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PRELIMINARY HUMAN HEALTH RISK ASSESSMENT (HHRA)

Beverley Assessment Area, South Australia

Submitted to:
Environment Protection Authority
Level 8, 250 Victoria Square
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REPORT

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1 Electronic Copy to SA EPA
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Acronyms and Abbreviations

Abbreviation/Acronym	Definition
ASV	Active Soil Vapour (Sample or Sampling Point)
ATSDR	Agency for Toxic Substances and Disease Registry (US)
COI	Chemical of Interest
CSM	Conceptual Site Model
enHealth	National Environmental Health Council
EPA	Environment Protection Authority
HHRA	Human Health Risk Assessment
HI	Hazard Index; the sum of HQ
HQ	Hazard Quotient
LOR	Limit of Reporting
m bgl	Metres Below Ground Level
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NEPM (ASC)	National Environment Protection (Assessment of Site Contamination) Measure
NHMRC	National Health and Medical Research Council
NIOSH	National Institute for Occupational Safety and Health (USA)
PCE	Tetrachloroethene
PSV	Passive Soil Vapour (Sample or Sampling Point)
RfC	Reference Concentration Expressed in units of micrograms of chemical per cubic metre of air ($\mu g/m^3$). A health benchmark derived to be protective of the general population. An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.
TCE	Trichloroethene
US EPA	United States Environmental Protection Agency
VHC	Volatile Halogenated Compound
VIA	Vapour Intrusion Assessment
WHO	World Health Organization

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1.0 INTRODUCTION

The South Australian Environment Protection Authority (SA EPA) engaged Golder Associates Pty Ltd (Golder) to conduct a groundwater and soil vapour investigation at targeted locations within a defined Assessment Area located in a portion of Beverley and Woodville South. The Assessment Area is centred around a former manufacturing facility on Pope Street, Beverley and contains numerous industrial and residential properties. The location of the Assessment Area is provided in Figure 1, Appendix A.

The primary objective of the investigation was to record concentrations of chemicals of interest (COI) within soil, groundwater, soil vapour and in ambient air at targeted locations within the Assessment Area. COI for the investigation included volatile organic compounds (VOC), with particular focus on the chlorinated hydrocarbons tetrachloroethene (PCE); trichloroethene (TCE); cis-1,2- and trans-1,2-dichloroethene (DCE), vinyl chloride and chloroform.

This data was used to undertake a preliminary vapour intrusion assessment (VIA) including modelling of potential vapour intrusion for property (building) types within the Assessment Area and estimation of site specific screening criteria for assessment of soil vapour and ambient air sampling results (Golder, 2015g).

The outcome of the VIA was used to undertake a human health risk assessment (HHRA) for the COI identified by the results of the environmental sampling works and for the property (building) types identified in the Assessment Area. The methodology, results and conclusions of the VIA have been provided under separate cover (Golder, 2015g). A summary of the overall assessment results, including both the VIA and HHRA, has also been provided under separate cover in the *Assessment Work Summary (April to October 2015): Beverley EPA Assessment Area* (Golder 2015h).

This report presents the methodology, results and conclusions of the HHRA.

2.0 SCOPE OF WORKS

The HHRA was undertaken in general accordance with the proposed scope of work outlined in Golder's proposal Beverley & Woodville South Groundwater and Soil Vapour Assessment (ref. P1418522-001-P-Rev0), dated 28 January 2015.

Golder recognise that HHRAs have been completed on behalf of SA EPA for a number of locations in South Australia involving similar COI (chlorinated ethenes), geological conditions (sediments of the Adelaide Plains), and human health receptors (residential dwellings). A preferred toxicity assessment and risk management approach has been previously determined by SA Government including SA EPA and SA Health. The scope of works for the VIA and the HHRA therefore sought to remain consistent with the methodology adopted at other assessment areas. The scope of works included the following:

- Review and adoption of vapour attenuation factors (α) estimated from the VIA for TCE and for each vapour migration and intrusion pathway.
- Review of environmental investigation data including the observations and results of samples of soil vapour, crawl-space air, ambient (surface) air and indoor air.
- Estimation of indoor air concentrations of TCE from reported concentrations of TCE in soil vapour and in crawl space air.
- Assessment of the potential for vapour concentrations to pose a risk to health by comparison with adopted TCE response ranges.
- Consideration of other (short-term) implications of the estimated exposure concentrations.

3.0 ASSESSMENT METHODOLOGY

The VIA and HHRA were undertaken following the general principles and methodology as provided in the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC, 2013) and with reference to other applicable Australian guidance including the Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth, 2012).

Response ranges (concentrations) of TCE in air had previously been developed and adopted for assessment of vapour migration and potential health risk for the Clovelly Park Mitchell Park Environmental Management Project (Government of South Australia, 2014). Golder understands that SA EPA has adopted the same response ranges for the Beverley Assessment Area.

The TCE response ranges (concentrations) have been established for direct comparison with modelled or measured air concentrations from vapour intrusion. Therefore a Hazard Identification and Dose-Response Assessment, as per NEPC (2013) and enHealth (2012) guidance, was not required.

The TCE response ranges incorporate an order of magnitude (factors of 10) approach to establish the significance of an air concentration and the indicated level of response. For example, a concentration 10 times higher than the “Investigation” response range would indicate a higher potential health concern and more urgent response timeframe. The response ranges therefore incorporate a measure of the ‘significance’ of the air concentration and a Risk Characterisation process was not required.

The process adopted for the HHRA was as follows:

- Reported concentrations of TCE in soil vapour at depth below surface, sub slab soil vapour and crawl space air were multiplied by the relevant attenuation factor as estimated in the VIA.
- The resulting estimated indoor air concentration was compared with the response ranges to identify the significance of the results and the level of action required.
- Reported concentrations of TCE in outdoor air, indoor air and subsurface utilities and services were compared directly with the response ranges to identify the significance of the results and the level of action required.

The concentrations of TCE in soil vapour, sub slab soil vapour, crawl space air, outdoor air and indoor air used for assessment of risk were sourced from reports prepared for previous stages of investigation and sampling works (Golder 2015a, 2015b, 2015d, 2015e) and from the conceptual site model (CSM) compiled from these investigation works (Golder, 2015f).

Whilst a multiple lines of evidence approach was used, the primary data used for the VIA and HHRA were the sample analysis results from shallow and medium depth soil vapour including sub-slab samples and crawl-space samples. These sample results represent the concentrations in closest proximity to receptors (overlying buildings) with a lower degree of uncertainty due to partitioning from groundwater and from migration through deeper soil profiles.

The attenuation factors for soil vapour or crawl space air to indoor air, as estimated from the VIA, are summarised in Table 1.

Table 1: Adopted Vapour Attenuation Factors, Beverley Assessment Area

Vapour Source Location or Depth (m)	Adopted Vapour Attenuation Factor "α" (unitless)	
	Concrete Slab on Grade Foundation	Timber Suspended Floor, Crawl Space
Crawl Space	Not Applicable	1
0 (Sub Slab)	2.6E-02	Not Applicable
0.85	1.0E-02	1.0E-02
1.85	9.1E-04	9.0E-04 (9.1E-04, refer note below)
3.85	3.8E-04	3.8E-04
6.35	2.2E-04	2.2E-04

Note – For the HHRA, attenuation factors for soil vapour at 1.85 m depth to indoor air for slab on grade and crawl space buildings are approximately equal. The slab on grade attenuation factor was adopted for both building types.

In order to estimate the potential indoor air concentration of a volatile chemical identified in soil vapour, an attenuation factor (designated "α") is required. The attenuation factor represents the change in concentration between the measured environmental location (such as a deep soil vapour sample) and the indoor air environment. The attenuation factor represents a number of different processes that may occur to reduce the concentration of the chemical, including biological degradation, dispersion, dilution and adsorption to soil particles.

The approach used in establishment of the response ranges is outlined in Government of South Australia (2014) and a relevant discussion from this document is presented below:

The indoor air level response range was developed following a review of international standards and research for TCE.

A joint workshop between SA Health, EPA, the Clovelly Park Mitchell Park Project Team, and the consultants undertaking the environmental investigations and human health/vapour intrusion risk assessment, was held to develop this indoor air level response range.

The workshop considered the scientific evidence for health effects from TCE exposure and reviewed various guidance on TCE action levels from around the world.

Agreement was reached at the workshop to establish ranges using levels prescribed by the US EPA as the lower limit and those of the World Health Organisation (WHO) as the upper limit for the ranges.

The basis of the agreement was taking a sensible balance between the highly conservative approach of the US EPA with the widely validated approach of the WHO.

These guidance levels are intended to be protective against cancer and other health risks over the course of a lifetime of continuous TCE exposure (70 years).

This approach is also consistent with Australian approaches to chemical assessment and regulation where the WHO is identified as a preferred source of guidance, in an absence of national regulatory standards.

While there is international consensus around the reference concentration of 2 µg/m^3 of TCE in indoor air as the trigger for further investigation, decision making frameworks for levels above this vary considerably and are the subject of ongoing scientific and public debate.

For the purposes of this investigation, 2 µg/m^3 of TCE in indoor air has been adopted as the level above which further action is necessary.

The ranges adopted above this level to determine differences in the nature and timing of the actions are based on increasing levels of health risk between levels such as 2 µg/m^3, 20 µg/m^3 and 200 µg/m^3.

Within the designated ranges it is very difficult to scientifically determine the differences in possible health risks within the particular action level ranges (eg between 3 µg/m^3 and 17 µg/m^3).

It is also important to note the science and understanding of the health effects of TCE are constantly evolving. Adjustments to the response levels may be appropriate as new information comes to hand.

The response ranges (TCE concentrations), and explanation of each range are provided in Figure 1 below, extracted from Government of South Australia (2014).

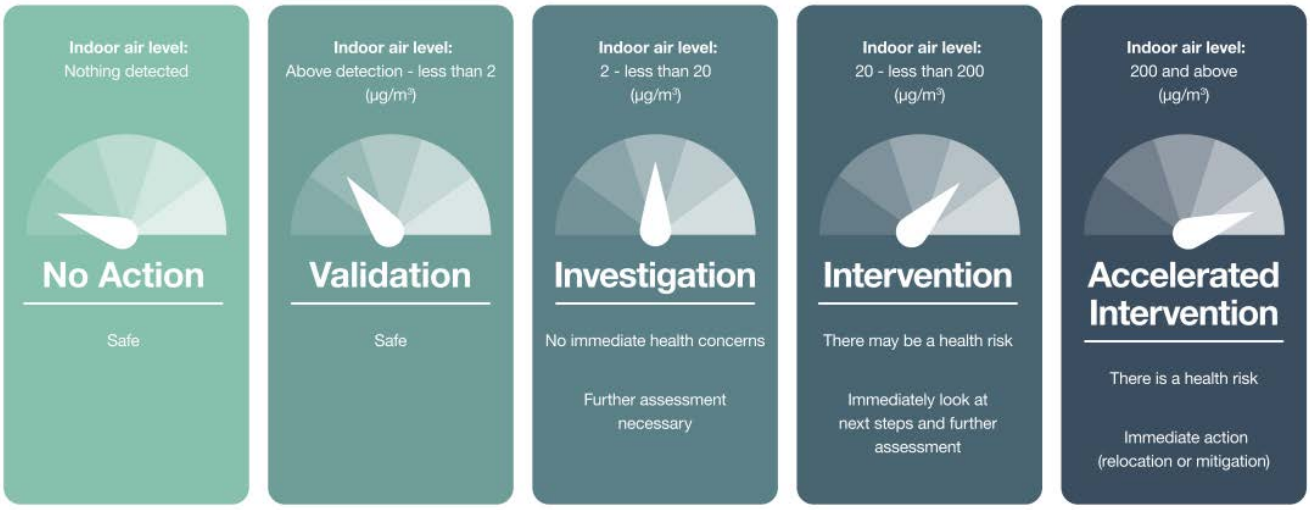

Figure 1: TCE Indoor Air Response Ranges (Government of South Australia, 2014)

Review of results from crawl space samples (Golder, 2015e) inferred that TCE concentrations obtained over a 24 hour sampling period (using vacuum canister methods) were consistent with TCE concentrations obtained over a 7 to 8 day sampling period (using passive sorbent methods). As the response ranges were adopted on the assumption of continuous exposure and the crawl space sample results did not infer significant variability in concentrations between 24 hour and 7 to 8 day durations, no adjustment was made to the response ranges to account for different sampling or potential exposure duration.

4.0 ESTIMATED VAPOUR CONCENTRATIONS

The EPA assessment program included sampling, including indoor air, crawl space air and sub slab soil vapour at properties within the Assessment Area and reported ranges of TCE concentrations as depicted in Figure 2 at these properties.

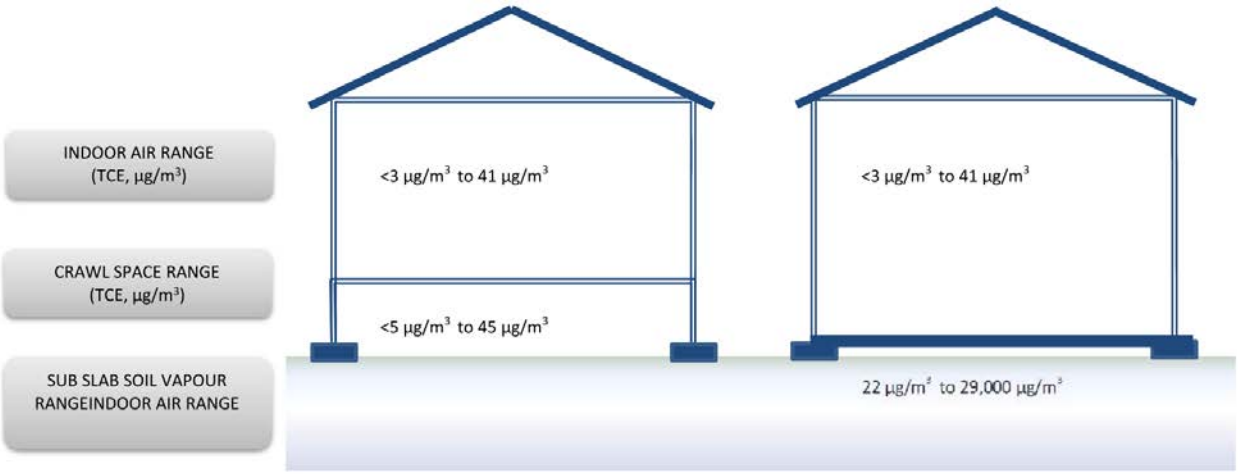

Figure 2: Range of Sub Slab, Crawl Space and Indoor Air TCE Concentrations Reported in Assessment Area

Property-specific environmental sampling results were available for 11 individual properties within the Assessment Area. Sampling was undertaken over several stages of works and a summary of the data available for each property is provided in Table 2.

Table 2: Summary of Property-Specific Environmental Sampling Data

Property ID	Soil Vapour Data <0.85m	Soil Vapour Data >0.85m	Sub Slab Data	Crawl Space Data	Indoor Air Data
Property 1	☑	☑	☑	☑	☐
Property 2	☑	☑	☑	☑	☐
Property 3	☐	☐	☐	☑	☐
Property 4	☐	☐	☑	☑	☐
Property 5	☐	☐	☑	☑	☑
Property 6	☐	☐	☑	☐	☑
Property 7	☐	☐	☑	☑	☑
Property 8	☐	☑	☑	☐	☑
Property 9	☐	☑	☐	☑	☐
Property 10	☐	☐	☐	☑	☐
Property 11	☑	☑	☑	☐	☐

Indoor air concentrations were either:

- Adopted from the results of samples obtained from indoor air at each property, or
- Estimated from the results of samples obtained from soil vapour, sub slab soil vapour or crawl space air by applying the relevant attenuation factors (for the sample media) as reported in the VIA (Table 1).

The measured or estimated (calculated) indoor air concentrations are presented in Appendix A as Figure A2 (Crawl Space Air Data), Figure A3 (Indoor Air Data), and Figure A4 (Soil Vapour Data include Sub Slab Data).

5.0 ASSESSMENT OF POTENTIAL HEALTH RISK

For the assessment of potential health risk to residential property within the Assessment Area, comparison was made between measured or estimated indoor air concentrations and the adopted response ranges.

Where a potential for health risk was indicated (Investigation and higher response ranges), the level of action and priority for action were indicated by the specific response range for the concentration.

5.1 Chronic, Intermediate and Acute Health Implications

With the exception of the “No Action” and “Validation” concentrations, the response ranges are not directly based on consideration of acceptable or unacceptable human health risk. The “Investigation”, “Intervention” and “Accelerated Intervention” response ranges are scaled (upwards by an order of magnitude at each level) from the “Validation” range. The response ranges are management action guidelines for use in assessing the need for action and priority with which that action is implemented. They are not intended to define or assess a ‘safe’ or ‘acceptable’ duration of exposure.

The “Validation” response range was based on the reference concentration (RfC) of 2 µg/m^3 adopted by the US EPA. The RfC is defined as:

> *An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.*

The “No Action” and “Validation” response ranges may therefore be considered to represent concentrations at which continuous, long-term exposure (‘chronic exposure’) is not anticipated to result in health risks.

The review and establishment of the chronic toxicological reference value for TCE also included consideration of a wide range of exposure durations (‘sub-chronic’ or ‘intermediate’) and effects. The effects included those relevant to sensitive subpopulations such as immune toxicity, developmental and reproductive toxicity. The studies documenting these effects involve short term or intermediate exposure durations.

Golder notes the draft revision to the ATSDR toxicological profile for TCE (ATSDR, 2014) adopts the 2 µg/m^3 reference concentration from US EPA as both a chronic (long term) Minimum Risk Level (MRL) and as an intermediate (sub chronic) MRL. ATSDR defines an intermediate duration as a period greater than 14 days and less than 1 year.

Because the acute health effects of TCE occur at higher concentrations than intermediate or chronic effects the chronic reference value is protective against acute health effects.

6.0 UNCERTAINTY AND SENSITIVITY ASSESSMENT

For the HHRA, the primary sources of uncertainty are:

- The environmental sampling data from the Assessment Area, including soil vapour, crawl space air and indoor air samples.
- The estimated attenuation factors and whether they are representative of the building and exposure conditions in the Assessment Area.
- The SA Government response ranges and whether they are relevant and protective for the Assessment Area.

Review of uncertainty was undertaken for the environmental sampling data within the environmental assessment reports (Golder, 2015a, 2015b, 2015d, 2015e) and within the VIA report (Golder, 2015g). A sensitivity assessment was undertaken for the vapour intrusion models and estimated attenuation factors within the VIA report (Golder, 2015g). For further information regarding the uncertainty and sensitivity of the assessment, reference should be made to these previous reports (Golder 2015a, 2015b, 2015d, 2015e, 2015g).

The basis of the response ranges is discussed in Section 0 and consideration of relevance to intermediate and acute health effects is provided in Section 5.1.

7.0 CONCLUSIONS AND ASSESSMENT OF HEALTH RISK

The measured indoor air and estimated (from soil vapour, sub slab vapour and crawl space air samples) indoor air concentrations of TCE were compared with the SA Government response ranges adopted for the Assessment Area. The background to the response ranges is discussed in Section 0, and for presentation purposes have been assigned colour codes as follows:

<Detection [A]	< 2 µg/m^3	2 to <20 µg/m^3	20 to <200 µg/m^3	200+ µg/m^3
No Action	Validation	Investigation	Intervention	Accelerated Intervention

A – See discussion below regarding sample results below detection limits.

Comparison between measured (indoor air), or estimated (from soil vapour or crawl space air) concentrations of TCE and the response ranges has been provided in Figures A2, A3 an A4 in Appendix A.

For the purposes of the risk assessment, where an indoor air sample or crawl space air sample reported a result less than the laboratory detection limit, but that detection limit was higher than 2 µg/m^3 the result was classified as "Validation".

Where a soil vapour sample reported a result less than the laboratory detection limit, but that detection limit was higher than 2 µg/m^3 the result was classified as "No Action" in consideration of the expected degree of attenuation between soil vapour samples and indoor air.

Table 3 provides a summary of the classification, with reference to the response ranges, for the individual properties targeted within the Assessment Area.

Table 3: Summary of Property Classification – Response Ranges

Property ID	Soil Vapour Data >0.85m	Soil Vapour Data <0.85m	Sub Slab Data	Crawl Space Data	Indoor Air Data
Data Priority ➔	5	4	2	2	1
Increasing Confidence in Data Source ➔					
Property 1	Investigation	Intervention	Intervention	Intervention	NA
Property 2	Investigation	Intervention	Intervention	Intervention	NA
Property 3	NA	NA	NA	Validation	NA
Property 4	NA	NA	Investigation	Investigation	NA
Property 5	NA	NA	Acc.Intervention	Intervention	Investigation
Property 6	NA	NA	Acc.Intervention	NA	Validation
Property 7	NA	NA	Acc.Intervention	Intervention	Intervention
Property 8	NA	Investigation	Acc.Intervention	NA	Investigation
Property 9	NA	Investigation	NA	Investigation	NA
Property 10	NA	NA	NA	Intervention	NA
Property 11	No Action	Investigation	Validation	NA	NA

NA – Not Assessed. Indicates that no data was available of the given type for the property.
Note – colour coding 'faded' for classifications where a higher priority data source is available. i.e. Property 9, crawl space data is displayed as a stronger colour than lower priority soil vapour data.

Data sources are listed in reverse order of priority, such that the response range indicated by indoor air data should be given greater weighting than the response range indicated by soil vapour data.

7.1 Residential "Zones"

No property-specific data has been collected for the majority of properties within the Assessment Area. To allow consideration of areas beyond those where property-specific investigations have been conducted, the Assessment Area has been divided into "Residential Zones" based on the estimated (theoretical) indoor air concentration of TCE estimated from active soil vapour data. It is noted that each Zone may also contain a number of non-residential properties. Each Residential Zone comprises a contiguous series of properties for which an identical response range classification has been assigned. A summary of the properties within each Residential Zone and the corresponding Response Range Classification is provided in Table 4. Residential Zone boundaries are presented in Figure 1, Appendix A.

The boundary of each Residential Zone has been interpreted based on available soil vapour data within each zone and near the boundaries of adjacent zones, as well as the current understanding of the conceptual site model for the Assessment Area (Golder 2015f). It is acknowledged the data for spatial distribution of soil vapour data is limited throughout many Residential Zones, and uncertainty exists regarding the appropriate classification of properties which are more distant from sample data.

Where such uncertainty exists, properties have been classified conservatively. Further assessment would be required to provide greater certainty and allow for less conservative classification of these properties.

Table 4: Summary of Response Range Classifications for Residential Zones (From Soil Vapour Data)

Residential Zone	Estimated Number of Residential Properties Within Zone	Associated Active Soil Vapour Data Points	Associated Passive Soil Vapour Data Points	Soil Vapour Data >0.85 m	Soil Vapour Data <0.85 m
1	43	SV-07, SV-13, SV-14, SV-16, SV-17, SV-23, SV-37, SV-38	PSV-13, PSV-14, PSV-30, PSV-31, PSV-32, PSV-33	No Action	No Action
2	53	SV-04, SV-05, SV-06, SV-11, SV-18, SV-24, SV-26, SV-27, SV-34	PSV-27, PSV-28, PSV-29, PSV-30, PSV-33, PSV-34, PSV-35, PSV-36, PSV-37, PSV-38, PSV-41, PSV-42, PSV-45	Investigation	Validation
3	6	SV-20	PSV-44, PSV-45	Validation	Investigation
4	5	SV-19	PSV-43	Investigation	Investigation
5	6	SV-05, SV-19, SV-31	PSV-36	Investigation	Intervention
6	18	SV-01, SV-02, SV-03, SV-09, SV-10, SV-12, SV-15, SV-21, SV-22, SV-35, SV-36	PSV-08, PSV-09, PSV-11, PSV-12, PSV-16, PSV-17, PSV-25, PSV-26	Intervention	Intervention
7	3	SV-08	PSV-47	No Action	Investigation
8	2	SV-28	PSV-04, PSV-05	NA	Accelerated Intervention
9	4	SV-25	PSV-15	NA	Accelerated Intervention
10	1	SV-32, SV-33, SV-34, SV-39, SV-40	PSV-10	NA	Investigation
11	1	SV-29, SV-30	PSV-07	NA	Investigation

Residential Zone	Estimated Number of Residential Properties Within Zone	Associated Active Soil Vapour Data Points	Associated Passive Soil Vapour Data Points	Soil Vapour Data >0.85 m	Soil Vapour Data <0.85 m
12	35	SV-26	PSV-01, PSV-02, PSV-03, PSV-06, PSV-18, PSV-19, PSV-20, PSV-21, PSV-22, PSV-23, PSV-24, PSV-46	NA	Validation

NA – Not Assessed. Indicates that no data was available of the given type for the zone.

Note – colour coding 'faded' for classifications where a higher priority data source is available. i.e. Zone 2, soil vapour data <0.85 m bgl is displayed as a stronger colour than soil vapour data >0.85 m bgl.

Data sources are listed in reverse order of priority, such that the response range indicated by shallow (<0.85 m bgl) soil vapour data should be given greater weighting than the response range indicated by deeper (>0.85 m bgl) soil vapour data.

8.0 RECOMMENDATIONS

Further assessment of potential health risks is recommended based on the level of modelled vapour intrusion and priority classification within each Residential Zone. The recommended further investigation program and decision process is described within the Vapour Mitigation Strategy (Golder 2015c). A copy of the Decision Flow Chart from the Vapour Mitigation Strategy is provided in Appendix B. The recommended next phase of investigation in each zone is described in Table 5.

Table 5: Recommended Investigation Actions for Residential Zones

Zone	Preliminary Action Category	Recommended Action	Estimated Number of Residential Properties
1	No Action	No further investigation recommended.	43
2	Validation	Confirm active soil vapour results within this zone by re-sampling existing soil vapour probes. A small number of additional strategically located soil vapour bores should also be considered to confirm that unacceptable risks do not exist within this zone. It is recommended that the additional active soil sampling be undertaken during the summer period to allow assessment of potential seasonal variations.	53
3	Investigation	Refinement of area wide screening assessment by additional shallow active soil vapour sampling in private properties. One soil vapour bore is recommended in each residential property within these Zones. Based on the outcomes of this soil vapour assessment, further property-specific investigation will be required in focused properties within these Zones, as described for Zone 6.	6*
4	Investigation		5
5	Intervention	As the density of sampling in this Zone is low, implement refinement of area wide screening as described for Zones 3 and 4 to potentially re-classify action categories for properties within this Zone. Subsequently implement property-specific investigations for properties remaining in this Zone as described for Zone 6.	6
6	Intervention	Implement property-specific investigations in accordance with the Vapour Mitigation Strategy, including: • building construction survey • crawl space sampling and/or sub-slab sampling (dependent on building construction) • soil gas sampling • property-specific vapour intrusion assessment.	18*
7	Investigation	As further area-wide screening in this Zone would be impractical, due to the level of existing area-wide assessment completed to date, implement property-specific investigations as described for Zone 6.	3
8	Accelerated Intervention	Implement property-specific investigations as described above for Zone 6; however on an expedited schedule. Consider undertaking preliminary indoor air sampling in conjunction with sub-floor monitoring.	2
9	Accelerated Intervention		3
10	Investigation	As further area-wide screening in these Zones would be impractical, due to the level of existing area-wide assessment completed to date, implement property-specific investigations as described above for Zone 6.	1
11	Investigation		1
12	Validation	Confirm active soil vapour results within this zone by re-	35

Zone	Preliminary Action Category	Recommended Action	Estimated Number of Residential Properties
		sampling existing soil vapour probe. A small number of additional strategically located soil vapour bores should also be considered to confirm that unacceptable risks do not exist within this zone. It is recommended that the additional active soil sampling be undertaken during the summer period to allow assessment of potential seasonal variations.	

*Zone includes one or more properties identified as commercial based on South Australian Government land use data (July 2015) but which appear to be used for residential purposes based on aerial photographs and/or observations from the property boundary.

As set out in the Decision Flow Chart within Appendix C, the need for installation of vapour mitigation systems in properties will be dependent on property-specific vapour intrusion assessment.

In addition to the recommended actions as set out in Table 5 for investigation of potential human health concerns, the following investigations are also recommended to address key data gaps within the conceptual site model (Golder 2015f):

- Assessment of the potential for preferential contaminant migration along West Street within the sewer line or unknown (potentially redundant) subsurface utilities. Sampling of vapour within the sewer and a ground penetrating radar (GPR) survey across West Street are recommended.
- Further assessment of the lateral extent of soil vapour impacts in the north-eastern portion of the assessment area (to further assist in source identification).
- Further assessment of groundwater to confirm likely contaminant source areas and allow future migration of TCE impacted groundwater to be assessed.

9.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in Appendix C of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

10.0 REFERENCES

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Report Signature Page

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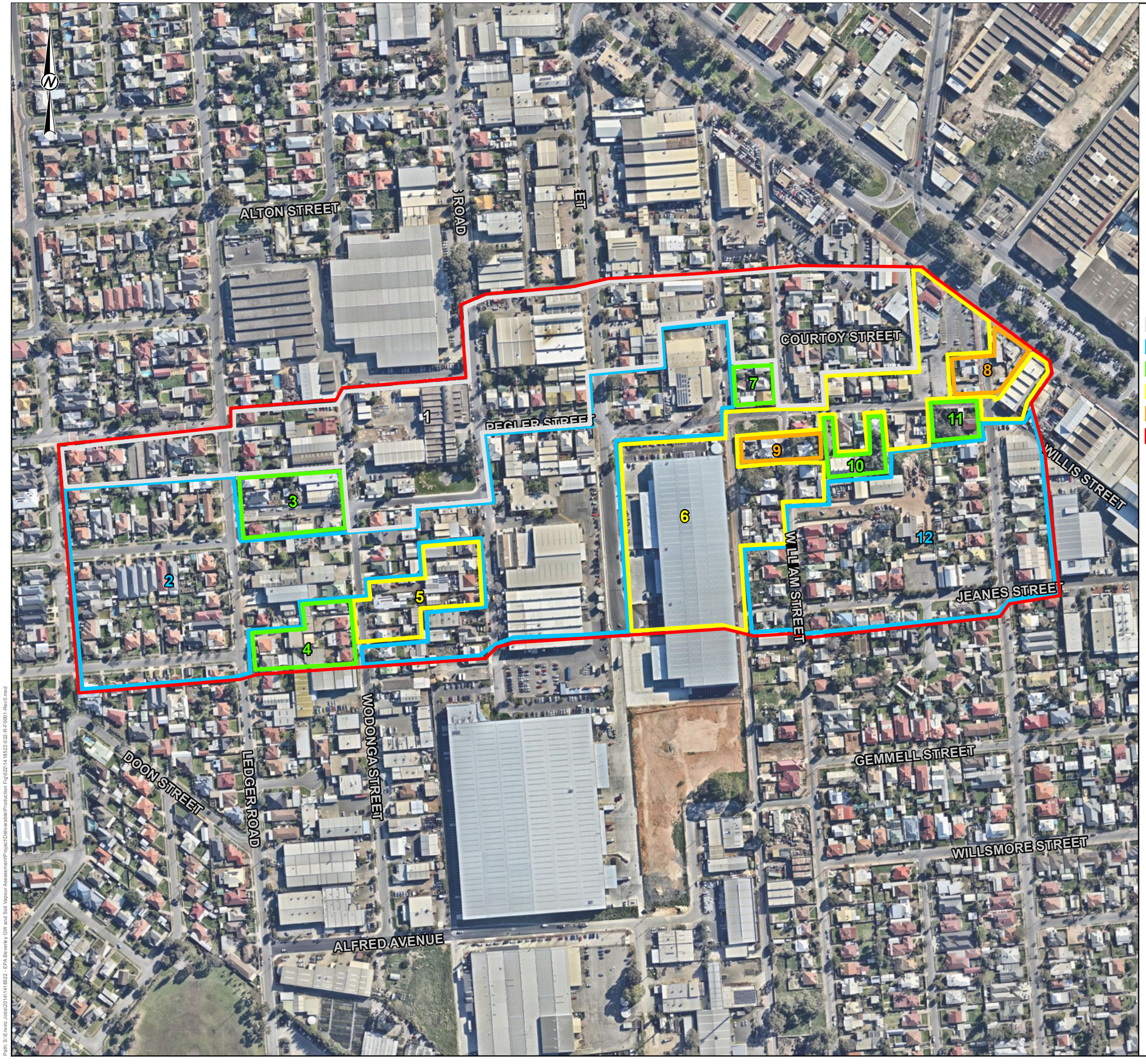
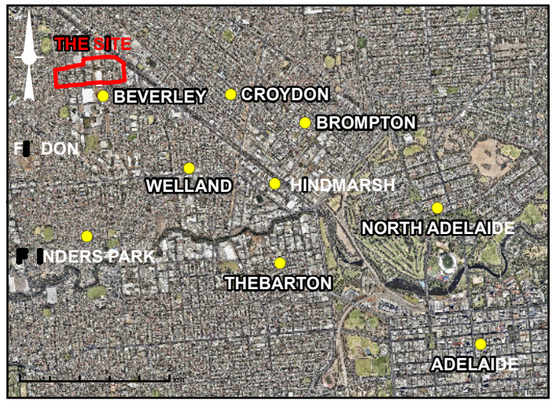
APPENDIX A

Figures



LOCATION MAP



LEGEND

Theoretical Indoor Air TCE Concentrations

- Below Laboratory Limit of Reporting - No Action
- < 2 µg/m^3 - Validation
- < 20 µg/m^3 - Investigation
- < 200 µg/m^3 - Intervention
- > 200 µg/m^3 - Accelerated Intervention
- Assessment Area

NOTES

1. The definition of each 'zone' has been based on estimated (theoretical) vapour concentrations within the zone. It is not inferred that a property within a zone will have or is likely to have indoor air concentrations at the indicated level. This figure must be viewed in consideration with the enclosed HHRA report.

0 30 60 90 120
METRES

REFERENCE SCALE: 1:3,500 (at A3)

PROJECTION: GDA 1994 MGA Zone 54

CLIENT
ENVIRONMENT PROTECTION AUTHORITY

PROJECT
HUMAN HEALTH RISK ASSESSMENT, BEVERLEY ASSESSMENT AREA, SOUTH AUSTRALIA

TITLE
PRELIMINARY RESPONSE RANGE CLASSIFICATIONS FOR RESIDENTIAL ZONES

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-09-23
PREPARED	KB
DESIGN	-
REVIEW	JC
APPROVED	JC

PROJECT No.	CONTROL	Rev.	FIGURE
1418522	022-R	0	1

FIGURE A2

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
CRAWL SPACE SAMPLING DATA

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 1	CRAWL SPACE							
Sample Location	CS1	CS1	CS2	CS2	W1	H4	W2	H5
Sample Type	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)
Sample Start	09:05 16/07/2015	09:15 10/07/2015	09:10 16/07/2015	09:30 10/07/2015	12:57 11/06/2015	04/06/2015 08:45	13:00 11/06/2015	04/06/2015 08:54
Sample Finish	09:05 17/07/2015	09:07 17/07/2015	09:10 17/07/2015	09:10 17/07/2015	12:30 12/06/2015	12/06/2015 12:30	12:30 12/06/2015	12/06/2015 12:35
Sample No.	15-868	15-862	15-870	15-863	15-658	15-722	15-659	15-723
Trichloroethene	**37**	**25**	**14**	**7.9**	**35**	**22**	**12**	**7.4**
Attenuation Factor - Indoor Air	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Estimated Indoor Air Concentration	**37**	**25**	**14**	**7.9**	**35**	**22**	**12**	**7.4**

PROPERTY 2	CRAWL SPACE							
Sample Location	CS3	CS3	CS4	CS4	W1	H1	W2	H3
Sample Type	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)
Sample Start	09:16 16/07/2015	09:45 10/07/2015	09:21 16/07/2015	09:51 10/07/2015	09:23 11/06/2015	04/06/2015 11:07	09:30 11/06/2015	04/06/2015 11:15
Sample Finish	09:20 17/07/2015	09:20 17/07/2015	09:23 17/07/2015	09:23 17/07/2015	10:30 12/06/2015	11/06/2015 11:53	10:30 12/06/2015	11/06/2015 12:05
Sample No.	15-871	15-865	15-872	15-866	15-656	15-719	15-657	15-721
Trichloroethene	**13**	**9.6**	**24**	**12**	**20**	**9.5**	**23**	**17**
Attenuation Factor - Indoor Air	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Estimated Indoor Air Concentration	**13**	**9.6**	**24**	**12**	**20**	**9.5**	**23**	**17**

PROPERTY 3	CRAWL SPACE	
Sample Location	W1	H6
Sample Type	Active (TO15)	Passive (Radiello)
Sample Start	11:00 11/06/2015	04/06/2015 10:30
Sample Finish	09:45 12/06/2015	11/06/2015 11:13
Sample No.	15-660	15-724
Trichloroethene	**<5**	**0.42**
Attenuation Factor - Indoor Air	**1**	**1**
Estimated Indoor Air Concentration	**<5**	**0.42**

FIGURE A2

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
CRAWL SPACE SAMPLING DATA

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 4	CRAWL SPACE				
Sample Location	1S	1R	2S	2R	3R
Sample Type	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)	Passive (Radiello)
Sample Start	15:14 05/08/2015	10:05 29/07/2015	15:41 05/08/2015	09:49 29/07/2015	14:05 06/08/2015
Sample Finish	14:20 06/08/2015	14:23 06/08/2015	13:59 06/08/2015	14:16 06/08/2015	13:38 07/08/2015
Sample No.	15-1006	15-996	15-1007	15-997	15-1002
Trichloroethene	**11**	**8.1**	**14**	**11**	**7.5**
Attenuation Factor - Indoor Air	**1**	**1**	**1**	**1**	**1**
Estimated Indoor Air Concentration	**11**	**8.1**	**14**	**11**	**7.5**

PROPERTY 5	CRAWL SPACE			
Sample Location	1S	1R	2S	2R
Sample Type	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)
Sample Start	14:48 05/08/2015	07:40 29/07/2015	14:40 05/08/2015	07:55 29/07/2015
Sample Finish	13:15 06/08/2015	13:19 06/08/2015	13:05 06/08/2015	13:05 06/08/2015
Sample No.	15-1004	15-994	15-1005	15-995
Trichloroethene	**24**	**21**	**11**	**6.3**
Attenuation Factor - Indoor Air	**1**	**1**	**1**	**1**
Estimated Indoor Air Concentration	**24**	**21**	**11**	**6.3**

PROPERTY 6	CRAWL SPACE
Sample Location	
Sample Type	
Sample Start	
Sample Finish	
Sample No.	
Trichloroethene	
Attenuation Factor - Indoor Air	**1**
Estimated Indoor Air Concentration	**0**

FIGURE A2

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
CRAWL SPACE SAMPLING DATA

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 7	CRAWL SPACE	
Sample Location	1S	1R
Sample Type	Active (TO15)	Passive (Radiello)
Sample Start	14:18 05/08/2015	10:31 29/07/2015
Sample Finish	11:52 06/08/2015	11:53 06/08/2015
Sample No.	15-1009	15-998
Trichloroethene	**38**	**19**
Attenuation Factor - Indoor Air	**1**	**1**
Estimated Indoor Air Concentration	**38**	**19**

PROPERTY 8	CRAWL SPACE
Sample Location	
Sample Type	
Sample Start	
Sample Finish	
Sample No.	
Trichloroethene	
Attenuation Factor - Indoor Air	**1**
Estimated Indoor Air Concentration	**0**

PROPERTY 9	CRAWL SPACE			
Sample Location	2S	2R	1S	1R
Sample Type	Active (TO15)	Passive (Radiello)	Active (TO15)	Passive (Radiello)
Sample Start	16:28 05/08/2015	11:32 29/07/2015	16:36 05/08/2015	11:40 29/07/2015
Sample Finish	13:22 06/08/2015	15:23 06/08/2015	15:24 06/08/2015	15:29 06/08/2015
Sample No.	15-1010	15-999	15-1011	15-1000
Trichloroethene	**17**	**9.3**	**4.9**	**14**
Attenuation Factor - Indoor Air	**1**	**1**	**1**	**1**
Estimated Indoor Air Concentration	**17**	**9.3**	**4.9**	**14**

FIGURE A2

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
CRAWL SPACE SAMPLING DATA

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 10	CRAWL SPACE	
Sample Location	1S	1R
Sample Type	Active (TO15)	Passive (Radiello)
Sample Start	16:05 05/08/2015	14:51 29/07/2015
Sample Finish	16:11 06/08/2015	16:08 06/08/2015
Sample No.	15-1012	15-1001
Trichloroethene	**45**	**25**
Attenuation Factor - Indoor Air	**1**	**1**
Estimated Indoor Air Concentration	**45**	**25**

PROPERTY 11	CRAWL SPACE
Sample Location	
Sample Type	
Sample Start	
Sample Finish	
Sample No.	
Trichloroethene	
Attenuation Factor - Indoor Air	**1**
Estimated Indoor Air Concentration	**0**

FIGURE A3

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
INDOOR AIR SAMPLING DATA

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

Sample Location	Property 5 Room 1	Property 5 Room 2	Property 5 Room 3	Property 5 Room 4	Property 5 Room 5	Property 5 Room 6
Sample Type	Primary	Primary	Primary	Primary	Primary	Primary
Sample Start	16:49 02/09/2015	16:58 02/09/2015	16:42 02/09/2015	16:52 02/09/2015	16:55 02/09/2015	17:02 02/09/2015
Sample Finish	16:16 03/09/2015	16:28 03/09/2015	16:10 03/09/2015	16:20 03/09/2015	16:24 03/09/2015	16:34 03/09/2015
Sample No.	15-1133	15-1134	15-1135	15-1136	15-1137	15-1138
Concentration (µg/m³)						
Trichloroethene	6.4	6.4	7.6	14	8.2	<3

Sample Location	Property 6 Room 1	Property 6 Room 2	Property 6 Room 3	Property 6 Room 4	Property 6 Room 5
Sample Type	Primary	Primary	Primary	Primary	Primary
Sample Start	18:08 31/08/2015	18:22 31/08/2015	18:25 31/08/2015	18:19 31/08/2015	18:26 31/08/2015
Sample Finish	16:54 01/09/2015	17:10 01/09/2015	17:06 01/09/2015	16:57 01/09/2015	17:01 01/09/2015
Sample No.	15-1120	15-1121	15-1122	15-1123	15-1124
Concentration (µg/m³)					
Trichloroethene	<5	<6	<4	<5	<5

Sample Location	Property 7 Room 1	Property 7 Room 2	Property 7 Room 3	Property 7 Room 4	Property 7 Room 5	Property 7 Room 5
Sample Type	Primary	Primary	Primary	Primary	Primary	Duplicate
Sample Start	17:15 31/08/2015	16:59 31/08/2015	17:04 31/08/2015	17:17 31/08/2015	17:22 31/08/2015	17:23 31/08/2015
Sample Finish	16:19 01/09/2015	16:12 01/09/2015	16:15 01/09/2015	16:21 01/09/2015	16:24 01/09/2015	16:26 01/09/2015
Sample No.	15-1114	15-1115	15-1116	15-1117	15-1118	15-1119
Concentration (µg/m³)						
Trichloroethene	27	32	28	41	13	14

Sample Location	Property 8 Room 1	Property 8 Room 2	Property 8 Room 3	Property 8 Room 4	Property 8 Room 4	Property 8 Room 5
Sample Type	Primary	Primary	Primary	Primary	Duplicate	Primary
Sample Start	10:03 02/09/2015	10:15 02/09/2015	10:19 02/09/2015	09:59 02/09/2015	09:59 02/09/2015	10:10 02/09/2015
Sample Finish	09:25 03/09/2015	09:29 03/09/2015	09:30 03/09/2015	09:20 03/09/2015	09:20 03/09/2015	09:26 03/09/2015
Sample No.	15-1126	15-1127	15-1128	15-1129	15-1130	15-1131
Concentration (µg/m³)						
Trichloroethene	9.4	<3	<3	5.9	6.4	<3

1

FIGURE A4

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
SOIL VAPOUR SAMPLING

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 1

Soil Gas Bore	SV09-S		SV09-M	SV09-P1		SV09-P2		SV09-D
Sample Date	27/04/2015	11/06/2015	28/04/2015	27/04/2015	11/06/2015	27/04/2015	11/06/2015	28/04/2015
Bore Depth (m)	0.85	0.85	1.85	Sub-Slab	Sub-slab	Sub-Slab	Sub-slab	3.85
Sample No.	15-442	15-647	15-443	15-440	15-648	15-441	15-649	15-444
Concentration (ug/m^3)								
Trichloroethene	**2400**	**1600**	**3600**	**1000**	**280**	**600**	**600**	**5500**
Attenuation Factor - Indoor Air	**1.00E-02**	**1.00E-02**	**9.10E-04**	**2.60E-02**	**2.60E-02**	**2.60E-02**	**2.60E-02**	**3.80E-04**
Estimated Indoor Air Concentration	**24.0**	**16.0**	**3.3**	**26.0**	**7.3**	**15.6**	**15.6**	**2.1**

PROPERTY 2

Soil Gas Bore	SV10-P1		SV10-P2		SV10-S		SV10M	SV10D
Sample Date	28/04/2015	11/06/2015	27/04/2015	11/06/2015	27/04/2015	11/06/2015	27/04/2015	27/04/2015
Bore Depth (m)	Sub-Slab	Sub-slab	Sub-Slab	Sub-slab	0.85	0.85	1.85	3.85
Sample No.	15-445	15-652	15-446	15-653	15-447	15-650	15-448	15-449
Concentration (ug/m^3)								
Trichloroethene	**2100**	**1600**	**2100**	**1700**	**3100**	**2700**	**6000**	**17000**
Attenuation Factor - Indoor Air	**2.60E-02**	**2.60E-02**	**2.60E-02**	**2.60E-02**	**1.00E-02**	**1.00E-02**	**9.10E-04**	**9.10E-04**
Estimated Indoor Air Concentration	**54.6**	**41.6**	**54.6**	**44.2**	**31.0**	**27.0**	**5.5**	**15.5**

PROPERTY 4

Soil Gas Bore	Property 4 - 4P
Sample Date	06/08/2015
Bore Depth (m)	Sub-slab
Sample No.	15-1015
Concentration (ug/m^3)	
Trichloroethene	**390**
Attenuation Factor - Indoor Air	**2.60E-02**
Estimated Indoor Air Concentration	**10.1**

PROPERTY 5

Soil Gas Bore	Property 5 - 3P
Sample Date	06/08/2015
Bore Depth (m)	Sub-slab
Sample No.	15-1014
Concentration (ug/m^3)	
Trichloroethene	**20000**
Attenuation Factor - Indoor Air	**2.60E-02**
Estimated Indoor Air Concentration	**520.0**

FIGURE A4

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
SOIL VAPOUR SAMPLING

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 6

Soil Gas Bore	**SV41-P**	**SV42-P**
Sample Date	07/08/2015	07/08/2015
Bore Depth (m)	Sub-slab	Sub-slab
Sample No.	15-1029	15-1030
Concentration (ug/m^3)		
Trichloroethene	**10000**	**6300**
Attenuation Factor - Indoor Air	**2.60E-02**	**2.60E-02**
Estimated Indoor Air Concentration	**260.0**	**163.8**

PROPERTY 7

Soil Gas Bore	**Property 7 - 2P**
Sample Date	06/08/2015
Bore Depth (m)	Sub-slab
Sample No.	15-1016
Concentration (ug/m^3)	
Trichloroethene	**24000**
Attenuation Factor - Indoor Air	**2.60E-02**
Estimated Indoor Air Concentration	**624.0**

PROPERTY 8

Soil Gas Bore	**Property 8 - 1P**	**Property 8 - 2P**	**SV39-S**	**SV40-S**
Sample Date	13/08/2015	13/08/2015	13/08/2015	13/08/2015
Bore Depth (m)	Sub-slab	Sub-slab	0.85	0.85
Sample No.	15-1035	15-1036	15-1033	15-1034
Concentration (ug/m^3)				
Trichloroethene	**29000**	**16000**	**1600**	**880**
Attenuation Factor - Indoor Air	**2.60E-02**	**2.60E-02**	**1.00E-02**	**1.00E-02**
Estimated Indoor Air Concentration	**754.0**	**416.0**	**16.0**	**8.8**

PROPERTY 9

Soil Gas Bore	**SV29-S**	**SV30-S**
Sample Date	06/08/2015	06/08/2015
Bore Depth (m)	1.05	0.85
Sample No.	15-1018	15-1019
Concentration (ug/m^3)		
Trichloroethene	**500**	**620**
Attenuation Factor - Indoor Air	**1.00E-02**	**1.00E-02**
Estimated Indoor Air Concentration	**5.0**	**6.2**

FIGURE A4

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
SOIL VAPOUR SAMPLING

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

PROPERTY 11

Soil Gas Bore	SV08-P1	SV08-P2		SV08-S		SV08-M	SV08-D
Sample Date	28/04/2015	28/04/2015	03/06/2015	28/04/2015	03/06/2015	27/04/2015	27/04/2015
Bore Depth (m)	Sub-Slab	Sub-Slab	Sub-slab	0.85	0.85	1.85	3.85
Sample No.	15-435	15-436	15-646	15-437	15-644	15-438	15-439
Concentration (ug/m^3)							
Trichloroethene	<6	**31**	**22**	**240**	**200**	<7	<7
Attenuation Factor - Indoor Air	**2.60E-02**	**2.60E-02**	**2.60E-02**	**1.00E-02**	**1.00E-02**	**9.10E-04**	**3.80E-04**
Estimated Indoor Air Concentration	**<6**	**0.8**	**0.6**	**2.4**	**2.0**	**<7**	**<7**

Soil Gas Bore	SV01-M		SV02-S		SV02-M	SV02-D	SV03-S		SV03-M	SV03-D
Sample Date	28/04/2015	02/06/2015	27/04/2015	02/06/2015	27/04/2015	27/04/2015	27/04/2015	02/06/2015	27/04/2015	27/04/2015
Bore Depth (m)	3.85	3.85	1.85	1.85	3.85	6.35	1.85	1.85	3.85	6.35
Sample No.	15-417	15-637	15-418	15-638	15-420	15-421	15-422	15-639	15-423	15-424
Concentration (ug/m^3)										
Trichloroethene	**78000**	**120000**	**40000**	**36000**	**93000**	**97000**	**7000**	**5800**	<7	**57000**
Attenuation Factor - Indoor Air	**3.80E-04**	**3.80E-04**	**9.10E-04**	**9.10E-04**	**3.80E-04**	**2.20E-04**	**9.10E-04**	**9.10E-04**	**3.80E-04**	**2.20E-04**
Estimated Indoor Air Concentration	**29.6**	**45.6**	**36.4**	**32.8**	**35.3**	**21.3**	**6.4**	**5.3**	**<7**	**12.5**

Soil Gas Bore	SV04-M		SV05-M		SV06-S		SV06-M	SV06-D	SV07-S		SV07-M	SV07-D
Sample Date	28/04/2015	02/06/2015	28/04/2015	02/06/2015	28/04/2015	02/06/2015	28/04/2015	28/04/2015	28/04/2015	02/06/2015	28/04/2015	28/04/2015
Bore Depth (m)	3.85	3.85	3.85	3.85	1.85	1.85	3.85	6.35	1.85	1.85	3.85	6.35
Sample No.	15-425	15-640	15-426	15-641	15-427	15-642	15-428	15-430	15-431	15-643	15-432	15-434
Concentration (ug/m^3)												
Trichloroethene	**3100**	**2800**	**5600**	**5500**	**530**	**490**	**1100**	**33**	**69**	**68**	**270**	**2700**
Attenuation Factor - Indoor Air	**3.80E-04**	**3.80E-04**	**3.80E-04**	**3.80E-04**	**9.10E-04**	**9.10E-04**	**3.80E-04**	**2.20E-04**	**9.10E-04**	**9.10E-04**	**3.80E-04**	**2.20E-04**
Estimated Indoor Air Concentration	**1.2**	**1.1**	**2.1**	**2.1**	**0.5**	**0.4**	**0.4**	**0.0**	**0.1**	**0.1**	**0.1**	**0.6**

Soil Gas Bore	SV11-S	SV12-S	SV13-S	SV14-S	SV15-S	SV16-S	SV17-S	SV18-S	SV19-S	SV19-M	SV19-D
Sample Date	17/07/2015	17/07/2015	17/07/2015	17/07/2015	17/07/2015	17/07/2015	17/07/2015	17/07/2015	16/07/2015	16/07/2015	16/07/2015
Bore Depth (m)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	1.85	3.85
Sample No.	15-873	15-874	15-875	15-876	15-877	15-878	15-879	15-880	15-881	15-882	15-883
Concentration (ug/m^3)											
Trichloroethene	**<8**	**5300**	**<8**	**<8**	**2400**	**<8**	**<8**	**150**	**2000**	**4900**	**23000**
Attenuation Factor - Indoor Air	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**9.10E-04**	**3.80E-04**
Estimated Indoor Air Concentration	**<8**	**53.0**	**<8**	**<8**	**24.0**	**<8**	**<8**	**1.5**	**20.0**	**4.5**	**8.7**

FIGURE A4

ASSESSMENT OF VAPOUR INTRUSION RISK PRIORITY
TCE CONCENTRATIONS
SOIL VAPOUR SAMPLING

RESPONSE RANGES	< Detection	< 2 µg/m3	2 to <20 µg/m3	20 to <200 µg/m3	200+ µg/m3
	"No Action"	"Validation"	"Investigation"	"Intervention"	"Accel. Intervention"

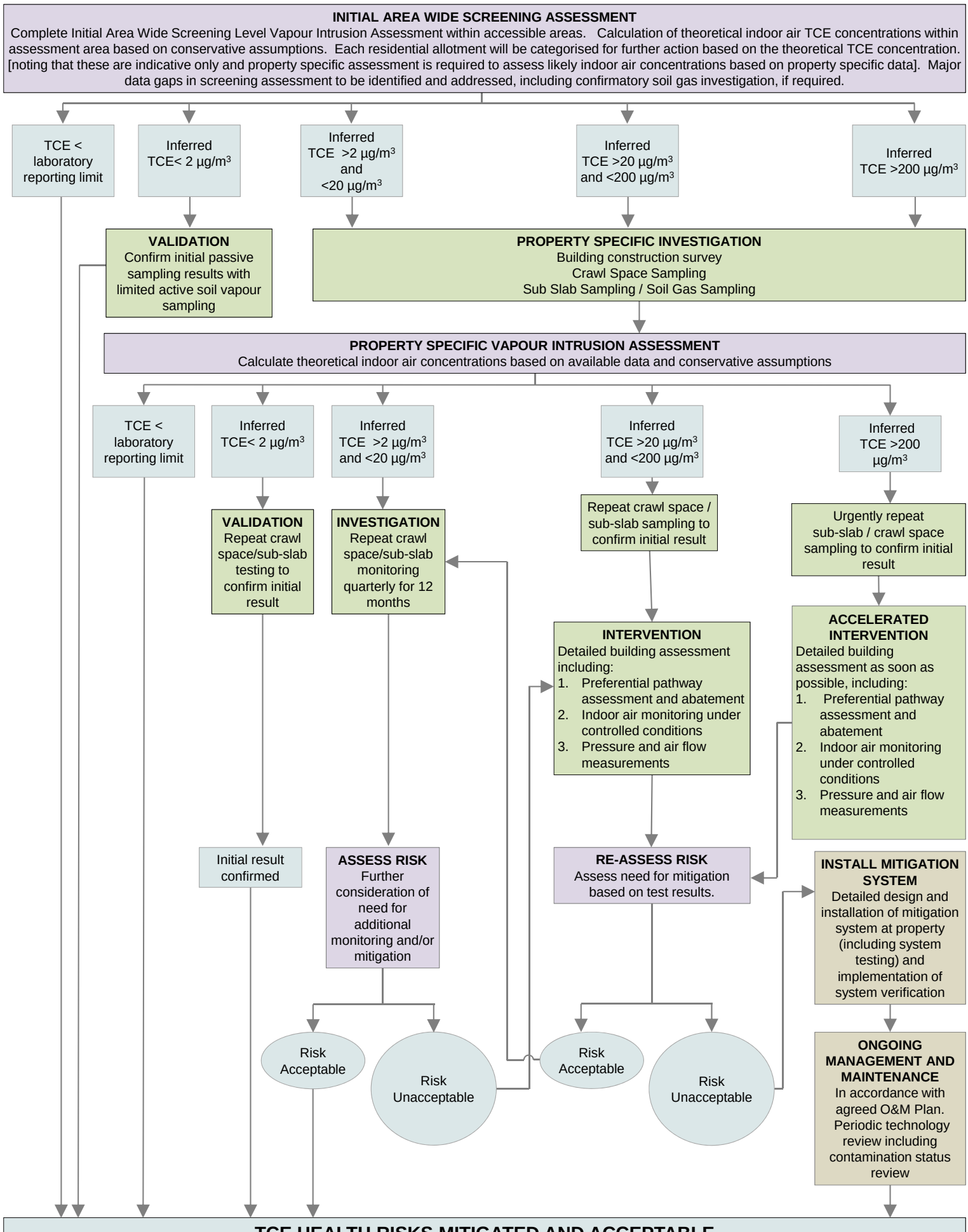
Soil Gas Bore	SV20-S	SV20-M	SV20-D	SV21-S	SV21-M	SV21-D	SV22-S	SV22-M	SV22-D	SV23-S	SV24-S	SV25-S
Sample Date	16/07/2015	16/07/2015	16/07/2015	16/07/2015	16/07/2015	16/07/2015	16/07/2015	16/07/2015	16/07/2015	17/07/2015	17/07/2015	16/07/2015
Bore Depth (m)	0.85	1.85	3.85	0.85	1.85	3.85	0.85	1.85	3.85	0.85	0.85	0.85
Sample No.	15-885	15-886	15-888	15-889	15-891	15-892	15-893	15-894	15-895	15-896	15-897	15-898
Concentration (ug/m^3)												
Trichloroethene	**360**	**290**	**1100**	**12000**	**22000**	**38000**	**19000**	**19000**	**52000**	**<8**	**57**	**20000**
Attenuation Factor - Indoor Air	**1.00E-02**	**9.10E-04**	**3.80E-04**	**1.00E-02**	**9.10E-04**	**3.80E-04**	**1.00E-02**	**9.10E-04**	**3.80E-04**	**1.00E-02**	**1.00E-02**	**1.00E-02**
Estimated Indoor Air Concentration	**3.6**	**0.3**	**0.4**	**120.0**	**20.0**	**14.4**	**190.0**	**17.3**	**19.8**	**<8**	**0.6**	**200.0**

Soil Gas Bore	SV26-S	SV27-S	SV28-S	SV31-S	SV32-S	SV33-S	SV34-S	SV35-S	SV36-S	SV37-S	SV38-S
Sample Date	16/07/2015	17/07/2015	17/07/2015	13/08/2015	06/08/2015	06/08/2015	06/08/2015	06/08/2015	06/08/2015	07/08/2015	13/08/2015
Bore Depth (m)	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.65	0.85	0.85
Sample No.	15-899	15-900	15-901	15-1031	15-1020	15-1021	15-1022	15-1024	15-1025	15-1028	15-1032
Concentration (ug/m^3)											
Trichloroethene	**100**	**80**	**25000**	**3100**	**<7**	**1400**	**83**	**3100**	**580**	**<8**	**16**
Attenuation Factor - Indoor Air	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**	**1.00E-02**
Estimated Indoor Air Concentration	**1.0**	**0.8**	**250.0**	**31.0**	**<7**	**14.0**	**0.8**	**31.0**	**5.8**	**<8**	**0.2**

APPENDIX B

Vapour Mitigation Strategy Decision Flow Chart

BEVERLEY ASSESSMENT AREA
VAPOUR MITIGATION STRATEGY – DECISION FLOW CHART



APPENDIX C

Important Information Relating to this Report

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

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The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

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Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

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By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

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