Landfill gas and groundwater investigation

Proposed *Yarrabilly Seniors Village* interface assessment, Lot 4 DP1092182, Cowra NSW

Ref: R8659sg
Date: 19 September 2017

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Environmental
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Client:	Cowra Shire Council Private Bag 342 Cowra NSW 2794
Assessor:	Dave Langston BNEWS Environmental Scientist
Authorising Officer:	Greg Madafiglio CPSS Senior Environmental Scientist
Interested authorities:	Cowra Shire Council
Report number:	R8659sg
Date:	19 September 2017

Summary report

Address: Interface area north of North Cowra landfill

Lot: Part of Lot 4 **Section:** - **DP:** 1092182

Dates of works 15 and 29 August 2017

Main areas of concern

Yarrabilly Seniors Village is proposed on part of Lot 4 DP1092182, Cowra NSW. The access road for the village is along the edge of a former landfill. The landfill may have resulted to the presence of landfill gases and contaminated groundwater that could impact the development.

Notable contaminant concentrations

Nil

Methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulphide and flow rate was not detected in the monitoring wells on 29 August 2017

Groundwater was not intercepted to a depth of 7.5m and 9.0m on granodiorite.

Nature of works carried out

Vapour and groundwater wells were constructed along the southern boundary of the proposed seniors' village adjacent to the historic landfill pit.

Monitoring of gases and flow rate in three shallow vapour wells using a GA5000 Landfill Meter. The gas screening value was calculated and compared with the EPA (2012) risk classification to determine requirements for further actions.

Groundwater wells were drilled up to a depth of 9.5m terminating on rock and the presence of groundwater measured.

Nature and extent of residual contamination

The gas screening value ranged from 0.003L/hr in GW2 to 0.0192L/hr in GW1. The wells on the site were determined to have a characteristic gas situation of 1 and a risk classification of very low.

No shallow groundwater was observed in the wells installed.

Risk factors

The potential contamination sources were hazardous ground gases and leachate from the landfill. The potential exposure pathways included indirect contact (inhalation) and direct (ingestion and absorption). The potential receptors included residential, on-site workers, visitors and the terrestrial environment.

Waste removed

No soil was removed as part of the contamination investigation.

Remediation summary

Nil

Statement of suitability

The risk to site users from soil gases associated with the landfill is considered to be very low.

No leachate or groundwater was encountered at time of inspection in the monitoring wells constructed. The proposed location of the seniors village buildings is suitable for proposed development.

This is an accurate summary of the report titled: Landfill gas and groundwater investigation – Part of Lot 4 DP1092182, Cowra NSW (Report number R8659c)

Produced by: Envirowest Consulting Pty Ltd Dated: 15/09/2017

Name: Gregory Madafiglio Certification details: Pending

CONTENTS

1. Introduction

Yarrabilly Seniors Village is proposed at Lot 4 DP1092182, Cowra NSW. A historic landfill is located on the southern boundary of the proposed site. A preliminary contamination investigation was undertaken after soil sampling. Additional subsoil investigations are required to evaluate the presence of landfill gases, leachate and possible impact on shallow groundwater from the former landfill south of the proposed development.

2. Scope of work

Envirowest Consulting Pty Ltd was commissioned by Cowra Shire Council to undertake an assessment to determine the presence of landfill gases, leachate and risk classification at the interface area for the proposed Yarrabilly Seniors Village, part of Lot 4 DP1092182, Cowra NSW.

The investigation will be undertaken in accordance with:

- NSW EPA (2012) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases*
- Contaminated Land Management Act 1997
- DEC (2006) *Contaminated Sites: Guidelines for the NSW Site Auditors Scheme*
- NEPC (2013) National Environment Protection (Assessment of Site Contamination) Measure 1999 Revised 2013 (National Environment Protection Council Service Corporation, Adelaide)
- EPA (2011) *Guidelines for Consultants Reporting on Contaminated Sites*

3. Site identification

Address	Landfill interface area for the proposed Yarrabilly Seniors Village Part of Lot 4 DP1092182 Cowra NSW 2794
Owner	Cowra Shire Council
Deposited plans	Lot 4 DP1092182
Australian Map Grid	Zone 55H 657540mE 6256039mN
Locality map	Figure 1
Aerial photograph	Figure 2
Investigation area	The interface area located to the north of historic North Cowra landfill- Approximately 2,800m^2

4. Site history

4.1 Zoning

Lot 301 DP726980 located to the west of the proposed development is zoned as RE1 – Public Recreation and Lot 4 DP1092182 as R1 – General Residential under the Cowra Local Environmental Plan 2012.

4.2 Land-use

The investigation area is a vacant lot adjacent to historic North Cowra landfill pit. The investigation area is currently used for grazing. A recently planted vegetation corridor traverses north is located to the west of the proposed development. The investigation area is referred to as the interface area and the proposed development will include an open space area between the historic tip and proposed units. Access to the site will be through the capped historic landfill.

4.3 Council records

Council has provided the Douglas Partners reports for review. No internal council records were available at time of writing.

4.4 Information sources

Site inspections on 15 and 29 August 2017 by Dave Langston
Interview with Cowra Shire Council representatives
Bathurst 1:250,000 Geological Sheet
Topographic map of area (Cowra 1:50,000 CMA of NSW)
NSW EPA records of public notices under the CLM Act 1997
Aerial photograph 1964, 1973, 1982, 1993, 2004 and 2011
NSW Natural Resource Atlas

4.5 Chronological list of site uses

The investigation area is currently vacant agricultural land located to the north of the landfill. Drilling within the interface area confirmed refuse from the landfill located further north than expected (Appendix 1). North Cowra Landfill received its final lift of refuse in June 1997. It is unsure when the landfill commenced, historical aerial photographs show disturbance from 1973.

The depth of the pit and quantity of waste received is unknown. The landfill was capped with a minimum of 500mm of clay.

4.6 Buildings and infrastructure

No buildings are located on the site. The southern and western boundaries are fenced.

4.7 Potential contaminants

Hazardous landfill gases originating from the landfill located approximately 20m to the south of the site are potential contaminants. Contaminants associated with landfill gases are methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide.

Possible groundwater contamination or leachate from the landfill may have migrated to the development area and are a risk if extracted.

4.8 Relevant complaint history

None known.

4.9 Contaminated site register

The site is not listed on the NSW EPA register of contaminated sites.

4.10 Neighbouring land-use

- North – Recreational and agricultural land
- East – Grazing land
- South – Historic North Cowra Landfill
- West – Recreational land

Neighboring land-uses have had significant impact on the site and the proposed development.

4.11 Integrity assessment

The information obtained is accurate as the review records have allowed. The information available is considered sufficient for the purpose of the assessment and believed to be correct by the investigator.

5. Site conditions and environment

5.1 Surface cover

The investigation area consists of dense vegetation cover consisting of pasture grasses.

5.2 Topography

The site is located at an elevation ranging between 359m and 374 metres and is located on a mid-slope of a granodiorite ridge line that traverses north. The topography is a gentle to moderate slope to the east into a drainage depression with an inclination of 6 to 15% and a north easterly aspect.

5.3 Soil and geology

Reference to the Bathurst 1:250 000 Soil Landscape Series Sheet SI5508cw indicates that the site is located within the Cowra Soil Landscape and underlain by the Cowra Granodiorite (Kovac *et al* 1990).

This soil landscape is dominated by red podzolic soil with siliceous sands on steep crests. Non-calcic brown soils and red-brown earths occur on more gentle slopes.

5.4 Hydrology

5.4.1 Surface water

Surface water on-site drains south and to the Waugoola Creek which is greater than 800 metres to the south east. Majority of incident rainfall is expected to infiltrate into the soil.

5.4.2 Groundwater

A search of the Department of Primary Industries- Office of Water did not identify any groundwater bores recorded within a 500 metre radius of the investigation area. Bores located in the area are used for irrigation, stock and domestic water supply and groundwater is highly linked to the present day river and creek. Groundwater recharge to the alluvial aquifer system occurs primarily from river leakage. Groundwater at the site is located at depths greater than 9.5m below the surface within rock and is unlikely to be encountered due to distance from waterways.

The site is located within the Upper Lachlan Alluvium groundwater management area and modelling indicates recharge occurs at 186.5 GL/ year with measured groundwater usage recorded at 94.1GL/ year. The groundwater on the site is not considered suitable for stock or domestic supply due to limited availability and high salinity.

6. Conceptual site model

6.1 Sources of contamination

Fill from the landfill on neighbouring site has the potential for contamination through lateral movement.

6.2 Contaminants of concern

The contaminants of concern identified from historical and current land-uses include:

- Former landfill (Landfill gas including methane, carbon dioxide and leachate
- Groundwater contamination from landfill

6.3 Potential receptors

The proposed land-use of the site is residential. The site is also located within 1km of Waugoola Creek which is a moderately disturbed ecosystem.

Human receptors include

- On-site works during proposed site works
- Residences
- Intrusive maintenance workers

Ecological receptors include

- Vegetation on the site and adjacent the site
- Aquatic ecosystems of Waugoola Creek

6.4 Exposure pathways

Pathways for exposure to contaminants are:

- Dermal contact following soil disturbance
- Ingestion after soil disturbance
- Inhalation of dust after soil disturbance
- Surface water and sediment runoff into nearby waterways
- Leaching of contaminants into the groundwater
- Direct contact of flora and fauna with the soil

6.5 Source receptor linkages

Potential source pathway receptor linkages are identified to enable evaluation of any adverse impact on human health or ecology.

The site is currently vacant. Vapours may penetrate sub-floor space and accumulate within the buildings or construction trenches created. Exposure to outdoor works is negligible. Any groundwater bores constructed on the site are unlikely to be used for drinking or irrigation.

7. Previous investigations

Previous investigations are known to have been undertaken partially and adjacent to the site.

7.1 *Preliminary contamination site investigation with limited sampling Proposed Entry Road- Yarrabilly Seniors Village Lots 1 to 4 DP1173223, Cowra NSW,* Douglas Partners Pty Ltd May 2017 (report number 88419.01)

A preliminary site investigation was undertaken by Douglas Partners Pty Ltd in May 2017 to determine the suitability for proposed access road to the senior's village on Lot 4 DP1173223. The investigation and sampling was predominantly undertaken adjacent to the interface area within the location of the landfill but included review of historical information, a site walkover excavation of eleven pits in the landfill area to enable representative identification of the landfill. Discrete soil samples were analysed for organochlorine pesticides (OCP), total recoverable hydrocarbons (TRH), polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), benzene, toluene, ethylbenzene, xylene (BTEX), pH and asbestos.

The investigation within the landfill area identified:

- Asbestos material located on site
- Soil sampling indicated elevated levels of benzo(a)pyrene from one excavation pit
- Levels of OCP, TPH, PAH, PCB and BTEX in all other soil samples collected from the site were below the adopted site criteria.
- Waste was encountered in a number of excavations pits
- Based on the findings of the assessment, the potential for gross contamination to be present within the landfill is considered to be moderate to high.

7.2 *Report on Preliminary Site Investigation with limited sampling, Proposed Aged Care Development Part Lot 4 DP1092182 Cowra NSW, Douglas Partners Pty Ltd May 2017* (report number 88419.01)

A contamination investigation of the proposed development was undertaken by Douglas Partners Pty Ltd in May 2017 at Lot 4 DP1092182. The proposed development will include the construction of 100 residential sub-lots, community building and internal pavements.

No contamination was found within the seniors village.

Recommendations included further investigations for groundwater, surface water and landfill gasses.

No excavation pits were constructed within the interface area.

8. Sampling and analysis plan and sampling methodology

8.1 Data quality objectives (DQO)

The development of data quality objectives is recommended by EPA NSW to provide a systematic framework for investigation of the soil at the site.

8.1.1 State the problem

The investigation area is the interface area located at the proposed *Yarrabilly Seniors Village*, part of Lot 4 DP1092182, Cowra NSW. The investigation area will be open space parkland/roadway and act as buffer between the landfill and senior's village, the site is to be developed for residential land-use. Further investigations are required to access the impact of vapour and groundwater contamination from the historic landfill and potential impacts to the proposed senior's village.

An investigation is required to evaluate the presence of landfill gases and leachate and the potential impact at interface area.

8.1.2 Identify the decision

The proposed land-use is residential. The first decision was if the levels of methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide exceeded the threshold for residential development within the interface area. The second decision was if groundwater was identified, are the results greater than the human health and ecological threshold for residential land-use.

8.1.3 Identify the inputs decision

Soil gas monitoring wells were installed in accordance with assessment of ground gases (EPA 2012). Soil gases (methane and carbon dioxide) and flow rates were assessed in the field by multigas detectors. The measurements were undertaken in accordance with EPA (2012) and DECCW (2010) using calibrated field equipment.

The gas screening values were compared with the *characteristic gas situation* and risk classification to determine risk to on-site users (Section 9).

Determine the impact on shallow groundwater and if leachate contamination is occurring within the interface area.

8.1.4 Define the boundaries of the study

The investigation area is the interface area north of the North Cowra Landfill site on part of Lot 4 DP1092182, Cowra NSW (Figure 1). The area of the site is approximately 2,800m^2. The site is in the local government area of Cowra Shire Council.

8.1.5 Develop a decision rule

The guidelines for soil gases were the characteristic gas situation (EPA 2012) (Section 9).

Contaminants of concern for the groundwater included heavy metals and hydrocarbons.

8.1.6 Specify acceptable limits on the decision errors.

The decision making process is listed in Appendix 1 of NSW DEC Guidelines for the NSW Auditor Scheme (2006).

8.1.7 Optimize the design for obtaining data

Soil gas sampling was undertaken as described in Sections 7.2 and 7.3.

No groundwater or leachate was encountered.

Quality assurance and quality control objective and indicators are described in Section 8.

8.2 Sampling design

A systematic sampling pattern was adopted to assess the site. The site was assessed at locations down-gradient of the source. Assessment of down-gradient locations allows the extent of ground gases to be determined. The assessment included construction of three boreholes to 3m and installation of gas monitoring wells in accordance with EPA (2012).

Two groundwater wells were installed up to a depth of 9.5m where drill refusal was encountered on granodiorite.

8.3 Sampling methods

Vapour wells were constructed up to a depth of 3.0m with a truck mounted drilling rig using a solid auger. The monitoring wells were constructed using 50mm diameter screw-jointed unplasticised PVC pipe. Screened sections with a 0.1mm slot were 1.5m in length from the base of the borehole in GW1, GW2 and GW3. The well was packed with gravel to a minimum depth of 200mm above the screen. Bentonite with a minimum depth of 600mm and concrete were used to seal the well annulus. The well was fitted with a valved cap to allow measurement of soil gases. Additional drilling and well installation details for the gas monitoring wells are presented in Appendix 1.

Groundwater wells were constructed up to a depth of 9.5m at drill refusal on granodiorite with a truck mounted drilling rig using a solid auger. The monitoring wells were installed using 50mm diameter screw-jointed unplasticised class 18 PVC pipe.

8.4 Analytes

Field measurement for soil gas concentrations were recorded for methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulphide. The flow rate for the borehole and relative pressure at the time of measurement were also recorded (Table 1).

Soil gases were evaluated using a calibrated GA5000 Landfill Meter to determine soil gas concentrations and borehole flow rates. The meter measured gas concentrations over a minimum period of 5 minutes. Maximum and steady concentrations were recorded.

Groundwater wells were dry at time of inspection. No field parameters or analysis were taken.

Table 1. Schedule of samples and laboratory analyses

Sample ID (Figure 2)	Location	Date measured	Measurements undertaken
GW1	Down-gradient of landfill	29/8/2017	Methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide, relative pressure
GW2	Down-gradient of landfill	29/8/2017	Methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide, relative pressure
GW3	Down-gradient of landfill	29/8/2017	Methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide, relative pressure
MW1	Down-slope	29/8/2017	Dry well, no field parameters or analysis taken
MW2	Across gradient	29/8/2017	Dry well, no field parameters or analysis taken

9. Quality assurance and quality control

9.1 Sampling design

The sampling program is intended to provide data as to the presence or absence of soil gases and evidence of leachate and potential impacts on the proposed development. The location of screen in the well was undertaken to maximise gas detection and, or encounter leachate from the historic landfill.

The number and location of samples taken is expected to provide an adequate assurance that the measurements are representative of the potential impacts on the interface area of the historic landfill.

9.2 Field procedures

The field measurement techniques were undertaken in accordance with industry accepted standard protocols (EPA 2012).

The landfill meter used for measurement of soil gases and flow rates was calibrated. The calibration certificate is presented in Appendix 4.

9.3 Data interpretation

The site was considered suitable for the proposed use if levels of contaminants did not exceed adopted thresholds.

10. Assessment criteria

10.1 Soil gas

The proposed land-use is residential.

The gas screening value (GSV) is used to determine the risk classification of a site from hazardous soil gases (EPA 2012). The GSV is calculated using the following formula:

GSV = maximum borehole flow rate (L/hr) x maximum gas concentration (%).

The calculation is undertaken for both methane and carbon dioxide and the worst case value adopted.

The GSV results were compared against the characteristic gas situation and subsequent risk classifications. The characteristic gas situation and subsequent risk classifications are listed in Table 2 as recommended in EPA (2012).

Table 6. Risk classification (EPA 2012)

Gas screening value threshold (L/hr)	Characteristic gas situation	Risk classification	Additional factors
<0.07	1	Very low risk	Typically methane <1%, v/v and/or carbon dioxide <5%, v/v, otherwise consider increase to Situation 2.
<0.7	2	Low risk	Borehole flow rate not to exceed 70L/hr, otherwise consider increase to Situation 3.
<3.5	3	Moderate risk	
<15	4	Moderate to high risk	Consider need for Level 3 risk assessment.
<70	5	High risk	Level 3 risk assessment required.
>70	6	Very high risk	Level 3 risk assessment required.

10.1 Groundwater/leachate

No groundwater/leachate was encountered on the assessment date.

11. Results

11.1 Soil profile

Soil boring identified the boundary of the landfill (Figure 2). Fill was encountered in three boreholes up to a depth of 1.5m. Vapour well boreholes GW1, GW2 and GW3 were constructed up to a depth of 3.0m in natural soil within the interface location. GW1 was located approximately 30m north of the landfill boundary, GW2 was located 35m and GW3 approximately 20m north of the landfill boundary. The proposed dwelling are located 10m north of the vapour wells. The soil profile of GW2 and GW3 comprised a brown to red/ brown sandy clay over yellow/brown to light grey sandy clay and gravelly sand (weathered granodiorite).

Fill was encountered to the depth of the borehole of 0.5m in MW1 constructed to the north of the landfill. The soil profile comprised an imported sandy clay capping layer to a depth of 0.5m with alluvial gravel

over sandy clay and gravelly sand (weathered granodiorite) before drill refusal at 9.5m. MW2 encountered similar soil profile and refused at 7.5m on weathered granodiorite. No fill was encountered in MW2.

11.2 Soil gases

Methane, carbon monoxide and hydrogen sulphide was not recorded in three vapour wells located adjacent to the landfill (Table 3). Carbon dioxide concentrations were the limiting factor on site.

Steady and peak carbon dioxide concentrations in GW1 were recorded at 2.1%. The borehole flow rate was recorded at 0.6L/hr. The characteristic gas situation was determined to be 1 and the risk classification from hazardous gases produced in the location of GW1 was very low (Table 3).

Steady and peak carbon dioxide concentrations for GW2 were 1.8% and for GW3 was 1.7%. Flow rates for GW2 and GW3 were 0.4L/hr and 0.2L/hr respectively. The characteristic gas situation was determined to be 1 and the risk classification from hazardous gases produced in the location of GW2 and GW3 was very low (Table 3).

Table 3. Gas monitoring results

Monitoring well number	Oxygen (%)		Carbon dioxide (%)		Flow rate (L/hr)	Gas screening value (L/hr)
	Peak	Steady	Peak	Steady		
GW1	16.3	16.7	2.1	2.1	0.6	0.013
GW2	16.2	16.8	1.8	1.7	0.4	0.007
GW3	17.1	17.4	1.7	1.7	0.2	0.002
Risk classification (EPA 2012)						
Very low risk						<0.07
Low risk						<0.7
Moderate risk						<3.5
Moderate to high risk						<15
High risk						<70
Very high risk						>70

11.3 Groundwater/ leachate

No groundwater or leachate was encountered in MW1 and MW2 that refused at a depth up to 9.5m in granodiorite located downslope and across gradient of the historic North Cowra Landfill.

12. Site characterisation

12.1 Environmental contamination

No contamination of the soil by landfill gases or groundwater/leachate was identified.

12.2 Chemical degradation

No contamination of the soil by landfill gases or groundwater/leachate was identified.

12.3 Exposed population

The risk to on-site users from landfill gases was determined to be very low.

13. Conclusions and recommendations

13.1 Summary

Three soil gas monitoring wells were installed on the site on 15 August 2017. GW1, GW2 and GW3 were installed to a depth of 3.0m in natural soil adjacent to the historic landfill pit. The soil profile comprised dark brown sandy clay over red brown, yellow brown sandy clay and dark grey sandy clay

(weathered granodiorite) from 0.9m in GW2. The gas wells were located 20-30m north of the interface area north of the historic North Cowra landfill.

Methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulphide and flow rate was measured in each monitoring well on 29 August 2017. Methane, carbon monoxide and hydrogen sulphide was not recorded in the vapour wells located adjacent to the landfill. Carbon dioxide concentrations were the limiting factor on site. Peak carbon dioxide concentration in GW1 was 2.1% and borehole flow rate was 0.6L/hr. Carbon dioxide concentration were less than 1.8% in GW2 and GW3. Borehole flow rates in GW2 and GW3 were 0.4L/hr and 0.2L/hr respectively.

The gas screening value ranged from 0.001L/hr in GW3 to 0.013L/hr in GW1. The wells on the site were determined to have a characteristic gas situation of 1 and a risk classification of very low.

The risk to site users from soil gases associated with the landfill is considered to be very low. No further actions are required. A vent trench along the landfill boundary is not required.

No groundwater or leachate was detected in the groundwater wells installed between the landfill and the development.

13.2 Assumptions in reaching the conclusions

It is assumed the sampling locations are representative of the site. An accurate history has been obtained.

13.3 Extent of uncertainties

The analytical data relate only to the locations sampled. Soil conditions can vary both laterally and vertically and it cannot be excluded that unidentified contaminants may be present.

13.4 Recommendation for further work

No further investigations are required. The investigation area located approximately 30m downslope of the historic landfill is not impacted by vapour or leachate and is thought to be an adequate buffer distance for the proposed development.

14. Report limitations and intellectual property

This report has been prepared for the use of the client to achieve the objectives given the clients requirements. The level of confidence of the conclusion reached is governed by the scope of the investigation and the availability and quality of existing data. Where limitations or uncertainties are known, they are identified in the report. No liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been predicted using the scope of the investigation and the information obtained.

The investigation identifies the actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing is interpreted by geologists, engineers or scientists who then render an opinion about overall subsurface conditions, the nature and extent of the contamination, it's likely impact on the proposed development and appropriate remediation measures. Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock or time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. It is thus important to understand the limitations of the investigation and recognise that we are not responsible for these limitations.

15. References

DEC (2006) *Contaminated Sites: Guidelines for the NSW Site Auditors Scheme* (NSW Department of Environment and Conservation: Chatswood)

DECCW (2010) *Vapour Intrusion: Technical Practice Note* (Department of Environment, Climate Change and Water, Sydney)

EPA (1995) *Contaminated sites: Sampling Design Guidelines* (NSW Environment Protection Authority: Chatswood)

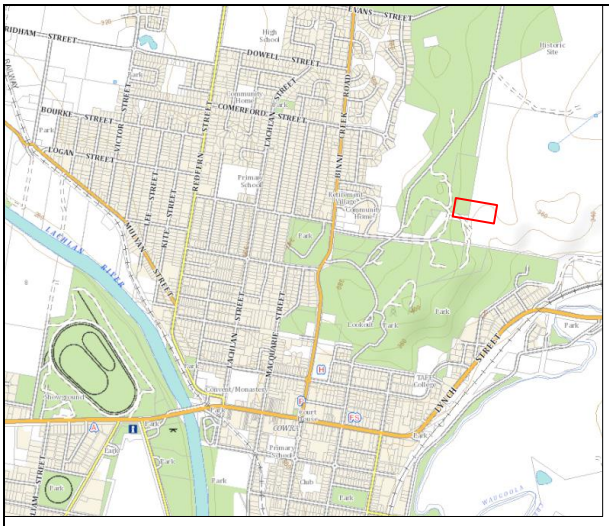
EPA (2011) *Guidelines for Consultants Reporting on Contaminated Sites* (NSW Environment Protection Authority: Chatswood)

EPA (2012) *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (Environment Protection Authority, South Sydney)

Kovac M, Murphy BW and Lawrie JA (1990) *Soil Landscapes of the Bathurst 1:250 000 Sheet Report,* Department of Land and Water Conservation of NSW, Sydney

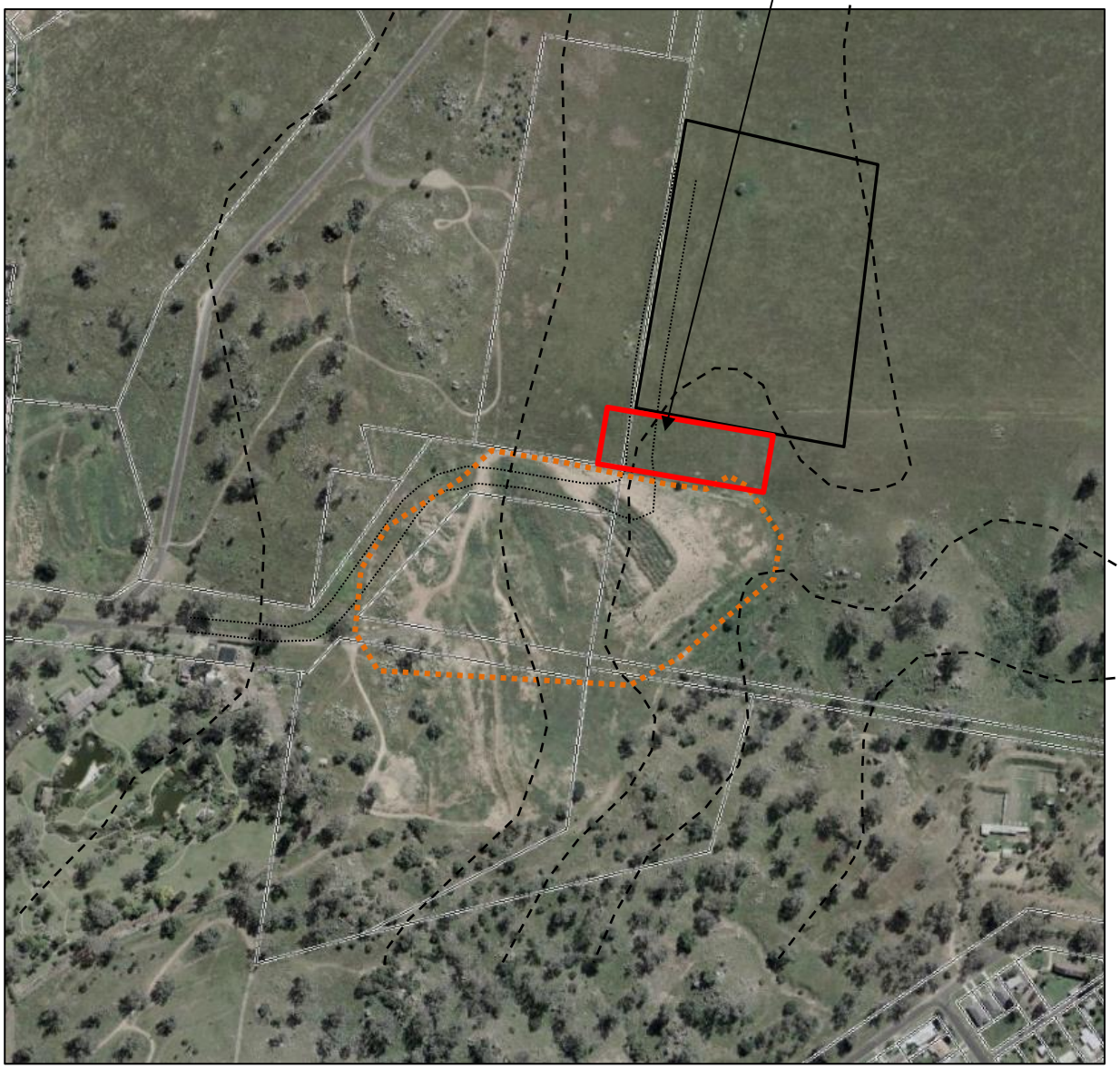
NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999* (National Environment Protection Council Service Corporation, Adelaide)

Figures



North

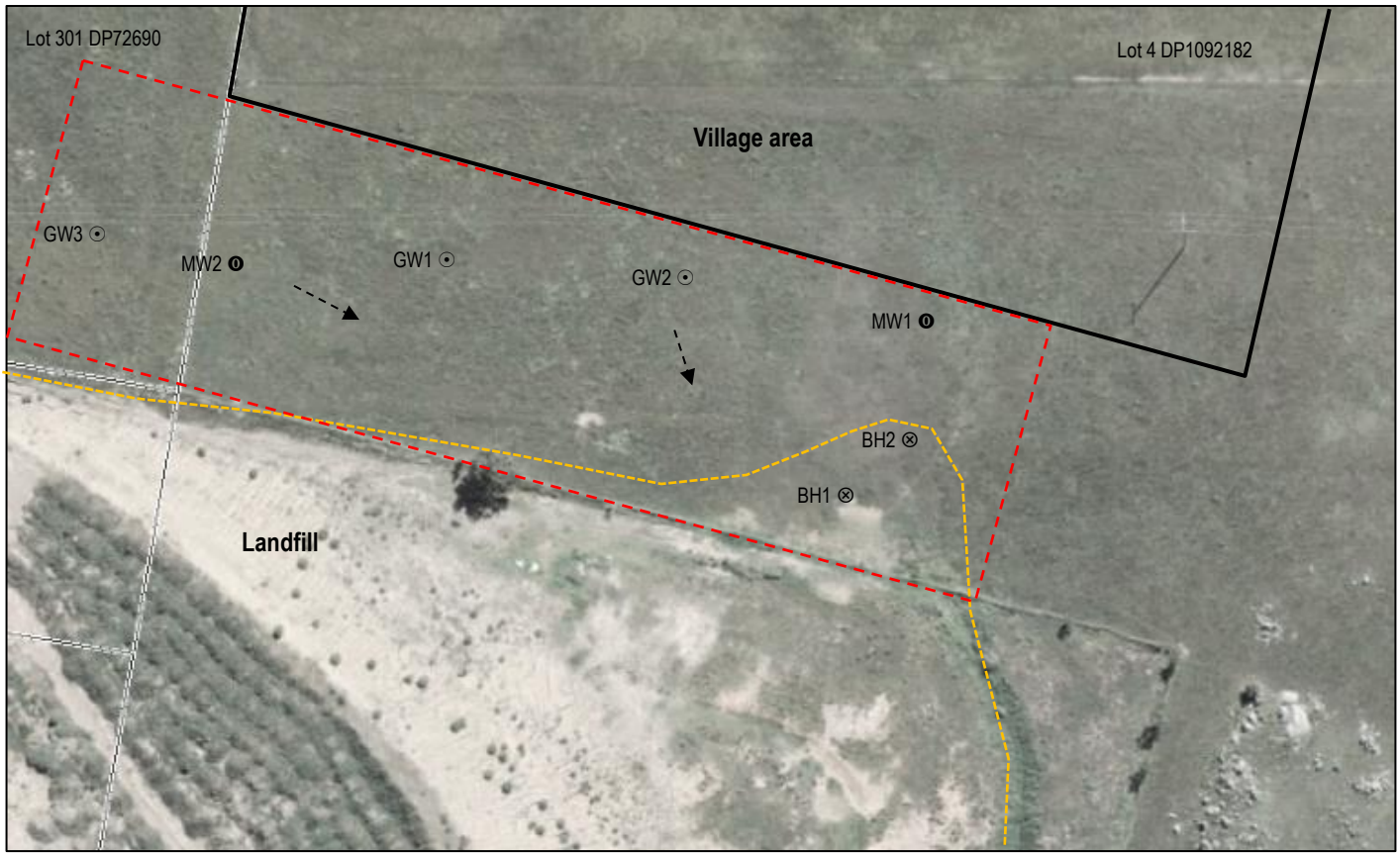
Site assessed



Legend

- Approximate Landfill
- Contour
- Investigation area
- Proposed access road
- Proposed seniors village

Figure 1. Site locality		
Proposed Yarrabilly Seniors Village, Lot 4 DP1092182, Cowra NSW		
	Envirowest Consulting Pty Ltd	
Job R8659sg	Drawn by: DL	Date: 19/9/2017



Legend

BH ⊗ Borehole location

MW1 ⊙ Monitoring well

Interface area

GW2 ⊙ Vapour well

Slope

Proposed village location

Approximate extent of landfill

Approximate Scale 1: 1,000

0 10 20 40m

Figure 2. Soil gas and groundwater monitoring well locations

Proposed Yarrabilly Seniors Village, Lot 4 DP1092182, Cowra NSW

Envirowest Consulting Pty Ltd

Job R8659sg	Drawn by: DL	Date: 19/9/2017

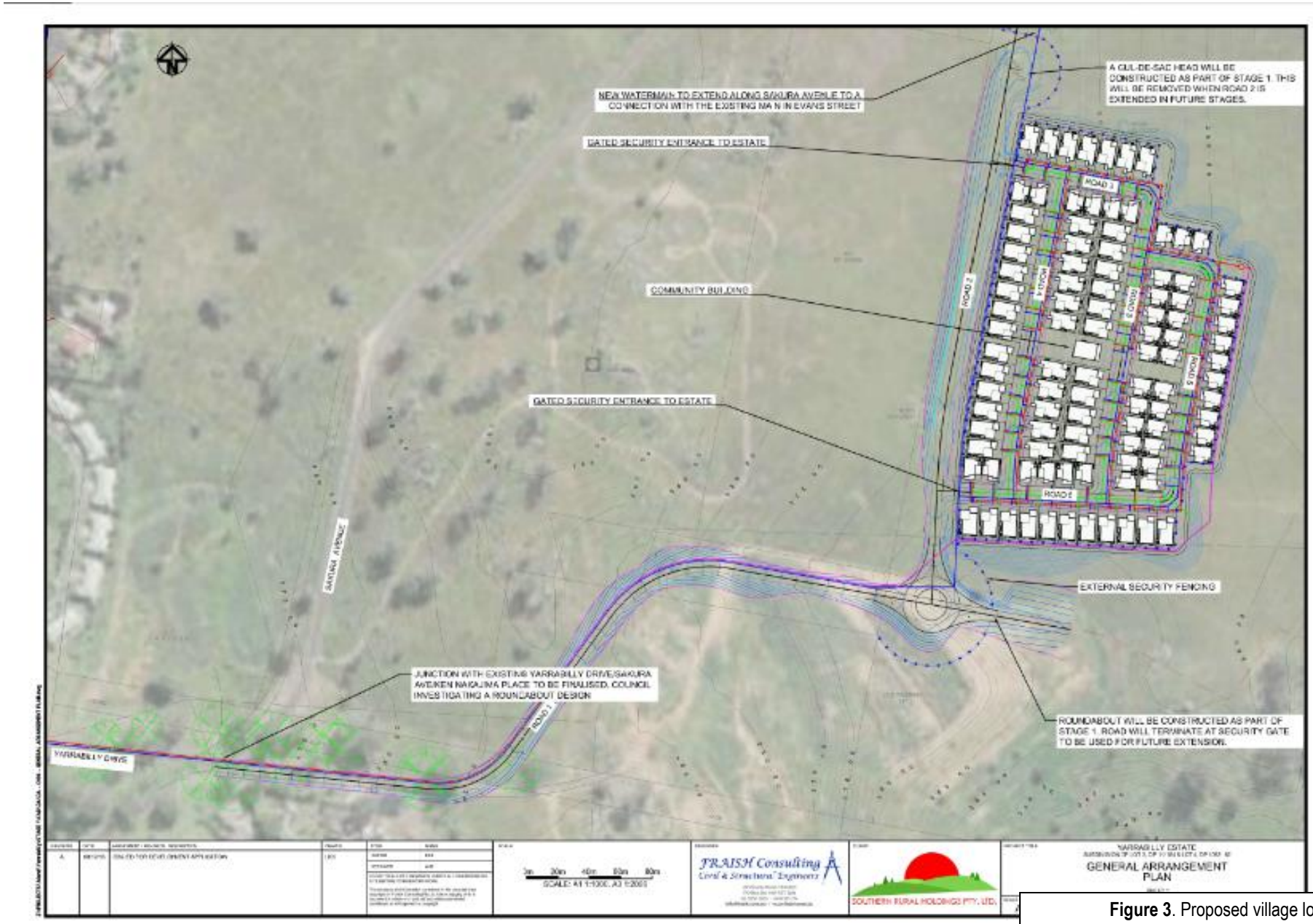


Figure 3. Proposed village location

Proposed Yarrabilly Seniors Village, Lot 4 DP1092182, Cowra NSW

	Envirowest Consulting Pty Ltd	
Job R8659sg	Drawn by: DL	Date: 19/9/2017

Figure 4. Photographs of the site

Soil gas monitoring well GW3 looking east

Looking south over interface area towards the landfill

Groundwater monitoring well GW2

Appendices

Appendix 1. Bore logs
Appendix 2. Sample analysis, quality assurance and quality control (QAQC)
Appendix 3. Field data sheet
Appendix 4. GA5000 Landfill Meter calibration record

Appendix 1. Bore logs

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: BH1 Location: 6m north of landfill boundary	Sampling method: EVH drill Logged by: DL Date: 15/08/2017

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
		FILL, red brown, silty clay	CH			M	F	M	-
0.5		FILL, light brown silty clay with trace sand Alluvial gravel plastic/ refuse	CI			M	F	M	-
1.0									
1.5									
		SILTY CLAY, dark grey, organic material	CI			M	F	M	-
2.0		SANDY CLAY, yellow brown	CI			M	F	M	-
		End of hole at investigation depth							
2.5									
3.0									
4.0									
4.5									
5.0									
4.0									

Soil classification:
Slope/nature of surface: 0-3%S
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Landfill refuse was identified to a depth of 1.5m

Samples	**Moisture**	**Consistency**	**Plasticity**
E – Environmental D – Disturbed U – Undisturbed VOC- volatile organic compounds (ppm)	*D* – Dry *M* – Moist, can be moulded *W* – Wet, free water on hands *Wp* – plastic limit *Wl* – liquid limit	Hand penetrometers (kPa) or description: *VS* – very soft , exudes between fingers *S* – soft, moulded by light finger pressure *F* – firm, moulded slightly by fingers *St* – stiff, can't be moulded by fingers, indented by thumb *VSt* – very stiff, indented with difficulty by thumb	*NP* – Non plastic *T* – Trace *VL* – Very low *L* – Low *M* – Medium *H* – High *VH* – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: BH2 Location: 16m north of landfill boundary	Sampling method: EVH drill Logged by: DL Date: 15/8/2017

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
0.5		FILL, brownish red silty clay with trace charcoal and plastic	Cl			M	F	M	-
1.0		End of hole at investigation depth							
1.5									
2.0									
2.5									
3.0									
3.5									
4.0									
4.5									
5.0									

Slope/nature of surface: 2-3%
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Fill to a depth of 0.7m

Samples	**Moisture**	**Consistency**	**Plasticity**
E – Environmental D – Disturbed U – Undisturbed VOC- volatile organic compounds (ppm)	*D* – Dry *M* – Moist, can be moulded *W* – Wet, free water on hands *Wp* – plastic limit *Wl* – liquid limit	Hand penetrometers (kPa) or description: *VS* – very soft , exudes between fingers *S* – soft, moulded by light finger pressure *F* – firm, moulded slightly by fingers *St* – stiff, can't be moulded by fingers, indented by thumb *VSt* – very stiff, indented with difficulty by thumb	*NP* – Non plastic *T* – Trace *VL* – Very low *L* – Low *M* – Medium *H* – High *VH* – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: MW1 Location: 40m north of landfill within drainage line	Sampling method: EVH drill Logged by: DL Date: 15/8/2017 Page 1 of 2

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
0.5		FILL, brown sandy clay with rounded river gravel and quartz	Cl			M	F	M	-
1.0		SANDY CLAY, red brown	Cl			M	F	M	-
1.5		SANDY CLAY, dark red with trace gravel	Cl			M	F	M	-
2.0		SANDY CLAY, yellow brown, extremely weathered rock (granodiorite)	Cl			M	St	M	-
2.5									
3.0									
3.5		SANDY CLAY, light brown/grey, weathered granodiorite with grey mottles in clay	CL			D	St	L	-
4.0									
4.5									
5.0									

Soil classification:
Slope/nature of surface: Level
Ground water: No free water identified in soil profile.
Soil salinity: Nil

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from +0.8.-6.5m, screen 6.5-9.50m, 3mm gravel 2.0-9.5m, bentonite 0.8-2.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: MW1 Location: 40m north of landfill within drainage line	Sampling method: EVH drill Logged by: DL Date: 15/8/2017 Page 2 of 2

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
5.5		GRAVELLY SAND, light grey, weathered granodiorite	GC			D	VSt	L	-
6.0									
6.5									
7.0									
7.5									
8.0									
8.5									
9.0									
9.5							H		
10.0		End of hole- drill refusal on rock							

Soil classification:
Slope/nature of surface: Level
Ground water: No free water identified in soil profile.
Soil salinity: Nil

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from +0.8.-6.5m, screen 6.5-9.50m, 3mm gravel 2.0-9.5m, bentonite 0.8-2.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: MW2 Location: Adjacent to property boundary	Sampling method: EVH drill Logged by: DL Date: 15/8/2017 Page 1 of 2

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
		SANDY CLAY, brown	Cl			M	F	M	-
0.5		SANDY CLAY, dark reddish brown	Cl			M	F	M	-
1.0									
1.5									
		SANDY CLAY, light brown/ grey	Cl			D	F	M	-
2.0									
2.5									
3.0									
		GRAVELLY SAND, light brown (weathered granodiorite)	GC			D	St	L	-
3.5									
4.0									
4.5									
5.0									

Slope/nature of surface: 0-4% east
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from +0.73-4.0m, screen 4.0-7.0m, 3mm gravel 3.0-7.0m, bentonite 2.0-3.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: MW2 Location: Adjacent to property boundary	Sampling method: EVH drill Logged by: DL Date: 15/8/2017 Page 2 of 2

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
5.5									
6.0		Increasing gravel							
6.5									
7.0		End of hole at drill refusal on rock							
7.5									
8.0									
8.5									
9.0									

Slope/nature of surface: 0-4% east
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from +0.73-4.0m, screen 4.0-7.0m, 3mm gravel 3.0-7.0m, bentonite 2.0-3.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: BH6 (GW1) Location: 30m north of the landfill boundary	Sampling method: EVH drill Logged by: DL Date: 15/8/2017

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
0.5		SANDY CLAY, dark brown	Cl			M	F	M	-
1.0		SANDY CLAY, red brown	Cl			M	F	M	-
1.5		SANDY CLAY, yellow brown							-
2.0									
2.5									
3.0									
3.5		SANDY CLAY, dark grey (weathered granodiorite)	CL			D	St VSt	L	-
4.0							H		
4.5		End of hole at investigation depth- Drill refusal							
5.0									

Slope/nature of surface: 0-2% south
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from 0-1.5m, screen 1.5-3.0m, 3mm gravel 2.0-3.0m, bentonite 1-2.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: BH7 (GW2) Location: 35m north of the landfill boundary	Sampling method: EVH drill Logged by: DL Date: 15/8/2017

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
		SANDY CLAY, dark brown	Cl			M	F	M	-
0.5		SANDY CLAY, red	Cl			M	F	M	-
1.0		SANDY CLAY, yellow brown (weathered granodiorite)	CL			L	-	CL	-
1.5									
2.0									
2.5									
3.0									
3.5									
4.0									
		End of hole at investigation depth							
4.5									
5.0									

Slope/nature of surface: 0-2% south
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from 0-1.5m, screen 1.5-3.0m, 3mm gravel 2.0-3.0m, bentonite 1-2.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Bore log sheet

Job: R8659sg Client: Cowra Shire Council Site: North Cowra Landfill Cowra NSW	Borehole No: BH8 (GW3) Location: 20m north of the landfill boundary	Sampling method: EVH drill Logged by: DL Date: 15/8/2017

Depth (m)	Graphic log	DESCRIPTION. Soil type/rock, grain size, structure, colour, minor components	Texture group	Samples	Bore construction	Moisture	Consistency	Plasticity	VOC (ppm)
0.5		SANDY CLAY, dark brown	Cl			M	F	M	-
1.0		SANDY CLAY, Dark brownish red	Cl			M	F	M	-
1.5		SANDY CLAY, yellow brown							-
2.0									
2.5									
3.0		SANDY CLAY, dark grey (weathered granodiorite)	CL			L	-	L	-
3.5									
4.0									
4.5		End of hole at investigation depth- Drill refusal							
5.0									

Slope/nature of surface: 0-2% south
Ground water: No free water identified in soil profile.

Remarks (fill, odour, root holes): Monitoring well installed (Class 18 UPVC 50mm diameter). Casing from 0-1.5m, screen 1.5-3.0m, 3mm gravel 2.0-3.0m, bentonite 1-2.0m, concrete seal.

Samples
E – Environmental
D – Disturbed
U – Undisturbed
VOC- volatile organic compounds (ppm)

Moisture
D – Dry
M – Moist, can be moulded
W – Wet, free water on hands
Wp – plastic limit
Wl – liquid limit

Consistency
Hand penetrometers (kPa) or description:
VS – very soft , exudes between fingers
S – soft, moulded by light finger pressure
F – firm, moulded slightly by fingers
St – stiff, can't be moulded by fingers, indented by thumb
VSt – very stiff, indented with difficulty by thumb

Plasticity
NP – Non plastic
T – Trace
VL – Very low
L – Low
M – Medium
H – High
VH – Very high

Appendix 2. Sample analysis, quality assurance and quality control (QAQC)

1. Data quality indicators (DQI)

1.1 Completeness

A measure of the amount of usable data for a data collection activity (total to be greater than 90%)

1.1.1 Field

Consideration	Requirement
Locations to be sampled	Described in the sampling plan
Depth to be sampled	Described in the sampling plan, each layer or explained
SOP appropriate and compiled	Described in the sampling plan
Experienced sampler	Sampler or supervisor
Documentation correct	Sampling log and chain of custody completed

1.1.2 Laboratory

Consideration	Requirement
Samples analysed	Number according to sampling and quality plan
Analytes	Number according to sampling and quality plan
Methods	EPA or other recognised methods with suitable PQL
Sample documentation	Complete including chain of custody and sample description
Sample holding times	Metals - 6 months mercury - 28 days OCP, OPP, PAH, TPH, PCB, BTEXN, phenols - 14 days

1.2 Comparability

The confidence that data may be considered to be equivalent for each sampling and analytical event

1.2.1 Field

Consideration	Requirement
SOP	Same sampling procedures to be used
Experienced sampler	Sampler or supervisor
Climatic conditions	Described as may influence results
Samples collected	Sample medium, size and preparation

1.2.2 Laboratory

Consideration	Requirement
Analytical methods	Same methods
PQL	Same
Same laboratory	Justify if different
Same units	Justify if different

1.3 Representativeness

The confidence (expressed qualitatively) that data are representative of each media present on the site

1.3.1 Field

Consideration	Requirement
Appropriate media sampled	Sampled according to sampling and quality
All media identified	Sampling media identified in the sampling and quality plan

1.3.2 Laboratory

Consideration	Requirement
Samples analysed	Blanks

1.4 Precision

A quantitative measure of the variability (or reproduced of the data)

1.4.1 Field

Consideration	Requirement
Field duplicates	Frequency of 5%, results to be within +/-40% or discussion required indicate the appropriateness of SOP

1.4.2 Laboratory

Consideration	Requirement
Laboratory and inter lab duplicates	Frequency of 5%, results to be within +/-40% or discussion required
Field duplicates	Frequency of 5%, results to be within +/-40% or discussion required
Laboratory prepared volatile trip spikes	One per sampling batch, results to be within +/-40% or discussion required

1.5 Accuracy

A quantitative measure of the closeness of the reported data to the true value

1.5.1 Field

Consideration	Requirement
SOP	Complied

1.5.2 Laboratory

Consideration	Requirement
Field blanks	Frequency of 5%, <5 times the PQL, PQL may be adjusted
Rinsate blanks	Frequency of 5%, <5 times the PQL, PQL may be adjusted
Method blanks	Frequency of 5%, <5 times the PQL, PQL may be adjusted
Matrix spikes	Frequency of 5%, results to be within +/-40% or discussion required
Matrix duplicates	Frequency of 5%, results to be within +/-40% or discussion required
Surrogate spikes	Frequency of 5%, results to be within +/-40% or discussion required
Laboratory control samples	Frequency of 5%, results to be within +/-40% or discussion required
Laboratory prepared spikes	Frequency of 5%, results to be within +/-40% or discussion required

2. Laboratory analysis summary

No laboratory analysis undertaken

3. Field quality assurance and quality control

Not applicable

4. Laboratory quality assurance and quality control

Not applicable

5. Data quality indicators (DQI)

5.1 Completeness

A measure of the amount of usable data for a data collection activity (total to be greater than 90%)

5.1.1 Field

Consideration	Accepted	Comment
Locations to be sampled	Yes	In accordance with sampling methodology, described in the report.
SOP appropriate and compiled	Yes	In accordance with sampling methodology
Experienced sampler	Yes	Environmental scientist
Documentation correct	Yes	Field sheets completed

5.1.2 Laboratory

Consideration	Accepted	Comment
Samples analysed	NA	
Analytes	NA	
Methods	NA	
Sample documentation	NA	
Sample holding times	NA	

5.2 Comparability

The confidence that data may be considered to be equivalent for each sampling and analytical event.

5.2.1 Field

Consideration	Accepted	Comment
SOP	Yes	Same sampling procedures used and sampled on one date
Experienced sampler	Yes	Experienced environmental scientist
Climatic conditions	Yes	Sampling log
Samples collected	Yes	Suitable size and storage

5.2.2 Laboratory

Consideration	Accepted	Comment
Analytical methods	NA	
PQL	NA	
Same laboratory	NA	
Same units	NA	

5.3 Representativeness

The confidence (expressed qualitatively) that data are representative of each media present on the site

5.3.1 Field

Consideration	Accepted	Comment
Appropriate media sampled	Yes	Sampled according to sampling and quality plan
All media identified	Yes	Soil gas sampling media identified in the sampling and quality plan

5.3.2 Laboratory

Consideration	Accepted	Comment
Samples analysed	NA	

5.4 Precision

A quantitative measure of the variability (or reproduced of the data)

5.4.1 Field

Consideration	Accepted	Comment
SOP	Yes	Complied
Field duplicates	NA	Not collected

5.4.2 Laboratory

Consideration	Accepted	Comment
Laboratory duplicates	NA	
Field duplicates (intra and inter laboratory)	NA	
Laboratory prepared volatile trip spikes	NA	

5.5 Accuracy

A quantitative measure of the closeness of the reported data to the true value

5.5.1 Field

Consideration	Accepted	Comment
SOP	Yes	Complied
Field blanks	NA	
Rinsate blanks	NA	

5.5.2 Laboratory

Consideration	Accepted	Comment
Method blanks	NA	
Matrix spikes	NA	
Matrix duplicates	NA	
Surrogate spikes	NA	
Laboratory control samples	NA	
Laboratory prepared spikes	NA	

6. Conclusion

All media appropriate to the objectives of this investigation have been adequately analysed and no area of significant uncertainty exist.

It is concluded the data is usable for the purposes of the investigation.

Appendix 3. Field data sheet

Envirowest Consulting *Pty Ltd* ABN 18 103 955 246
• 9 Cameron Place, PO Box 8158, Orange NSW 2800 • Tel (02) 6361 4954 •
• Fax (02) 6360 3960 • Email admin@envirowest.net.au • Web www.envirowest.net.au •

Environmental
Geotechnical
Asbestos
Services

Field data sheet – landfill gas monitoring

Date: 7 May 2014 Job number: 10297 Assessor: Leah Desborough

Site address: Proposed Yarrabilly Seniors Village, Lot 301 DP726980 and Lot 4 DP1092182, Cowra NSW

Client: Cowra Shire Council

Monitoring well number	Methane (CH_4) (%)		Carbon dioxide ($C0_2$) (%)		Oxygen (O_2) (%)	Carbon monoxide (CO) (ppm)	Hydrogen sulphide (H_2S) (ppm)	Flow rate (L/h)	Gas screening value (L/hr)	Relative pressure (mb)
	Peak	Steady	Peak	Steady						
GW1	0.4	0.4	19.2	19.2	13.1	0	0	0.1	0.0192	-0.01
GW2	0	0	4.1	2.0	19.6	0	0	0.2	0.0082	0.39
GW3	0	0	3.8	3.8	16.0	0	0	0.4	0.0152	-0.03

Weather conditions: Fine

Comments:

Appendix 4. GA5000 Landfill Meter calibration record

ThermoFisher SCIENTIFIC

The world leader in serving science

RENTALS

Equipment Report - GEOTECHNICAL INSTRUMENTS GA5000

This Gas Meter has been performance checked and calibrated as follows:

Sensor	Concentration	Zero	Span	Traceability Lot #	Pass?
CH_4	60 %	0.0 %	60.0 %	591518C13	☑
CO_2	40 %	----------	40.0 %	591518C13	☑
O_2	20.9 %	0.0 %	20.9 %	AIR	☑
CO	100 ppm	0 ppm	100 ppm	1834367C8	☑
H_2S	25 ppm	0 ppm	25 ppm	669646C28	☑
H_2 CO/H2 compensated only	1000 ppm	0 ppm	1000 ppm	689132C17	☑

☑ Battery Status 100 %
☑ 10 minutes test complete
☑ Electrical Safety Tag attached (AS/NZS 3760)

☑ In-Line filters checked
☑ Data cleared

Tag No: 000915

Valid to: 21/11/2017

Date: 25/08/2017

Signed: Mike Hs

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $30 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Returned	Item
☑	☐	Performance check / Battery 100 %
☑	☐	Sampling tubing with In-Line filter
☑	☐	Out let tubing (internal flow pod only)
☑	☐	Well cap Quick connect fitting with tubing and In-Line filter
☑	☐	Power Supply
☑	☐	Operating Quick Guide behind foam on lid of case "
☑	☐	Manual behind foam on lid of case "
☑	☐	Spare Inline Filters Qty 1 ☑
☑	☐	H_2S filter
☑	☐	Data Cable and Software CD
☑	☐	Soft case with carry strap
☑	☐	Carry case
☐	☐	Check to confirm electrical safety (tag must be valid)

Date: 25/08/2017

Signed: Mike Hs

TFS Reference	CS007377	Return Date:	/ /
Customer Reference		Return Time:	
Equipment ID	GA5000-13	Condition on return:	
Equipment Serial No.	6502797		