Expert Opinion on Landfill Gas, Hume Planning Scheme Amendment C207: Sunbury South Precinct Structure Plan

Hi Quality Quarry Products Landfill, 600 Sunbury Road, Bulla

Prepared for:
Victorian Planning Authority
35 Collins Street
Melbourne VIC 3000

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List of Acronyms

Acronym	Definition
ACM	Asbestos containing material
AMG	Australian Map Grid
BH	Borehole
BPEM	Best Practice Environmental Management
CCL	Compacted clay liner
CQAP	Construction quality assurance plan
CSM	Conceptual site model
EPA	Environment Protection Authority (Victoria)
GCL	Geosynthetic clay liner
GHD	GHD Pty Ltd
LEL	Lower explosive limit
HA	Harwood Andrews Legal
LFG	Landfill gas
m	Metre
m^3	Cubic metres
m AHD	Metres above Australian Height Datum
m bgl	Metres below ground level
MWRRG	Metropolitan Waste and Resource Recovery Group
PCBs	Polychlorinated biphenyls
PIW	Prescribed industrial waste
SEPP	State Environment Protection Policy
SEPP GoV	State Environment Protection Policy (Groundwaters of Victoria)
SEPP WoV	State Environment Protection Policy (Waters of Victoria)
SV	Sustainability Victoria
UEL	Upper explosive limit
UK EA	United Kingdom Environment Agency
USEPA	United States Environment Protection Agency
VOC	Volatile organic compound
VPA	Victorian Planning Authority

1.0 Introduction

1.1 Engagement

I, Patrick Clarke, an employee of Senversa Pty Ltd (Senversa) have been engaged by the Victorian Planning Authority (VPA) to provide my expert opinion on landfill buffers in relation to Amendment C207 to the Hume Planning Scheme – Sunbury South Precinct Structure Plan (Amendment C207).

Senversa's Melbourne offices are located at Level 6, 15 William Street, Melbourne.

A copy of Plan 3 from Amendment C207, showing the extent of the amendment, is included in **Appendix A** of this report.

My opinion relates to an appropriate landfill buffer around the existing landfill operated by High-Quality Quarry Products Pty Ltd (HQQP). The landfill (the HQQP Landfill) is located at 600 Sunbury Road, Bulla at the eastern margins of the area covered by Amendment C207, immediately west of Emu Creek (refer to **Figure 1** and Plan 3 in **Appendix A)**.

1.2 Brief

I was briefed, on behalf of VPA, by Mr Greg Tobin and Ms Tessa D'Abbs of Harwood Andrews Legal (HA) in relation to my opinion. A copy of the letter from HA briefing me is included in **Appendix B**.

In its brief, HA requested I consider the following:

1. *the approximate extent of the landfill buffer having regard to your areas of expertise;*
2. *the planning controls proposed in UGZ9 to apply within the buffer, in particular the applied zones and Clauses 3.7 and 3.8;*
3. *how you would expect the landfill buffer to be implemented in practice; and*
4. *the submissions referred to the Panel in relation to the landfill buffer.*

Consistent with my brief, I considered the following submissions in relation to the landfill buffer:

- No. 33 – Sustainability Victoria (SV);
- No. 61 – HQQP;
- No. 69 – Metropolitan Waste and Resource Recovery Group (MWRRG); and
- No. 82 – Environment Protection Authority Victoria (EPA).

1.3 Scope of Opinion

My opinion is in relation to the application of the controls documented in Clause 3.8 of Schedule 9 to the Urban Growth Zone (UGZ9). Clause 3.8 applies to an area within a 500 m buffer from the HQQP Landfill, as indicated in Plan 3 of Amendment C207 (refer to **Appendix A**), and places a requirement on any applications to subdivide land, use land or construct a building or carry our works on land within the buffer to:

- "*Demonstrate that the development will not have any material adverse impact on the ability of the operator of the Hi-Quality landfill at 600 Sunbury Road to comply with the Best Practice Environmental Management: Siting, Design, Operation and Rehabilitation of Landfills….; and*
- *Be accompanied by a landfill gas risk assessment undertaken by a suitably qualified professional in relation to the site, or a 53V (risk of harm) audit….at the discretion of the responsible authority in consultation with the Environment Protection Authority. A landfill gas risk assessment should include:…"*

Based on my experience as an environmental auditor and consultant assessing landfill gas risk, I interpret Clause 3.8 to apply to the potential migration of landfill gas beneath the boundaries of the HQQP Landfill, through the subsurface, and risks to surrounding land uses. The hazards considered in a landfill gas risk assessment include potential for explosion, fire, asphyxiation by exclusion of oxygen in breathing zones and exposure to toxic chemical vapours in the landfill gas.

Clause 3.7 of UGZ9 relates to application of the Landfill Buffer in relation to impacts of odour from the HQQP Landfill, and presumably the composting facility at the site. On the basis that VPA has sought an opinion on odours from Mr Peter Ramsay of Peter J Ramsay & Associates Pty Ltd, I have not considered the impact of odours associated with the landfill or composting facility.

1.4 Qualifications

I am a Senior Principal Geological Engineer employed by Senversa Pty Ltd (Senversa). A copy of my curriculum vitae is provided in **Appendix C**.

I completed a Bachelor of Engineering in Geological Engineering at the Royal Melbourne Institute of Technology (RMIT) in 1987. Since 1988 I have worked continuously as a consultant providing advice on solid waste management, landfills, contaminated site assessment, soil and groundwater remediation and projects across Australia, the United States of America (for three years) and Asia. I have particular experience in environmental issues associated with landfills, including assessment of landfill gas emissions and management of those emissions.

I am an Environmental Auditor (Contaminated Land), appointed pursuant to the Environment Protection Act, 1970 (the EP Act) by the EPA. I was appointed in April 2002 and have been an active environmental auditor since that time. My statutory environmental auditing activities have included auditing of landfills gas risk and landfill construction works, under Section 53V of the EP Act. I am an active member of the EPA's landfill auditor group, which provides feedback and input into the regulation of landfills in Victoria.

I was the founding President of the Victorian Branch of the Australian Contaminated Land Consultants Association (ACLCA), elected into that role by my peers in the contaminated land consulting industry. I am a Fellow of the Institute of Engineers Australia (FIEAust), a Chartered Professional Engineer (CPEng) and Engineering Executive (EngExec). I am listed on the National Engineering Register (NER) and the Asia-Pacific Economic Cooperation (APEC) Engineers Register.

Recent experience I believe is relevant to the proceedings before VCAT includes the following:

- A Section 53V environmental audit of landfill gas risk associated with a former landfill at Quarry Park in Footscray, Victoria. The audit involved assessment of landfill gas to existing residential development immediately adjacent to the former landfill and a proposed residential development. Recommendations of the audit included application of planning controls by the relevant authority to areas on and surrounding the landfill.
- A Section 53V environmental audit of landfill gas risk associated with a former landfill at Sir Doug Nichols Reserve, Thornbury, Victoria. The audit involved assessment of landfill gas risk to an aboriginal cultural centre and child care facility located on the former landfill and surrounding residential and industrial uses. Recommendations of the audit included application of planning controls by the relevant authority to areas on and surrounding the landfill.
- A landfill gas risk assessment and recommendations on planning controls associated with a former landfill at Vincent Road, Wangaratta, Victoria.
- Section 53V environmental audit of landfill gas risk associated with the former Bosworth Landfill, Bairnsdale, Victoria.

1.5 Involvement to Date

Prior to my engagement by VPA, my only involvement with the HQQP Landfill was to provide an expert opinion in relation to draft conditions of the EPA Licence for the contaminated soil processing facility (Site B) located at the premises. I was engaged by EPA to provide that advice in relation to an appeal by HQQP against the draft licence conditions. The appeal was to be heard at the Victorian Civil and Administrative Appeals Tribunal (VCAT). I understand the licence conditions were agreed by EPA and HQQP through mediation.

2.0 Basis for Opinion

2.1 Available Information

I was provided with the following information by HA:

- VPA, Sunbury South Precinct Structure Plan, November 2016;
- Hume Planning Scheme Amendment C207 and concurrent permit application P18858, Explanatory Report;
- Hume Planning Scheme Amendment C207, Instruction Sheet;
- Hume Planning Scheme Amendment C207 Ordinance, incorporating;
    - Clause 32.07 Residential Growth Zone;
    - Schedule 1 to Clause 32.07 Residential Growth Zone;
    - Schedule 9 to the Special Use Zone;
    - Schedule 10 to the Special Use Zone;
    - Schedule 9 to the Urban Growth Zone;
    - Schedule to the Heritage Overlay;
    - Schedule 3 to the Incorporated Plan Overlay;
    - Schedule 4 to the Incorporated Plan Overlay;
    - Schedule to Clause 52.17;
    - Schedule to Clause 61.03;
    - Schedule to Clause 66.04;
    - Schedule to Clause 66.06; and
    - Schedule to Clause 81.01.
- Hume Planning Scheme Amendment C207 Maps;
- VPA, Precinct Structure Plan, Background Report, November 2016
- EPA Licence number 45279 (last amended 10 April 2017) for 600 Sunbury Road, Bulla, VIC 3428;
- EPA Licence number 129589 (last amended 26 June 2017) for 570 Sunbury Road, Bulla, VIC 3428;
- EPA Licence number 136116 (last amended 29 June 2017) for 570 Sunbury Road, Bulla, VIC 3428;
- VPA, PSP 74 Sunbury South, Submission to EPA Internal Planning Review Panel, 20 March 2017;
- EPA Victoria, Amendment C207 and C208 to the Hume Planning Scheme, 4 July 2017; and
- VPA, Amendment C207, Sunbury South PSP 74 submission summary and associated submissions;

I was also able to review the following documents, sourced from the EPA website:

- Cardno Victoria Pty Ltd, Environmental Audit of Landfill Operations, 600 Sunbury Road, Bulla VIC 3428 (CARMS 61707-10), September 2015 (Operations Audit report, 2015).

- GHD Pty Ltd, Part B Construction Environmental Audit, Bulla Landfill Cell 2 Western Extension (CARMS 61707-11_b), February 2016.
- GHD Pty Ltd, Part C Construction Environmental Audit, Bulla Landfill Cell 2 Western Extension (CARMS 61707-11_c), February 2016.

Copies of the following documents were provided to me, through HA, by HQQP:

- Cardno Victoria Pty Ltd, Groundwater and Landfill Gas Bore Installation Program (V161499Report 01.1), December 2016.
- GHD Pty Ltd, Risk Assessment and Monitoring Program Update, Hi-Quality Landfill, Sunbury, January 2017.
- Lane Piper Pty Ltd, Daameeli Geological Summary & Figures, July 2011.

2.2 Site Inspection

On 8 August 2017, I was provided with the opportunity to conduct an inspection of the site. I met with Mr Lance Ingrams, Divisional Business Development and Planning Manager for HQQP and Mr Richard Strates of Dominion Property Group who assists HQQP with management of environmental issues at the site.

Messers Ingrams and Strates were able to confirm the status of landfill cell development, EPA licence amendments, proposed site infrastructure works, environmental assessment and auditing works currently in progress and provide background information on the site setting and surrounds. They also took me on a tour of the site, which provided me with an indication of the geology beneath the site and general context of the landfill within the surrounding landscape.

During our discussions, we identified some recently completed consultant's reports which would be helpful in forming an opinion in relation to landfill gas risk around the site (refer to **Section 2.1**).

2.3 EPA Licence

The EPA Licence for the site (Licence No.: 45279, last amended 10 April 2017) permits disposal of the following waste categories in landfill cells at the site:

- Prescribed industrial waste (PIW) including Category C drilling mud and Category C Soil.
- Solid inert waste.
- Asbestos and materials with polychlorinated biphenyls (PCBs).

I understood that approval to dispose of Solid Inert Waste was given for the HQQP Landfill in 2016. Prior to that time, with the exception of waste from the 2010 bushfires, waste placed in landfill cells at the site consisted of PIW, asbestos and materials with PCBs.

The EPA Licence includes the currently approved layout of landfill cells (Schedule 1B) and the pre-settlement contours (Schedule 1C), which would form the subgrade level for the landfill cap to be progressively installed over the landfill cells.

The landfill cell layout presented in the EPA Licence was used in the preparation of **Figures 1** and **2**. Pre-settlement contours in Schedule 1C of the EPA Licence were used in the preparation of the conceptual cross section in **Figure 2**.

2.4 Operations Audits

I obtained a copy of the Operations Audit report 2015 for the HQQP Landfill, prepared by Mr Anthony Lane of Cardno, from the EPA website. I understand from Lance Ingrams that the 2015 report is the most recent Operations Audit report for the HQQP Landfill.

At that time, Mr Lane was unable to form an opinion in terms of landfill gas risk and recommended the installation of additional landfill gas and groundwater monitoring wells to provide a more comprehensive monitoring network.

Additional landfill gas and groundwater monitoring wells were installed during 2016 and are documented in a Cardno report (Cardno, 2016).

Mr John Nolan has been appointed by HQQP to replace Mr Lane as the Operations Auditor for the HQQP Landfill. I understand that Mr Nolan is currently conducting the 2017 Operations Audit and his report is due later this year.

I understand the scope of the 2017 Operations Audit includes review and verification of the GHD report titled Risk Assessment and Monitoring Program Update. HQQP provided me with a copy of this report through HA.

Landfill gas monitoring data was not included in the reports available to me in forming this opinion.

In its report, GHD assessed the current landfill gas risk of subsurface migration and potential for impacts on beneficial use of land, risk to human health, to be “medium”. The risk ranking of “medium” for Item 7.2a Landfill Gas Management in the Risk Register (Appendix A of GHD, 2017) included the following comment:

- *“…increased consequence with respect to potential migration to underground services and uncertainty (no current monitoring results)”.*

2.5 Construction Audit

I obtained a copy of the Construction Environmental Audit for the Cell 2 Western Extension, prepared by Mr Peter Egberts of GHD. The Construction Audit report documents the as-built elevations of the basal liner for the first cell constructed as part of the Western Extension of the northern landfill cell development.

I was informed by Mr Ingrams that the intention for the design of the westernmost cell will be to extend the basal liner from the existing cell at a 3% slope up to the western margin of the landfill.

The landfill cell construction details and the information provided by Mr Ingrams were used to develop the conceptual cross section (A – A’) included in **Figure 2**.

During my site inspection, basalt rock of the Older Volcanics had been excavated to produce quarry product from the area to be covered by the westernmost cell in the northern landfill development (refer to **Figure 2**). Basalt of the Older Volcanics Formation was present in the floor and walls of the excavation. The depth of the excavation during my inspection was approximately 4 m to 5 m.

I understand from Mr Ingrams that rock may be removed to a greater depth in the area beneath the future landfill cell. Excavation of basalt over this area would necessitate placement of fill into the excavation to form a subgrade for the westernmost landfill cell consistent with a 3% grade leading up to the western limit of the cells.

2.6 Proposed Stormwater Drainage

During my site inspection, Mr Ingrams informed me that a stormwater drainage feature is proposed to direct stormwater entering the HQQP premises from the southwest, north along the western boundary of the premises to Emu Creek. The approximate alignment of the stormwater drain, as I understand it, is shown in **Figures 1** and **2**.

A conceptual design, prepared by Alluvium, was shown to me onsite which indicated the drainage feature would be an open drain, excavated into the existing surface along the western boundary of the premises adjacent to the northern cell development (refer to **Figure 2**). Buried stormwater pipes were not part of the conceptual design.

I understand the approximate alignment of the stormwater drain is also shown on Plan 3 of Amendment C207 (refer to **Appendix A**). However, I was informed by Mr Ingram that the alignment shown in Plan 3 may change somewhat.

2.7 Site Geology

HQQP provided me with a copy of a report prepared by Lane Piper, dated July 2011, which summarises the site geology. My understanding of the geology of the site is based on the Lane Piper report, the Cardno Bore Installation report (Cardno, 2016) and observations during the site visit.

As indicated in the Lane Piper report, the geology of the site is complicated, involving fill and six geological formations of varying extent and thickness across the site. The geology is further complicated by quarrying activities.

In general terms, the geological sequence beneath the site consists of the following formations, from youngest (uppermost) to oldest (lowermost):

- Quaternary Alluvium.
- Quaternary Newer Volcanics.
- Tertiary Brighton Group.
- Tertiary Older Volcanics.
- Tertiary Werribee Formation.
- Ordovician Dargile Formation.

As indicated in the Lane Piper report, quarrying activities within the footprint of the southern landfill cell development currently extend down through the Tertiary Older Volcanics into the underlying Werribee Formation. Quarrying within the footprint of the northern landfill cell development currently involves removal of basalt of the Tertiary Older Volcanics.

The most critical area to understand the geology of the site and surrounds, with respect to understanding landfill gas risk associated with Amendment C207, is beneath and west of the northern landfill cell development. Formations present west of the landfill represent the potential pathways for subsurface migration of landfill gas toward the proposed sensitive uses.

Geology to the east of the northern cell development and around the southern cell development is reasonably well defined by borehole information. The area west of the northern cell development is not well understood.

A conceptual cross section showing the potential lithological sequence around the northern cell development (Section A - A' shown on **Figure 1**) is presented in **Figure 2**.

Based on borehole logs and observations during my site inspection, the following can be stated with some confidence in relation to the area west of the northern cell development:

- Basalt of the Tertiary Older Volcanics outcrops at the surface beneath the northern cell development.
- The landform and geological mapping suggest that clay rich soil of the Newer Volcanics outcrop on the surface of the plateau west of the HQQP Landfill, the area proposed for re-zoning to sensitive uses.

The clay-rich soil of the Newer Volcanics present on the surface of the plateau west of the HQQP Landfill is presumably underlain by an unknown thickness of basalt rock. Typically, the break in slope around the edges of such plateaus approximate the extent of the Newer Volcanics. Formations outcropping in the steeper slopes around the plateaus are generally comprised of material which more easily erodes, such as the Brighton Group.

The break in slope west of the northern cell development occurs at an elevation of approximately 198 m AHD and approximately 187 m AHD southwest of the southern cell development (refer to **Figures 1** and **3**).

Based on information available to me, there is no clear evidence of the formations outcropping in the slope rising from the northern cell development, west toward the area proposed for re-zoning to residential use.

It should also be noted that the Sunbury Geology map suggests an area of Quaternary Alluvium, not shown in **Figure 2**, may be present along the western boundary of the northern cell development.

3.0 Relevant Guidance and Assessment Methodology

3.1 Landfill Gas Hazards

The primary risks associated with subsurface migration of landfill gas from a landfill typically assessed as part of a landfill gas risk assessment and of relevance to Landfill Buffers are as follows:

- Risks to human health including:
  - Potential explosion and fire hazards associated with accumulation of methane at concentrations at or above 20% of the lower explosive limit (i.e. 1% methane v/v) on-site or beneath surrounding properties.
  - Potential asphyxiation associated with oxygen exclusion by major components of landfill gas (i.e. methane and carbon dioxide) within confined spaces on-site or on surrounding properties.
  - Exposure to toxic vapours of trace chemicals.
- Risks to vegetation and other elements of ecosystems on surrounding land.

3.2 Regulatory Guidance on Landfill Buffers

The primary source of regulatory guidance in relation to Landfill Buffers is EPA Publication No. 788.3 the Best Practice Environmental Management – Siting, Design, Operation and Rehabilitation of Landfills (the Landfill BPEM), dated August 2015. Key elements of the EPA guidance in the Landfill BPEM relating to landfill buffers are summarised as follows:

- Buffer distances are intended to protect sensitive uses surrounding a landfill from *"…any impacts resulting from a failure of landfill design or management or abnormal weather conditions.*" As such, the buffers must be protective of "upset" conditions that may arise from poor practices rather than risk associated with sound engineering and management practices.
- The buffers should consider landfill gas impacts including those hazards summarised in **Section 3.1**.
- Buffers should be measured from the sensitive land use to the edge of the closest landfill cell.
- For a municipal (putrescible) waste landfill (Type 2 landfill) (refer to Table 5.1 in the Landfill BPEM) the required buffer distance with respect to landfill gas is 500 metres for a minimum of 30 years post-closure.
- For a solid inert waste landfill (Type 3 landfill) (refer to Table 5.1 in the landfill BPEM) the required buffer distance with respect to landfill gas is 200 metres for a minimum of 30 years post-closure.
- "*Subject to an evaluation demonstrating that the environment will be protected and amenity of the sensitive areas will not be adversely affected, lesser buffer distances may be applied subject to a risk assessment that considers design and operational measures*."
- All buildings and structures should be considered, including;
  - Buildings and structures used for sensitive or non-sensitive uses.
  - Change of use.
  - Infrastructure installation.
  - Installation of pipelines.

- Where a proposed development, or planning scheme amendment, would have the effect of encroaching into the landfill buffers, the responsible authority should require an environmental audit under Section 53V of the Environment Protection Act. Where a responsible authority has "…relevant and sufficient information from previous assessments or audits, this may be relied on in making a decision."

Although not detailed in current EPA guidance, varying the required landfill buffers has been accepted by EPA based on a well-supported assessment of landfill gas risk. Appropriate landfill gas risk assessments should be based on a conceptual site model (CSM) supported by sufficient relevant monitoring data.

3.3 Conceptual Site Model

A CSM considers the linkages associated with off-site sub-surface lateral migration of landfill gas. A CSM is a representation of the complex relationship between the contaminant sources, pathways and receptors, i.e. pollution linkages.

Development of a CSM requires assessment of the key elements of the model including the following:

- The nature, extent, age and moisture content of waste potentially acting as a source of landfill gas and, in particular, methane and carbon dioxide.
- Engineering controls surrounding waste sources such as landfill liners, capping and gas mitigation structures.
- The environmental setting of the site including the topography, geology and hydrogeology of the site and surrounds.
- Proximity of potential receptors with respect to landfill gas hazards.
- Potential subsurface pathways for landfill gas migration including: more gas permeable geological features (e.g. sand layers and fracture zones), poorly compacted or granular fill and subsurface infrastructure (e.g. drains and granular backfill around pipelines).
- The presence, and concentrations, of methane and carbon dioxide in waste and in the subsurface along potential pathways from waste to sensitive receptors.
- Potential pressure gradients that may drive subsurface movement of landfill gas. Factors affecting the development of vapour pressure gradients in the subsurface include:
    - Landfill gas generation rates.
    - The effectiveness of natural formations, landfill liner and cap to confine landfill gas.
    - Water table or leachate level fluctuations in or around the landfill.
    - Rainfall events saturating capping layers and/or causing wetting fronts to migrate downwards through waste layers.
    - Changes in atmospheric pressure conditions.
- Evidence that potential source-pathway-receptors linkages may be complete.

My assessment of aspects of the CSM for landfill buffers around the HQQP landfill is summarised in the following sections.

3.3.1 Nature of the Waste

The HQQP Landfill is defined as a Type 2 landfill in the EPA Licence on the basis that it receives PIW, asbestos and material containing PCBs. However, the 500 m landfill buffer required for Type 2 landfills in the Landfill BPEM is relevant to putrescible wastes, which are the waste stream most likely to produce significant volumes of methane and carbon dioxide. The Type 2 wastes disposed at the HQQP landfill are likely to generate less methane and carbon dioxide than solid inert waste.

On the basis that the waste stream received at the HQQP Landfill most likely to generate methane and carbon dioxide, the key drivers of explosion, fire and asphyxiation hazards, is solid inert waste, I believe the landfill is more appropriately considered a Type 3 landfill in terms of landfill gas risk.

In my opinion the landfill buffer for a Type 3 landfill, 200 m, is a more appropriate starting point for application to the HQQP Landfill.

The chemical concentration criteria for Category C soils places limits on the likely maximum concentrations of volatile chemicals in waste placed in the HQQP Landfill. In my opinion, the Type 3 landfill buffers are likely to be a sufficiently conservative starting point for migration of trace organic chemical vapours at the HQQP Landfill.

3.3.2 Extent of Waste

The lateral extent of waste at the HQQP Landfill appears well defined in the EPA Licence and the detailed designs being prepared for landfill cell construction. As such, the starting point for buffer measurement is well defined, refer to **Figures 1** and **2**.

The placement of waste in the landfill is generally on the surface of the site rather than within a quarry. Side-lining systems will be required on the eastern side of landfill cells in the northern and southern development areas. Based on my current understanding of cell development, sideliners against natural formations will not be required on the western side of the cell developments.

Waste not being placed against natural formations on the western side of the landfill should significantly reduce the risk of subsurface migration.

3.3.3 Engineering Controls

The minimum lining systems for existing cells in the HQQP Landfill are understood to consist of 1 m of compacted clay liner (CCL). Cells more recently constructed comprise multiple low permeability liner layers of CCL, geosynthetic clay liners (GCL) and geomembrane, consistent with Type 2 landfill requirements under the Landfill BPEM.

Type 2 lining systems represent a high level of engineering control under the Victorian regulatory system. If no other Type 2 wastes are disposed to a landfill, Type 2 lining systems are a requirement for landfills receiving putrescible waste rather than solid inert waste.

I assume that application of the requirement for a Type 2 lining system at the HQQP Landfill was for protection of groundwater quality associated with trace contaminants in PIW wastes rather than control of landfill gas.

It is reasonable to assume that EPA will require future cells to be lined with similar Type 2 lining systems and a capping system consistent with those requirements.

No specific landfill gas controls appear to have been incorporated in the landfill infrastructure to date. Implementation of landfill gas controls can significantly mitigate risk of off-site migration in the subsurface.

Landfill gas controls may involve means of reducing gas pressures within the waste or intercept landfill gas migrating between the landfill and sensitive receptors. Landfill gas controls that may potentially be installed at the HQQP Landfill include:

- Passive landfill gas venting systems beneath the landfill cap.
- Interceptions systems around the margins of the landfill cells.
- Active landfill gas extraction systems.

Passive Landfill Gas Venting Beneath Caps

Passive landfill gas venting systems beneath landfill caps are currently optional under EPA regulations.

In my opinion, passive venting systems should be installed beneath any landfill cap for a putrescible or solid inert waste landfill capped with a system consistent with the indicative designs for Type 2 and 3 landfills (refer to Table 8.1 of the Landfill BPEM). Passive venting systems assist in providing a safe working environment during construction of capping systems (e.g. risk of fire and explosion during geomembrane welding activities) and controlling build-up of landfill gas pressures within the waste. Build-up of landfill gas pressures in the waste can cause slope failures due to “whaling” of low permeability layers (e.g. geomembrane) and increase risk of off-site migration of landfill gas in the subsurface.

Landfill Gas Interception Systems

Typically, landfill gas interceptions systems involve installation of bores or trenches to vent gas to atmosphere and/or low gas permeable barriers in potential pathways for off-site, subsurface migration.

An example of a landfill gas interception system that could be installed at the HQQP Landfill, with the potential to significantly reduce landfill buffers, would be to backfill the western side of the excavation beneath the future landfill cell on the western boundary with a permeable material (e.g. basalt screenings). A high permeability trench would allow landfill gas moving into the Older Volcanics beneath the landfill to vent to atmosphere before it crossed the site boundary (refer to **Figure 2**).

Active Landfill Gas Extraction

Provided other landfill gas risks are effectively managed, active landfill gas extraction systems are only required at a landfill where sufficient gas is generated to represent a commercially viable energy resource. Typically, the primary objective of active extraction systems is to generate power and management of off-site emissions is a secondary objective.

3.3.4 Potential Pathways and Receptors

Key sensitive receptors include buildings and structures that may be constructed on land west of the HQQP Landfill proposed for re-zoning for sensitive uses (i.e. residential and industrial). The sensitive use zones are located on the plateau landform west and southwest of the HQQP Landfill.

Typical potential pathways for landfill gas migration include more gas permeable layers within the natural formations, loosely compacted fill and porous backfill around underground services. Elements of potential pathways from the source, waste in cells, to sensitive receptors west of the HQQP Landfill are illustrated in **Figure 2**.

The more gas permeable formations that may be present west of the HQQP Landfill include:

- Fractures and joints in the basalt of the Older Volcanics.
- Sand and gravel layers in the Brighton Group.
- Fractures and joints in the basalt of the Newer Volcanics.
- Sand and gravels in Quaternary Alluvium.
- Loosely compacted fill.

Conversely, there may be multiple fine grained, clay-rich, materials in the subsurface which would retard landfill gas migration. The presence of gas permeable and retarding layers has yet to be confirmed west of the HQQP Landfill along the key pathways of concern.

I note that the surface soils on the plateaus west of the HQQP Landfill are more likely to consist of highly plastic clays. Typically, the clay soils will extend to approximately 1.5 m to 3.0 m below the ground surface. As such, they may retard potential gas migration into on-ground buildings and structures.

3.3.5 Landfill Gas Data

No documented landfill gas monitoring data were available for my review.

During my site inspection, Mr Lance Ingrams indicated that his recollection was that results of the first round of landfill gas monitoring did not detect methane in any bores installed around the landfill and the only methane detected, approximately 10%, was in bores installed in the waste.

If correct, the methane levels in waste are low for a landfill receiving solid inert waste and consistent with a landfill which has received predominantly PIW to date. However, it is noted that the HQQP Landfill is now receiving solid inert waste and that waste will presumably be placed in the westernmost cells. Consequently, it is reasonable to expect that methane and carbon dioxide concentrations in the waste will increase over time.

3.3.6 Landfill Gas Pressures

No documented data on gas pressures in the waste were available for my review.

Build-up of landfill gas pressures in waste is a key driver for off-site migration of landfill gas in the event of a failure in lining systems. If waste is contained within high quality liner and capping systems without landfill gas extraction or passive venting structures, significant gas pressures can develop.

Given the relatively high standard of engineering control likely to be incorporated in basal lining and capping systems in future cells, it would not be unreasonable to expect significant landfill gas pressures to build up in the waste in future cells.

It is also likely that the highest gas pressures develop after the landfill has been capped. Based on my understanding of timing, the northern cell development will not be completed for 8 to 10 years.

4.0 Opinion on Landfill Gas Buffers

4.1 Summary of Opinion

I recommend that uses within the landfill buffer should be limited to “informal outdoor recreation.”

Any buildings and structures installed within the landfill buffer must include engineering controls (vapour barriers and ventilation layers) designed by an appropriately qualified person.

Any underground services constructed within the buffer must include engineering controls to avoid the infrastructure, and trenches in which they are installed, acting as pathways for landfill gas migration.

My recommendation on the extent of landfill buffers in relation to subsurface migration of landfill gas is presented in **Figure 3**.

Based on the nature of waste in the HQQP Landfill I believe it is prudent to adopt the landfill buffer distance of 200 m required for Type 3 landfills as a starting point. The waste type with the greatest potential to generate methane and carbon dioxide in the HQQP Landfill is solid inert waste, which is defined as a Type 3 waste material in the Landfill BPEM.

The extent of the landfill buffer is based on the 200 m buffer distances required for Type 3 landfills with the following modifications:

Toward Sensitive Use Zoning West of the HQQP Landfill

In my opinion, the most critical pathways for potential landfill gas migration are:

1) from the northern cell development, west toward an area proposed for residential re-zoning (refer to the alignment of Section A – A’ shown on **Figure 1**), and
2) from the southern cell development, southwest toward an area proposed for industrial use.

I am recommending that the landfill buffer in these directions extend beyond the required 200 m buffer to approximately 50 m beyond the break in slope at the margins of the plateaus, where sensitive uses will be located under Amendment C207. I have assumed the 198 m AHD contour line and 187 m AHD contour line represent the margins of the western and southwestern plateaus respectively (refer to **Figure 3**). The maximum extent of the landfill buffers in this direction would be approximately 315 m from landfill cells.

The recommended landfill buffers would cover the slopes below the plateaus where the geology is not well understood and should ensure buildings and structures associated with residential, commercial and industrial zones will be constructed on the clay-rich soils of the Newer Volcanics.

Regardless of the uncertainty associated with the geology in these areas, I think it is a reasonably conservative assumption that any subsurface migration of landfill gas from the HQQP landfill is likely to discharge to atmosphere on the slopes beneath the plateau rather than migrate significantly beyond recommended buffers beneath the plateaus.

Informal outdoor recreational use along the margins of the plateau overlooking the HQQP Landfill would, in my opinion, be a compatible use of that land.

In the unlikely event of “upset” conditions arising, vacant land at the top of the plateau would allow the licence holder for the landfill and EPA to more easily implement contingency measures between the landfill and sensitive receptors.

Emu Creek

Where Emu Creek is located closer than 200 m from landfill cells, I am recommending a reduced buffer distance on the basis that the elevation of the creek is well below the base of waste in the landfill. As such, any subsurface migration of landfill gas through formations surrounding the waste is likely to discharge to atmosphere in the slope well above the banks of Emu Creek.

Slopes East of the Landfill

Similar to a reduced buffer for Emu Creek, I have recommended the buffer on the eastern side of the landfill follow an elevation contour approximately 10 m below the base of landfill cells.

4.2 Applicability of Clause 3.8

In considering the landfill buffers, I have attempted to apply a conservative approach to assessing areas which may be impacted by extreme “upset” circumstances based on information currently available to me.

I have also been mindful that landfill buffers significantly limit the use of land to which they are applied and should not be applied in an overly conservative manner.

I am also mindful of the somewhat unrealistic expectations that **Clause 3.8** places on a proponent for a development on property surrounding the landfill. In particular, expecting a party associated with a surrounding property to be able to have access to sufficient information to form an opinion on landfill gas risk from a nearby landfill.

In my opinion, the only way to conduct a landfill gas risk assessment around a landfill, without having to default to conservative engineering controls, is to base the assessment on detailed data of the geology and landfill gas conditions at the landfill and the area between the landfill and development site (i.e. a CSM).

There is currently no assured access to reliable information relating to landfill gas risk at a landfill for parties involved in surrounding properties. The current status of information available through the Operations Audit process at the HQQP Landfill is a clear example of the limitations of information available to surrounding property owners. My experience is that a similar situation would exist at the vast majority of operating and former landfills in Victoria.

Consequently, a proponent for development on a surrounding property within a landfill buffer will be required to complete an investigation, which will provide unreliable results in terms of potential “upset” conditions at the landfill site, or default to installation of engineering controls such as vapour barrier and ventilation layers.

In making my recommendations regarding landfill buffers I have attempted to apply buffers that would not unnecessarily require proponents of surrounding development to undertake landfill gas risk assessments or unnecessarily install engineering controls.

I believe an onus should be placed on the Licence Holder for the landfill and the EPA to make data relevant to landfill gas risk more available and to regularly review the appropriateness of the landfill buffers. Both these objectives could be achieved by including assessment of appropriateness of landfill gas buffers in the scope of Operations Audits for operating landfills and environmental audits of closed landfills.

I have also made a recommendation for inclusion of a condition in UGZ9 allowing the landfill buffers to be amended (refer to **Section 4.3.2**) when more relevant information is available.

4.3 Suggested Amendments to UGZ9

4.3.1 Clauses 2.4 and 2.8

Inclusion of Underground Services

I believe Clause 3.8 should apply to planning applications that involve any building or structure within the Landfill Buffers. Basements and pits should be particularly highlighted in **Clause 2.8** as structures of concern in relation to landfill gas risk.

Structures to which Clause 3.8 apply should include any subsurface infrastructure such as pits, drains, water mains, sewers, power lines, communications cables. Subsurface infrastructure can represent a pathway for migration of landfill gas beyond the landfill buffer to sensitive receptors. Engineering controls should be incorporated into underground infrastructure to mitigate the infrastructure, or backfill in the trenches containing the infrastructure, acting as pathways for landfill gas migration.

Based on the above, I recommend that **Clause 2.8** is amended to include the requirement for a permit for works associated with underground services within the Landfill Buffer in relation to their potential to act as preferential pathways for migration and accumulation of landfill gas including:

- stormwater drains;
- pits;
- water mains;
- sewers;
- power lines; and
- communications cables.

Informal Outdoor Recreation

I recommend removal of “informal outdoor recreation” from the list of uses in **Clause 2.4** of UGZ9 for which the Landfill Buffer (Clause 3.8) would apply. It is my experience that public open space is an appropriate land use within Landfill Buffers.

I make this recommendation on the assumption “informal outdoor recreation” would not typically involve construction of a building or structure of some kind and would not require installation of underground services or structures. I assume that the previous recommendations for an amendment to **Clause 2.4** would address this issue.

4.3.2 Future Revision of Landfill Buffers

Based on the information available, I have had to take a conservative approach in recommending landfill buffers at this time. Availability of additional information and detailed understanding of engineering and management controls to be implemented post-closure of the landfill may allow significant reductions in the landfill buffer distances.

I recommend that a condition is added to the planning scheme which allows the landfill buffer to be reduced by the planning authority based on the following:

- The responsible authority may review the landfill buffers based on the findings of a 53V (risk of harm) audit and in consultation with the Environment Protection Authority.

5.0 Statement and Limitations

In preparing this opinion, I have made all inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant to my knowledge have been withheld from the Panel.

My opinion presented in this report is qualified by the following limitations and uncertainties:

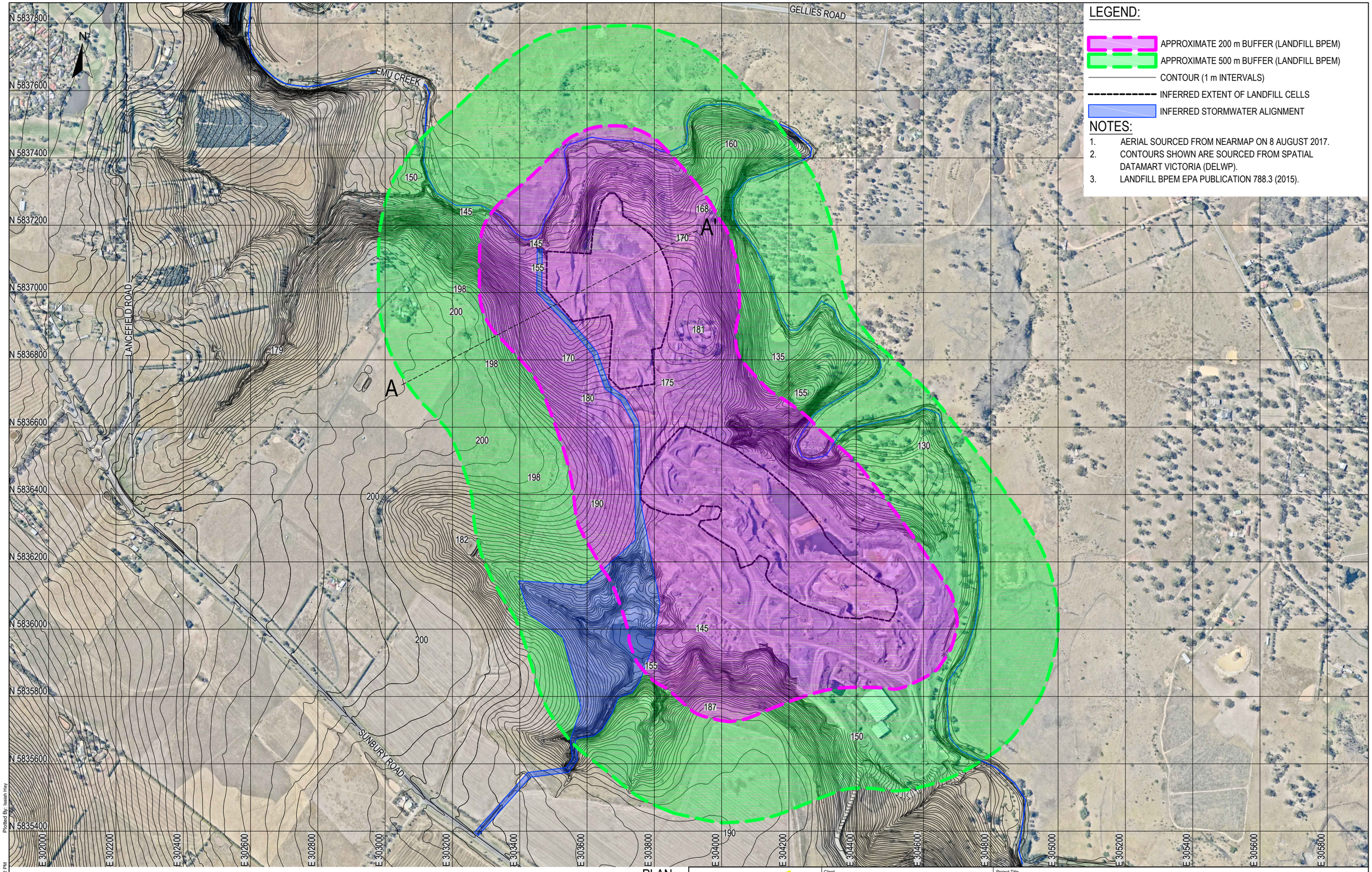
- Information was provided to me by VPA and HQQP at the time of preparation of this opinion. Additional information relating to landfill gas risk that may by gathered or be provided to VPA may materially change my opinion regarding the landfill buffers.
- I am an environmental auditor appointed by the EPA but I have not conducted a statutory audit of landfill gas risk, as recommended in the Landfill BPEM. This report represents my opinion based on experience in assessing landfill gas risk around landfill sites.

6.0 References

EPA Victoria. (2015). Siting, design, operation and rehabilitation of landfills Publication 788.3. Melbourne: EPA Victoria.

EPA Victoria. (2016). Landfill Licensing Guidelines Publication 1323.3. Melbourne: EPA Victoria.

Figures



LEGEND:

- APPROXIMATE 200 m BUFFER (LANDFILL BPEM)
- APPROXIMATE 500 m BUFFER (LANDFILL BPEM)
- CONTOUR (1 m INTERVALS)
- INFERRED EXTENT OF LANDFILL CELLS
- INFERRED STORMWATER ALIGNMENT

NOTES:

1. AERIAL SOURCED FROM NEARMAP ON 8 AUGUST 2017.
2. CONTOURS SHOWN ARE SOURCED FROM SPATIAL DATAMART VICTORIA (DELWP).
3. LANDFILL BPEM EPA PUBLICATION 788.3 (2015).

PLAN

SCALE 1:10000

0 100 200 300m

SCALE 1:10000 AT ORIGINAL SIZE

THIS DRAWING IS TO BE PRINTED IN COLOUR. IF THIS DRAWING IS NOT PRINTED IN COLOUR THEN YOU DO NOT HAVE THE CORRECT VERSION. THIS NOTE IS RED.

senversa
Address: Level 6, 15 William Street Melbourne Victoria 3000
Phone: (03) 9606 0070
Website: www.senversa.com.au

Client: VICTORIAN PLANNING AUTHORITY

Project Title: EXPERT OPINION ON LANDFILL GAS
HUME PLANNING SCHEME AMENDMENT C207: SUNBURY SOUTH

Figure Title: LANDFILL CELL LAYOUT AND LANDFILL BPEM BUFFERS

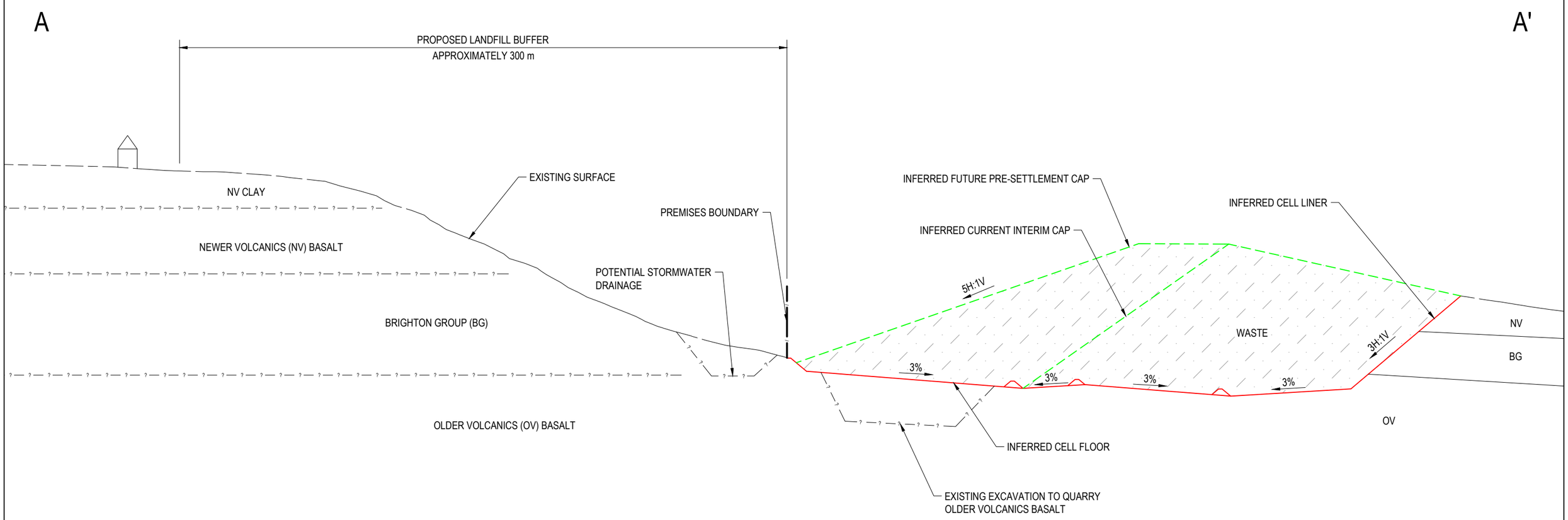
Reviewed	P. CLARKE	Drawn	I. HAY				
Approved	P. CLARKE	Date	11.08.2017	A3	Scale AS SHOWN	File No M13556_002_F001	Figure No 1	Rev 0

Plotted By: Isaiah Hay
Plot Date: 11 August 2017 - 2:41:32 PM

File location: Y:\09_Jobs\3.VIC_Jobs\M13556_VPA_BULLA_TECH ADVICE\5_Dwgs_Figs\1_CADD\M13556_002_F001.dwg

NOTES:

1. INFERRED PRE-SETTLEMENT CAP LEVELS SHOWN ARE FROM GHD PTY LTD SKETCH 4 DATED JUNE 2015 PRESENTED IN CARDNO VICTORIA PTY LTD REPORT TITLED "ENVIRONMENTAL AUDIT OF LANDFILL OPERATIONS, 600 SUNBURY ROAD, BULLA VIC 3428" DATED SEPTEMBER 2015.
2. INFERRED CONTOURS OF THE EXISTING SURFACE SHOWN ARE SOURCED FROM SPATIAL DATAMART VICTORIA (DELWP).
3. INFERRED CELL FLOOR LEVELS SHOWN ARE BASED ON THE WESTERN EXTENSION DESIGN DRAWINGS PREPARED BY GHD PTY LTD DATED 25 MARCH 2015.



SECTION A
HORIZONTAL 1:2000
VERTICAL 1:800
F001

24m
16
8
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SCALE 1:800 AT ORIGINAL SIZE

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

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Plotted By: Isaiah Hay
Plot Date: 11 August 2017 - 2:41:34 PM

File location: Y:\09_Jobs\3.VIC_Jobs\M13556_VPA_BULLA_TECH ADVICE\5_Dwgs_Figs\1_CADD\M13556_002_F002.dwg

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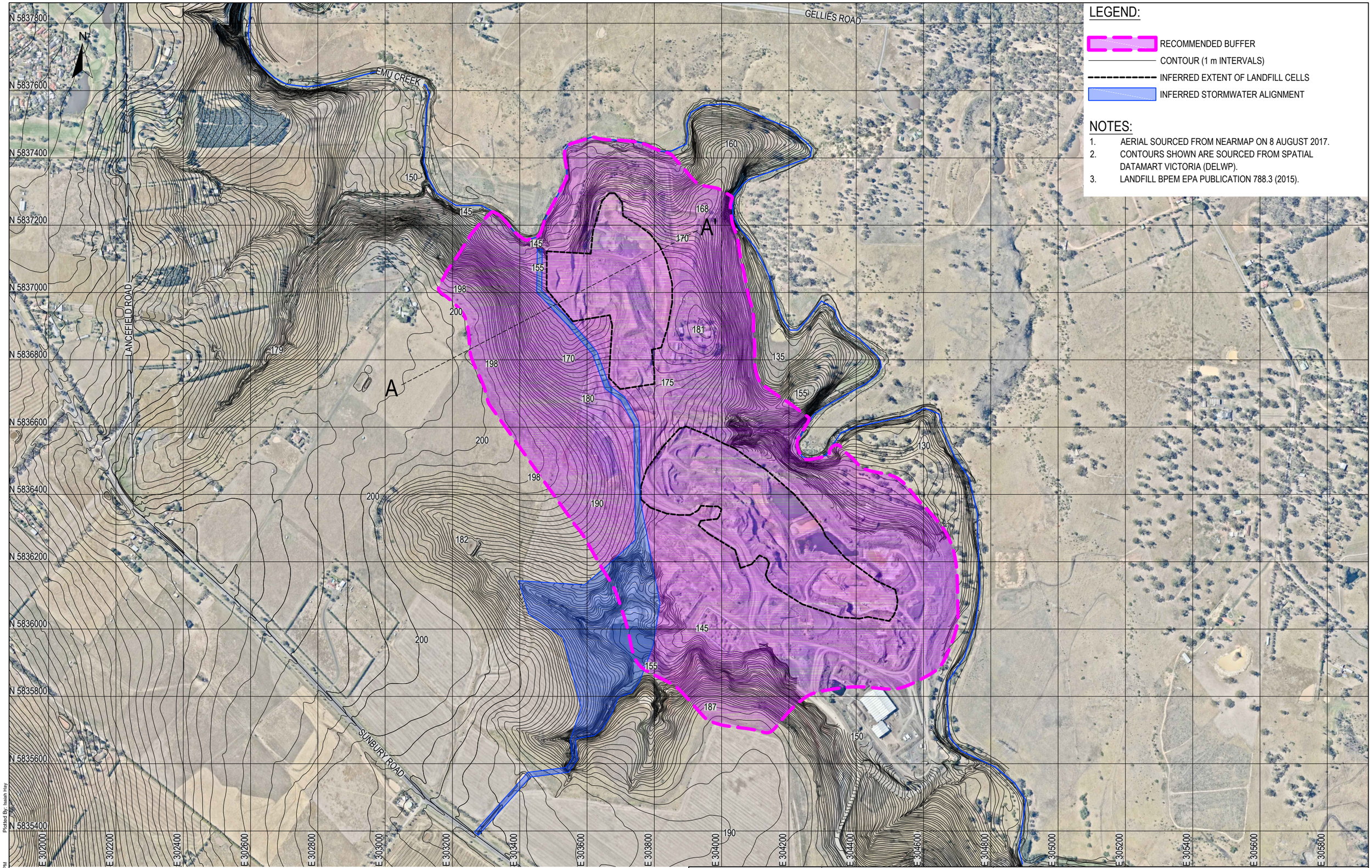
Client: VICTORIAN PLANNING AUTHORITY

Project Title: EXPERT OPINION ON LANDFILL GAS
HUME PLANNING SCHEME AMENDMENT C207: SUNBURY SOUTH

Figure Title: CONCEPTUAL CROSS SECTION

Reviewed	P. CLARKE	Drawn	I. HAY				
Approved	P. CLARKE	Date	11.08.2017	A3	Scale AS SHOWN	File No M13556_002_F002	Figure No 2	Rev 0



LEGEND:

- RECOMMENDED BUFFER
- CONTOUR (1 m INTERVALS)
- INFERRED EXTENT OF LANDFILL CELLS
- INFERRED STORMWATER ALIGNMENT

NOTES:

1. AERIAL SOURCED FROM NEARMAP ON 8 AUGUST 2017.
2. CONTOURS SHOWN ARE SOURCED FROM SPATIAL DATAMART VICTORIA (DELWP).
3. LANDFILL BPEM EPA PUBLICATION 788.3 (2015).

PLAN
SCALE 1:10000

0 100 200 300m
SCALE 1:10000 AT ORIGINAL SIZE

THIS DRAWING IS TO BE PRINTED IN COLOUR. IF THIS DRAWING IS NOT PRINTED IN COLOUR THEN YOU DO NOT HAVE THE CORRECT VERSION. THIS NOTE IS RED.

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Client: VICTORIAN PLANNING AUTHORITY

Project Title: EXPERT OPINION ON LANDFILL GAS
HUME PLANNING SCHEME AMENDMENT C207: SUNBURY SOUTH

Figure Title: RECOMMENDED BUFFER

Reviewed	P. CLARKE	Drawn	I. HAY				
Approved	P. CLARKE	Date	11.08.2017	A3	Scale AS SHOWN	File No M13556_002_F003	Figure No 3	Rev 0

Plotted By: Isaiah Hay
Plot Date: 11 August 2017 - 2:41:38 PM

File location: Y:\09_Jobs\3.VIC_Jobs\M13556_VPA_BULLA_TECH ADVICE\5_Dwgs_Figs\1_CADD\M13556_002_F003.dwg

Appendix A: Plan 3 from Amendment C207

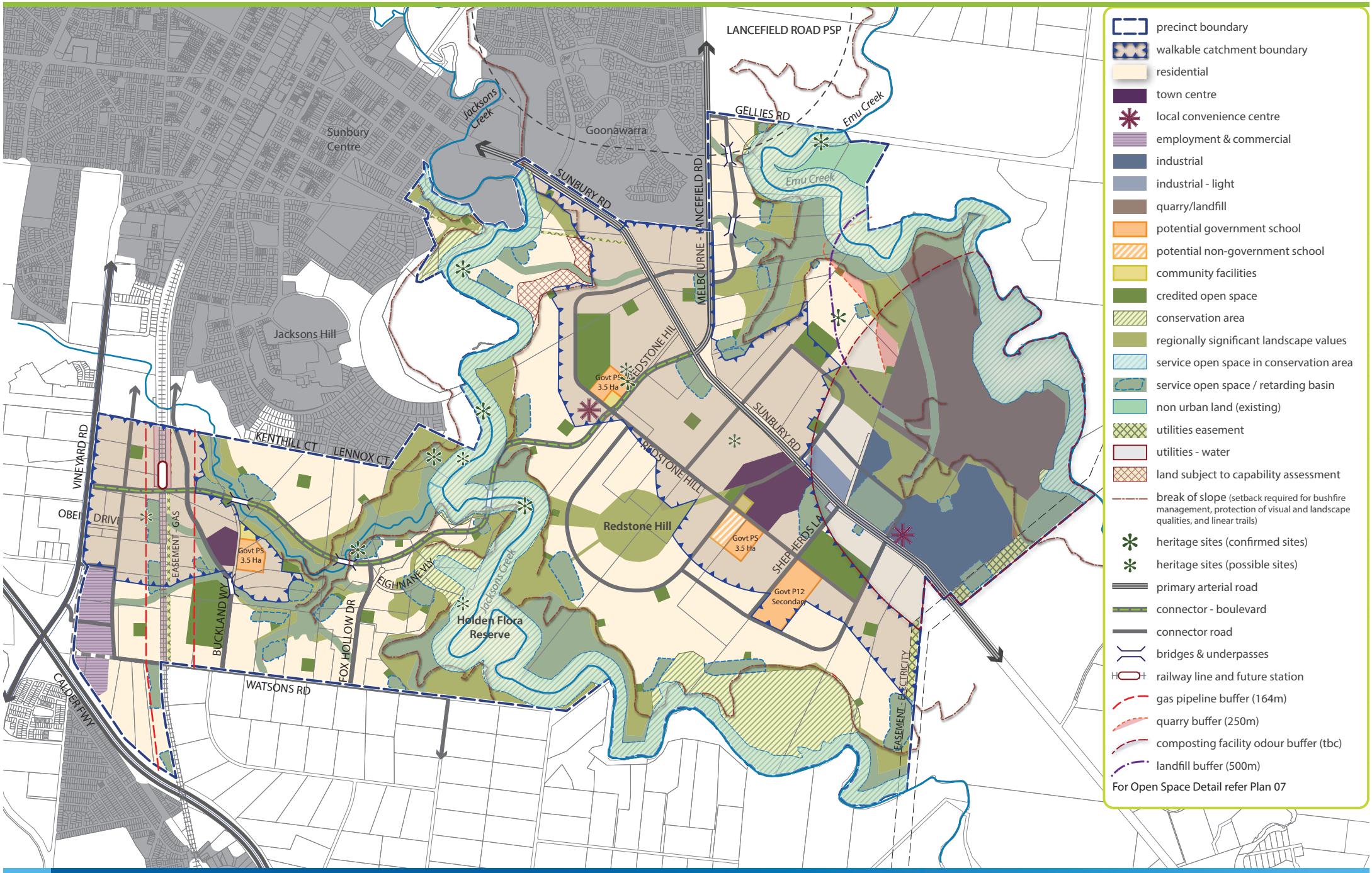
Plan 3 - Future Urban Structure

Sunbury South Precinct Structure Plan

1:32,000 @ A4

0 300 600 900 1,200 1,500m

N



Appendix B: Brief from Harwood Andrews

HARWOOD ANDREWS

Our ref: 4TED 21702183
Contact: Tessa D'Abbs
Direct Line: 03 9611 0117
Direct Email: tdabbs@ha.legal
Principal: Greg Tobin

Level 5, 707 Collins Street
Melbourne VIC 3008

DX 30970

PO Box 633
Collins St West VIC 8007

T 03 9620 9399
F 03 9620 9288

ABN 98 076 868 034

harwoodandrews.com.au

10 July 2017

Patrick Clarke
Senversa

Email: patrick.clarke@senversa.com.au

Subject to legal professional privilege

Certified B Corporation

Dear Patrick,

Amendment C207 to the Hume Planning Scheme – Sunbury South PSP
Amendment C208 to the Hume Planning Scheme – Lancefield Road PSP

We act for the Victorian Planning Authority (**VPA**) in relation to the above two amendments, which propose to incorporate the Sunbury South PSP and Lancefield Road PSP into the Hume Planning Scheme.

The amendments are listed to be heard at a Panel hearing commencing on 21 August 2017, with the VPA appearing for five days in the first week.

We have been instructed to brief you to:

1. review this letter and the enclosed brief of documents;

2. advise if you are in a position to provide expert landfill buffer evidence on behalf of the VPA at the hearing:
    a. in support of the amendments as exhibited; or
    b. subject to any issues you consider should be addressed by way of post-exhibition changes; and

3. provide a fee proposal to prepare an expert witness statement and present evidence at the hearing.

We request that you maintain availability during the week of 21 August 2017 pending your consideration of the amendments and consideration of your fee proposal by the VPA.

The Panel has not yet issued directions regarding the circulation of expert evidence, but we anticipate this may be up to 7 business days prior to the hearing.

In the event you are instructed to prepare an expert witness statement, we have enclosed a copy of the Planning Panels Victoria Guide to Expert Evidence in your brief of documents.

Background

The VPA is the planning authority in respect of the amendments. The landfill buffer issue arises in relation to Amendment C207 and the Sunbury South PSP.

The Sunbury South PSP identifies a buffer of 500 metres for the landfill located at 570-600 Sunbury Road, Bulla, operated by Hi-Quality. Copies of the EPA licences for this landfill are included in your brief.

Schedule 9 to the Urban Growth Zone (**UGZ9**), exhibited as part of the Amendment, includes:

- Clause 2.2, which sets out the zones to apply in the PSP area, including within the landfill buffer; and
- Clauses 3.7 and 3.8, which relate to planning permit applications within the landfill buffer.

The VPA received 94 submissions in response to exhibition of the Sunbury South PSP and 93 submissions in response to exhibition of the Lancefield Road PSP. Of these, 52 submitters have requested to be heard at the Panel hearing. The hearing is anticipated to be scheduled for approximately 8 weeks.

The submissions of most relevance to your evidence are:

- No. 33 – Sustainability Victoria
- No. 61 – Hi-Quality
- No. 69 – Metropolitan Waste and Resource Recovery Group
- No. 82 – EPA Victoria

The VPA sought input from the EPA in preparing the PSPs for exhibition and has sought further comments from the EPA following exhibition. This further correspondence with the EPA is included in your brief.

We are instructed that the EPA indicated to the VPA at one stage that a 200 metre buffer may be appropriate to be applied to the landfill, although this is not reflected in its written comments.

Scope

You are requested to consider:

1. the appropriate extent of the landfill buffer having regard to your areas of expertise;
2. the planning controls proposed in UGZ9 to apply within the buffer, in particular the applied zones and Clauses 3.7 and 3.8;
3. how you would expect the landfill buffer to be implemented in practice; and
4. the submissions referred to the Panel in relation to the landfill buffer.

Brief

We have provided you with an electronic copy only of the brief of documents at this stage. Please advise if you would like us to provide you with a hard copy.

Your fees

We request that you send your fee proposal directly to the VPA, by email to Sarah McMaster at sarah.mcmaster@vpa.vic.gov.au, copied to Greg Tobin at gtobin@ha.legal and Tessa D'Abbs at tdabbs@ha.legal.

We confirm that you should not commence any substantive work on this matter until you have received confirmation that your fee proposal has been approved.

Our client will remain responsible for your fees. We require that any tax invoices be addressed to the VPA, by email to Sarah McMaster.

Legal professional privilege

We confirm that your professional opinion is sought in the context of us providing legal advice in relation to these amendments. Our advice, and your advice by virtue of you being engaged by us, attracts legal professional privilege. Our client is therefore not required to disclose any advice provided by you to any other party unless that legal professional privilege is waived.

To ensure that legal professional privilege is maintained, we request that you do not advise anyone, other than our client or Harwood Andrews, that you have been requested to provide expert advice in relation to this matter.

We will notify you if legal professional privilege is waived in respect of your advice.

Next steps

If you have any queries or require any further information, please contact Greg Tobin on 5225 5252 or Tessa D'Abbs on 9611 0117.

Yours sincerely,

HARWOOD ANDREWS

Encl.

Index to Brief of Documents

Guide to expert evidence	
1.	Planning Panels Victoria Guide to Expert Evidence
Exhibited documents	
Sunbury South PSP	
2.	Sunbury South PSP
3.	C207 Explanatory report and instruction sheet
4.	C207 Planning Scheme ordinance
5.	C207 Planning Scheme maps
Lancefield Road PSP	
6.	Lancefield Road PSP
7.	C208 Explanatory report and instruction sheet
8.	C208 Planning Scheme ordinance
9.	C208 Planning Scheme maps
Background report	
10.	Background report – Sunbury South and Lancefield Road
Landfill buffer	
11.	EPA licences
12.	EPA comments
Submissions in response to exhibition (referred to Panel)	
13.	Sunbury South PSP submissions
14.	Lancefield Road PSP submissions
15.	VPA summary table of Sunbury South submissions
16.	VPA summary table of Lancefield Road submissions
Panel documentation	
17.	PPV appointment letter

Appendix C: Curriculum Vitae for Patrick Clarke

Patrick Clarke
Senior Principal

Qualifications & Certifications

Bachelor of. Engineering., Royal Melbourne Institute of Technology (RMIT), 1987
Graduate of the Australian Institute of Company Directors Course (GAICD), 2003

Career Profile

Patrick Clarke is a Senior Principal Geological Engineer and Environmental Auditor (Contaminated Land), appointed pursuant to the Environment Protection Act (Vic), 1970. Patrick has over 28 years consulting experience on landfill projects throughout Australia, the United States of America (three years) and the Asia-Pacific region. His key areas of expertise include environmental auditing, landfill engineering, contaminated site assessment and remediation, contaminant hydrogeology and geotechnology.

He has particular expertise in environmental issues associated with landfills. Patrick has worked on over 50 operating and former landfills in Australia and overseas. Landfill projects in which Patrick played a key role included site selection, landfill licensing, assessment of groundwater and landfill gas impacts, implementation of landfill gas mitigation measures, engineering design of landfill liner and capping systems and environmental auditing of landfill operations and landfill cell construction.

Expertise *(update list accordingly)*

Waste Management
Landfill Engineering
Statutory Environmental Audits (Contaminated Land)
Contaminant Hydrogeology and Groundwater Remediation

Key Industry Sectors *(update list accordingly)*

Petroleum and Petrochemical
Property Development and Management
Waste Management
Manufacturing

Employment History

2009 (current): Senversa Pty Ltd
1999 to 2008: HLA & ENSR Australia
1988 to 1999: URS Australia Pty Ltd

Memberships *(update list accordingly)*

Chartered Professional Engineer - Institution of Engineers, Australia from 1992.
Member of the Australian Land and Groundwater Association
Member of the EPA Victoria, Groundwater Approvals Working Group (GWAWG)

Professional Training & Development

- Developed and Conducted Training Workshops for Contaminated Land Professionals in Groundwater Assessment and Cleanup to the Extent Practicable (CUTEP) on behalf of the ACLCA (Vic. Branch) and the Environment Protection Authority Victoria (EPAV).
- Certificate of Appreciation as Founding President of the Australian Contaminated Land Consultants Association (Victorian Branch)
- University of Waterloo, Short Course, Assessment and Remediation of DNAPL Contaminated Sites.
- Developed and Conducted Training Workshop on Siting and Design of Landfills for EPAV staff.
- 40 hour OSHA Health and Safety Training

Project Experience

LANDFILL GAS ASSESSMENT AND MANAGEMENT

Patrick has been involved in assessment and management of landfill gas at a number of operating and former landfills from the late 1980s through to current projects. He has been at the forefront of implementation of innovative assessment methodologies of hazards associated with methane emissions from former landfills in Victoria since the Brooklands Green Estate incident in Cranbourne, Victoria. Patrick has and is conducting statutory environmental audits on former landfill sites arising from recent EPA initiatives following from the Ombudsman's report on Brooklands Green Estate. Landfill gas projects Patrick has been involved in include the following:

- Section 53V Audit of methane emissions from the Quarry Park Landfill, Footscray, Victoria.
- Section 53V Audit of methane emissions from the former landfill at Sir Doug Nichols Reserve, Thornbury, Victoria.
- Vincent Road Landfill, assessment of landfill gas risk to neighbouring residential properties associated with a former landfill, Wangaratta, Victoria (2013).
- Section 53V Audit of methane emissions from the Bosworth Road Landfill, Bairnsdale, Victoria.
- Assessment of landfill gas emissions, risk assessment and development of a landfill gas monitoring system for the McClelland Road Landfill, Frankston, Victoria.
- Assessment of landfill gas emissions and resource potential from the Trumans Road Landfill, Rye, Victoria.
- Assessment of landfill gas emissions from a former landfill into adjoining office/warehouse buildings and implementation of a landfill gas interception and venting system, Reg Harris Reserve, Oakleigh, Victoria.
- Assessment of landfill gas emissions from a former landfill into a commercial building on an adjoining property and implementation of a landfill gas interception and venting system, Brickmakers Park, Victoria.
- Implementation of a landfill gas interception and venting system between a former landfill and adjoining residential properties, Western suburbs, Melbourne, Confidential Client.
- Assessment of landfill gas emissions, Twenty Nine Palms Air Force Base, California, U.S.A.

LANDFILL ENGINEERING AND ENVIRONMENTAL MANAGEMENT

Patrick has been involved in over 40 landfill projects in Australia, the USA and Asia. He has played a key role in site selection, approvals, hydrogeological evaluation, assessment of leachate generation, detailed landfill design, management advice and landfill gas management. His landfill project experience includes:

- Corangamite Shire Council, Naroghid Landfill; construction audits of landfill cells, landfill caps and leachate pond.
- Victory Road, Deals Road, Carroll Road and Fraser Road Landfills; multiple landfill cell construction audits.
- Carrol Road Landfill; cap design verification and construction audit.
- Benalla Regional Landfill; construction audits of landfill cells and leachate ponds.
- Vincent Road Landfill; landfill gas risk assessment.
- Devil Bend Landfill, landfill cell and cap design and construction audits.
- Maddingley Brown Coal Landfill, annual groundwater audits from 2005 to 2014.
- Summerhill Landfill, Newcastle; Leachate Management Plan and Engineering Options Assessment
- Brooklyn Landfill; Works Approval, detailed design and hydrogeological evaluation
- Frankston Landfill, Landfill Gas Management Plan
- Jones Road Landfill, Liner Construction Audit
- Werribee Prescribed Waste Landfill; Engineering Design

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