert Waste Unit Weight (t/m^3)**
9 Mile Quarry	21 March 2006	1.58
Driver Road	22 March 2006	1.57
Quinns Road	23 March 2006	1.40
9 Mile Quarry	31 March 2006	1.66
Conversion Factor		**1.55**

Appendix A

Figures 1 - 5



LEGEND

- Investigation Boundary
- Investigation Locations

MAP UNITS PROJECTED IN MGA ZONE 50
NOTE THAT POSITIONAL ERRORS CAN BE > 5M IN SOME AREAS
AERIAL PHOTOGRAPHY SOURCED FROM DLI - 2005 PERTH METRO MOSAIC
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SCALE

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LOCALITY MAP

Perth South Metro

CREATED BY	CHECKED	APPROVED
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HEIGHT DATUM: **METADATA RECORDED:**

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DEVELOPMENT OF WASTE MEASUREMENT MODEL
Figure 1
RCG, 9 Mile Quarry
21 March 2006

LEGEND

- Investigation Boundary
- Investigation Locations

MAP UNITS PROJECTED IN MGA ZONE 50
NOTE THAT POSITIONAL ERRORS CAN BE > 5M IN SOME AREAS
AERIAL PHOTOGRAPHY SOURCED FROM DLI - 2005 PERTH METRO MOSAIC
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SCALE

25 0 25 50 75m

1:2,500 at A3

LOCALITY MAP

Perth North Metro

CREATED BY	CHECKED	APPROVED
VLC		

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DEVELOPMENT OF WASTE MEASUREMENT MODEL
Figure 3
RCG, Quinns Road
23 March 2006

LEGEND

- Investigation Boundary
- Investigation Locations

MAP UNITS PROJECTED IN MGA ZONE 50
NOTE THAT POSITIONAL ERRORS CAN BE > 5M IN SOME AREAS
AERIAL PHOTOGRAPHY SOURCED FROM DLI - 2005 PERTH METRO MOSAIC
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SCALE

25 0 25 50 75m

1:2,500 at A3

LOCALITY MAP

Perth North Metro

CREATED BY	CHECKED	APPROVED
VLC		

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HEIGHT DATUM: **METADATA RECORDED:**

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REVISION	DRAWING NO
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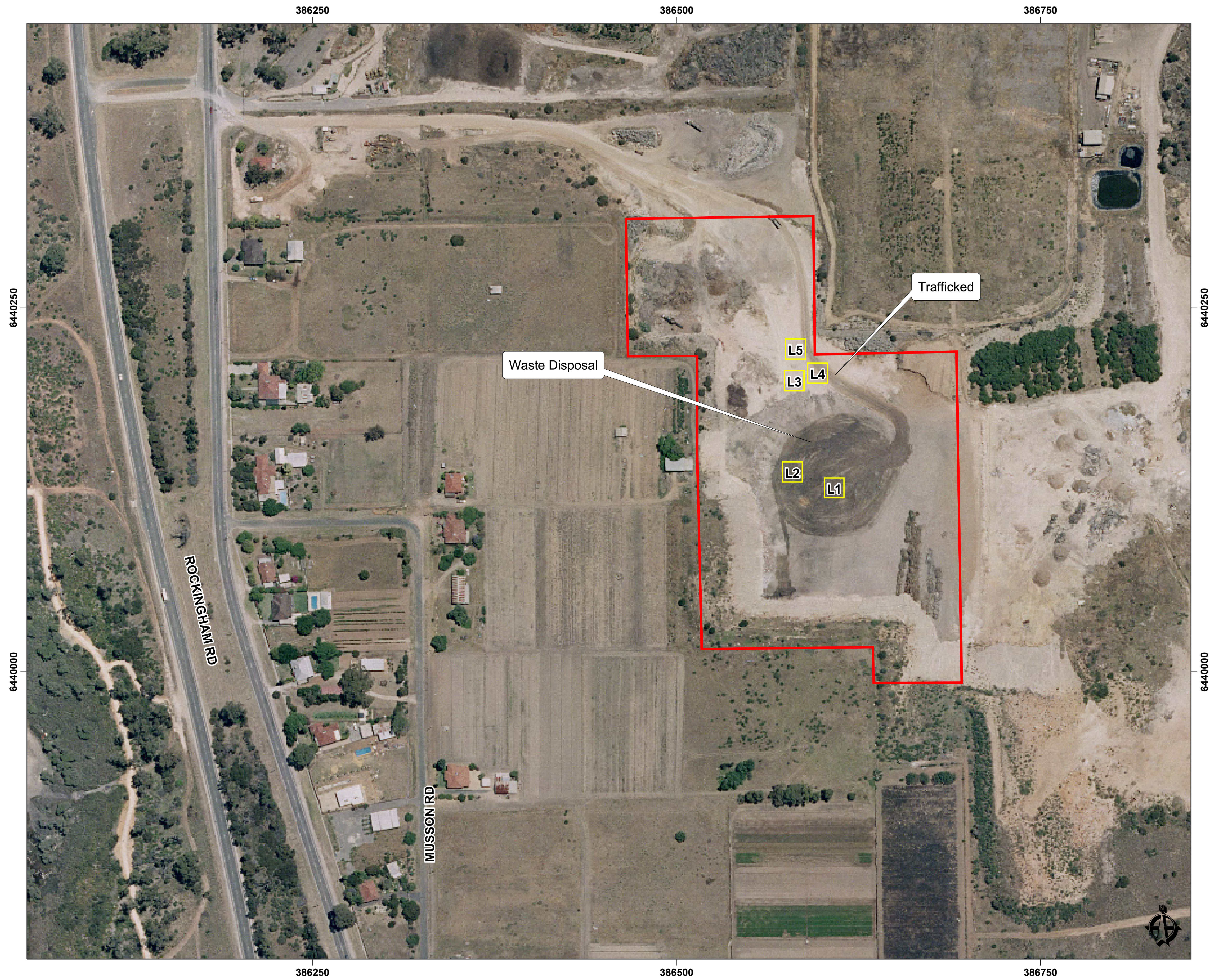
DEVELOPMENT OF WASTE MEASUREMENT MODEL
Figure 2
Non Organic Disposals, Driver Road
22 March 2006



LEGEND

- Investigation Boundary
- Investigation Locations

MAP UNITS PROJECTED IN MGA ZONE 50
NOTE THAT POSITIONAL ERRORS CAN BE > 5M IN SOME AREAS
AERIAL PHOTOGRAPHY SOURCED FROM DLI - 2005 PERTH METRO MOSAIC
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SCALE

25 0 25 50 75m

1:2,500 at A3

LOCALITY MAP

Perth South Metro

CREATED BY	CHECKED	APPROVED
VLC		

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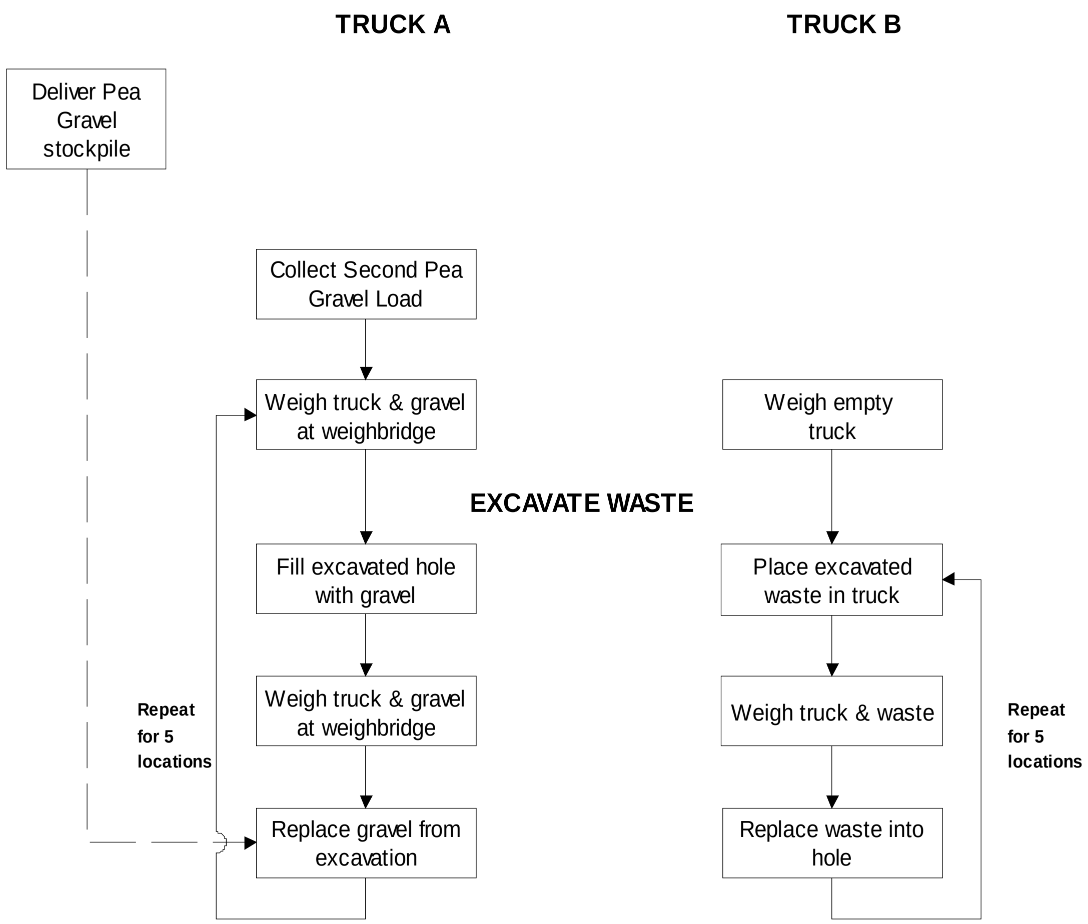
DEVELOPMENT OF WASTE MEASUREMENT MODEL
Figure 4
RCG, 9 Mile Quarry
31 March 2006

Figure 5: Measurement Methodology



Appendix B

Plates 1 – 10

Plate 1: **Truck A** filled to defined level (140 mm below top of truck bed sidewalls)

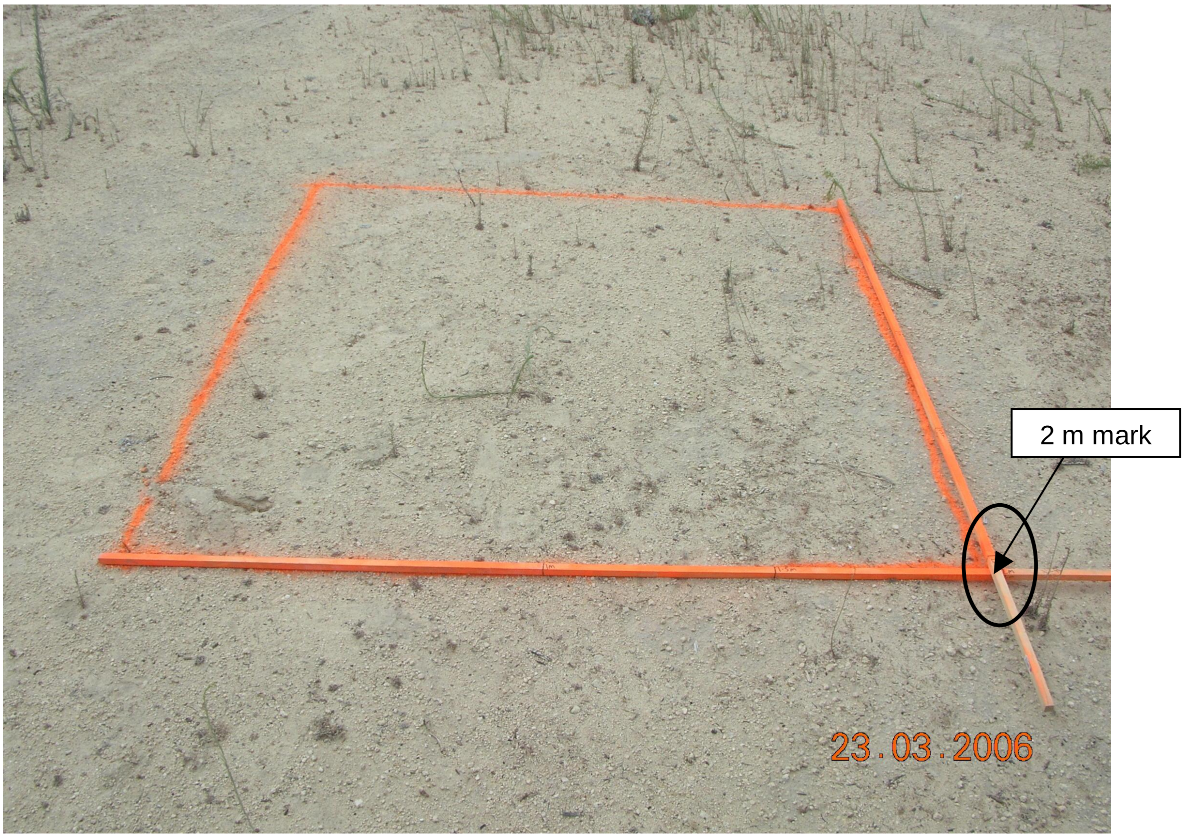


Plate 2: 2 m x 2 m test pit marked-out for excavation by backhoe

Plate 3: 2 m x 2 m test pit with **Truck B** alongside to collect excavated waste to be weighed

Plate 4: Waste from excavated test pit being placed in **Truck B**

Plate 5: Periodic check of measurements of excavated test pit

Plate 6: **Truck B** and excavated waste being weighed

Plate 7: Excavated test hole backfilled to surface with pea gravel

Plate 8: Pea gravel backfill being removed and placed into **Truck A**

Plate 9: Weighing **Truck A** following replacement of pea gravel backfill

Plate 10: Waste replaced, as much as practical, into excavation

Appendix C

Inert Waste Unit Weight Calculations

Waste Measurement Model
Inert Waste Unit Weight Calculations

9 Mile Quarry (RCG Pty) 21/03/06

Data used in calculations	
Tare Weight - Truck A (t)	8.92
Tare Weight - Truck B (t)	9.34
Unit weight of Pea Gravel (t/m^3)	1.82

	TRUCK A					TRUCK B				
Hole Number	**Pre-Backfill Weight (Truck/Pea Gravel)**	**Post-Backfill Weight (Truck/Pea Gravel)**	**Weight of Pea Gravel Backfill**	**Estimated Pea Gravel Backfill Volume(1)**	**Pre-Backfill Excavation Measured Volume**	**Post-Excavation Weight (Truck/Waste)**	**Weight of Excavated Waste**	**Waste Unit Weight(2)**	**Waste Unit Weight**	**Notes**
	t	**t**	**t**	**m^3**	**m^3**	**t**	**t**	**t/m^3**	**t/m^3**	
1	22.72	16.28	6.44	3.54	4.96	16.28	6.94	1.40	**1.96**	material buried longer than holes 3 to 5
2	20.46	15.12	5.34	2.93	4.03	15.1	5.76	1.43	**1.96**	material buried longer than holes 3 to 5
3	19.28	14.08	5.20	2.86	5.38	14.9	5.56	1.03	**1.95**	
4	16.80	11.64	5.16	2.84	4.80	14.78	5.44	1.13	**1.92**	
5	18.62	14.00	4.62	2.54	4.55	14.28	4.94	1.08	**1.95**	
								Average	**Average**	
								1.22	1.95	t/m^3 of waste

NOTES: (1)Based on Calculated Unit Weight of Pea Gravel
(2)Based on Excavation Measurements
(3)Utilizing Estimated Pea Gravel Volume & Excavation Measurement Methods

Average Unit Weight(3) **1.58** **t/m^3**

Driver Road (NOD) 22/03/06

Data used in calculations	
Tare Weight - Truck A (t)	8.90
Tare Weight - Truck B (t)	9.32
Unit weight of Pea Gravel (t/m^3)	1.82

	TRUCK A					TRUCK B				
Hole Number	**Pre-Backfill Weight (Truck/Pea Gravel)**	**Post-Backfill Weight (Truck/Pea Gravel)**	**Weight of Pea Gravel Backfill**	**Estimated Pea Gravel Backfill Volume[1]**	**Pre-Backfill Excavation Measured Volume**	**Post-Excavation Weight (Truck/Waste)**	**Weight of Excavated Waste**	**Waste Unit Weight[2]**	**Waste Unit Weight**	**Notes**
	t	t	t	m^3	m^3	t	t	t/m^3	t/m^3	
1	23.08	17.36	5.72	3.14	4.78	15.72	6.40	1.34	**2.04**	
2	22.10	17.14	4.96	2.73	4.76	14.98	5.66	1.19	**2.08**	
3	19.54	13.62	5.92	3.25	5.19	15.54	6.22	1.20	**1.91**	this hole excavated in area where materials buried had been firstly crushed
4	17.44	11.44	6.00	3.30	5.06	15.48	6.16	1.22	**1.87**	this hole excavated in area where materials buried had been firstly crushed, and there was a higher content of packaging materials as opposed other hole excavations
5	22.08	15.94	6.14	3.37	5.93	15.38	6.06	1.02	**1.80**	

NOTES:
[1]Based on Calculated Unit Weight of Pea Gravel
[2]Based on Excavation Measurements
[3]Utilizing Estimated Pea Gravel Volume & Excavation Measurement Methods

	Average	**Average**	
	1.19	**1.94**	t/m^3 of waste
Average Unit Weight[3]	**1.57**	**t/m^3**	

Waste Measurement Model
Inert Waste Unit Weight Calculations

Quinns Road (RCG Pty) 23/03/06

Data used in calculations	
Tare Weight - Truck A (t)	9.04
Tare Weight - Truck B (t)	9.36
Unit weight of Pea Gravel (t/m^3)	1.82

	TRUCK A					TRUCK B				
Hole Number	**Pre-Backfill Weight (Truck/Pea Gravel)**	**Post-Backfill Weight (Truck/Pea Gravel)**	**Weight of Pea Gravel Backfill**	**Estimated Pea Gravel Backfill Volume[(1)]**	**Pre-Backfill Excavation Measured Volume**	**Post-Excavation Weight (Truck/Waste)**	**Weight of Excavated Waste**	**Waste Unit Weight[(2)]**	**Waste Unit Weight**	**Notes**
	t	**t**	**t**	**m^3**	**m^3**	**t**	**t**	**t/m^3**	**t/m^3**	
1	22.62	17.18	5.44	2.99	5.95	15.22	5.86	0.99	**1.96**	
2	21.30	14.90	6.40	3.52	5.75	15.60	6.24	1.09	**1.77**	
3	20.00	13.88	6.12	3.36	6.05	15.40	6.04	1.00	**1.80**	
4	18.58	12.60	5.98	3.29	6.83	15.26	5.90	0.86	**1.80**	
5	16.96	10.42	6.54	3.59	5.72	15.42	6.06	1.06	**1.69**	

	Average	**Average**	
	1.00	**1.80**	t/m^3 of waste
Average Unit Weight[(3)]	**1.40**	**t/m^3**	

NOTES: [(1)]Based on Calculated Unit Weight of Pea Gravel
[(2)]Based on Excavation Measurements
[(3)]Utilizing Estimated Pea Gravel Volume & Excavation Measurement Methods

9 Mile Quarry (RCG Pty) 31/03/06

Data used in calculations	
Tare Weight - Truck A (t)	8.60
Tare Weight - Truck B (t)	9.06
Unit weight of Pea Gravel (t/m^3)	1.82

	TRUCK A					TRUCK B				
Hole Number	**Pre-Backfill Weight (Truck/Pea Gravel)**	**Post-Backfill Weight (Truck/Pea Gravel)**	**Weight of Pea Gravel Backfill**	**Estimated Pea Gravel Backfill Volume(1)**	**Pre-Backfill Excavation Measured Volume**	**Post-Excavation Weight (Truck/Waste)**	**Weight of Excavated Waste**	**Waste Unit Weight(2)**	**Waste Unit Weight**	**Notes**
	t	**t**	**t**	**m^3**	**m^3**	**t**	**t**	**t/m^3**	**t/m^3**	
1	22.82	17.08	5.74	3.15	6.55	15.70	6.64	1.01	**2.11**	
2	21.16	15.78	5.38	2.96	5.81	15.60	6.54	1.13	**2.21**	
3	19.24	13.38	5.86	3.22	4.75	15.92	6.86	1.44	**2.13**	
4	16.62	12.04	4.58	2.52	5.76	15.10	6.04	1.05	**2.40**	
5	21.64	15.88	5.76	3.16	6.05	15.52	6.46	1.07	**2.04**	
								Average	**Average**	
								1.14	**2.18**	t/m^3 of waste

NOTES: (1)Based on Calculated Unit Weight of Pea Gravel
(2)Based on Excavation Measurements
(3)Utilizing Estimated Pea Gravel Volume & Excavation Measurement Methods

Average Unit Weight(3) **1.66** **t/m^3**

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