APPENDIX C
COMPARATIVE HEALTH RISK ASSESSMENT

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Made by	**Belinda Goldsworthy, Nwakamma Ahubelem**
Checked by	**Belinda Sinclair**
Approved by	**Fiona Robinson**
Description	**Ramboll Environ Australia Pty Ltd has prepared this Comparative Health Risk Assessment (CHRA) as supporting information for the Capped Waste Stockpile Waste Management Options Evaluation Study at the request of Hydro Aluminium Kurri Kurri.**

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Ramboll Environ
Level 2, Suite 19B
50 Glebe Road
PO Box 435
The Junction
NSW 2291
Australia
T +61 2 4962 5444
F +61 2 4962 5888
www.ramboll-environ.com

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ABBREVIATIONS

µg	Microgram
µg/L	micrograms per litre
µS	Micro Siemens
ADI	Acceptable Daily Intake
AEC	Area of Environmental Concern
AEL	Acceptable Exposure Level
AF	Assessment Factor
ANZECC	Australian and New Zealand Environment and Conservation Council
ATSDR	Agency for Toxic Substances and Disease Registry
B	Bioavailability
BaP	Benzo(a)pyrene
bgs	Below ground surface
CalEPA	California Environmental Protection Agency
CCO	Chemical Control Order
CH_4	Methane
CHRA	Comparative Health Risk Assessment
cm	Centimetres
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoPC	Chemical of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CWS	Capped Waste Stockpile
DAF	Dermal Absorption Factor
DEC	Department of Environment and Conservation
DPI	Department of Primary Industries
EC	Electrical Conductivity
EPA	Environment Protection Authority
EPC	Exposure Point Concentration
ESA	Environmental Site Assessment
GAF	Gastrointestinal Absorption Factor
GLC	Ground Level Concentration
H_2S	Hydrogen Sulfide
ha	Hectares
HCN	Hydrogen Cyanide
HI	Hazard Index
HIL	Health Investigation Level
HQ	Hazard Quotient
HRA	Human Health Risk Assessment
ILCR	Increased Lifetime Cancer Risk

IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
kg	Kilograms
km	Kilometre
L	Litre
m	Metre
m^2	Square metre
mg/kg	Milligrams per kilogram
mg	Milligram
mm	Millimetre
MARL	Maximum Allowable Risk Level
MDI	Mean Daily Intake
MRL	Minimal Risk Level
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NOEL	No-Observed Effect Level
NOAEL	No-Observed-Adverse-Effect-Level
NO_2	Nitrogen Dioxide
NSW	New South Wales
OEHHA	Office of Environment Health Hazard Assessment
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
ppm	Parts per million
PPRTV	Provisional Peer Reviewed Toxicity Value
RSLs	Regional Screening Levels
RfC	Reference Concentration
RfD	Reference Dose
SO_2	Sulfur Dioxide
SPL	Spent Pot Liner
SPR	Source-Pathway-Receptor
TC	Tolerable Concentration (in air)
TDI	Tolerable Daily Intake
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
US EPA	United States Environmental Protection Agency
WHO	World Health Organisation

EXECUTIVE SUMMARY

This Comparative Health Risk Assessment (CHRA) was prepared by Ramboll Environ Australia Pty Ltd (Ramboll Environ) on behalf of Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to inform the Capped Waste Stockpile Waste Management Options Evaluation Study (the Management Options Analysis) for submission to the NSW Environmental Protection Authority (EPA). This CHRA was prepared to assess the implications to human health from the identified Management Options for the Capped Waste Stockpile (CWS) at the former Hydro Aluminium Kurri Kurri aluminium smelter located at Hart Road Loxford (the Smelter).

This CHRA also assessed the potential health risk associated with a number of different 'additional scenarios' for each Management Option, that were considered to have a lower probability of occurrence such as exposure scenarios associated with potential failures in technology or as a result of human error. Assessment of these additional scenarios was undertaken to provide the Project stakeholders information regarding potential health risks that could occur however unlikely the probability of the event was considered to be. The CHRA estimated health risks for these additional scenarios assuming that they occurred as a single isolated event. The Management Options Analysis then scaled these results in accordance with their assigned probability of occurrence, which was used to estimate the total risk associated with each of the Management Options.

This CHRA was undertaken in accordance with Australian recommended guidance for performing human health risk assessments. This process involved 1) reviewing the project description, 2) identifying the source-pathway-receptor (SPR) linkages for each activity (i.e. developing a conceptual site model (CSM)), and 3) quantitatively and qualitatively assessing the potential health risk for all complete SPR linkages.

A summary of the CSM, which formed the basis of the CHRA, is provided below:

- *Health Impact Sources:* chemicals which exceeded appropriate Tier 1 health-based assessment criteria in groundwater, surface water, soil and soil gas in the CWS and down-hydraulic gradient. Asbestos within the CWS was also considered to be a health impact source. Particulate and vapour concentrations were not predicted to occur above Tier 1 health-based acute and chronic assessment criteria.
- *Exposure pathways and receptors*: **Table C0.1** summarises the human receptors and exposure pathways that were assessed in the CHRA. Offsite recreational children who play near/in surface water bodies in the Swamp Creek area were considered to be the most sensitive offsite receptors. Onsite Workers for the Do Nothing scenario were considered to undertake activities such as monitoring and minor capping repairs that do not reach the CWS material. Onsite Workers for Management Options 2-7 were considered to undertake activities associated with remediation of the CWS material.

Table C0.1 Conceptual Site Model Summary

Exposure Pathway	Onsite CWS Workers	Onsite Monitoring Workers[b]	Offsite Recreational Receptors[c]	Offsite Intrusive Maintenance Worker[d]
Dermal contact and incidental ingestion of soil	✓ (Options 2-7)	X	X	X
Dermal contact and incidental ingestion of groundwater	✓ (Options 2-7)	✓ (Do Nothing and Options 2-4)	✓ (Do Nothing)	✓ (Do Nothing)

Inhalation of vapours within the CWS excavation from groundwater	✓ (Options 2-7)	X	X	X
Exposure to asbestos	✓ (Options 2-7)[a]	X	X	X

Notes:
✓ Indicates a potential exposure pathway is present which will be assessed further in the CHRA
X Indicates a potential exposure pathway is not considered to be present, and will not be assessed further in the CHRA
a) Potential health risks are assessed qualitatively for the asbestos exposure scenario.
b) Monitoring workers for the CWS (Do Nothing) and proposed Containment Cell (Options 2-4)
c) Adult and child recreational users of the Swamp Creek area located down hydraulic gradient of the CWS (Do Nothing scenario)
d) Adult workers who undertake intrusive activities to maintain already installed subsurface utilities located in the down gradient area of the CWS (Do Nothing scenario)

On the basis of the available data and identified assumptions, the quantitative risk characterisation process identified that:

- Do Nothing scenario:
  - Threshold and non-threshold health risks for onsite workers who conduct monitoring of the CWS leachate were low and acceptable.
  - Health risks were similarly low for future offsite maintenance workers undertaking repairs on subsurface utilities where groundwater enters a trench.
  - Unacceptable health risks were identified for offsite recreational receptors who have the potential to incidentally ingest fluoride in surface water during recreational play in surface water bodies in the Swamp Creek area.
- Management Options 2-7:
  - Threshold and non-threshold health risks for onsite workers who conduct monitoring of the proposed onsite Containment Cell leachate were low and acceptable.
  - Potentially unacceptable threshold health risks were identified via the incidental ingestion of groundwater (driven by fluoride concentrations) and dermal contact with groundwater (driven by benzo(a)pyrene concentrations) during removal of the CWS material.
  - Threshold risks for the other exposure pathways (direct contact with soil and vapour inhalation within the CWS excavation) were considered to be low and acceptable.
  - Potentially unacceptable carcinogenic health risks were identified for Management Options 2-7 with estimates ranging between 1 in 50,251 (Management Options 2 and 4) and 1 in 4762 (Management Option 6). Dermal contact with benzo(a)pyrene in groundwater was identified to be the risk driving compound and exposure pathway for Management Options 2-7.

Potential health risks associated with exposure to asbestos within the CWS material was assessed by considering the number of activities that involved disturbance of the CWS material (defined as a soil disturbance event) and the duration of each activity. Each soil disturbance event was allocated a value of 0.5, which was then multiplied by the duration of the event (measured in years). Therefore the Management Option with the greater number of soil disturbance events and longer duration would result in a higher 'Asbestos Health Risk' value. This process identified that the Management Option with the greatest asbestos health risk was Management Option 6, followed by (in descending order):

- Management Option 3
- Management Option 5
- Management Option 7
- Management Option 4
- Management Option 2
- Do nothing (this Management Option had '0' asbestos health risk).

The asbestos risk estimates were greater for the Management Options involving more soil disturbance activities (such as Management Option 3) and for Management Options with a longer overall project duration (such as Management Option 6). Management Option 2 had the lowest asbestos health risk due to the shorter project duration time, and only three soil disturbance events.

Results presented in this CHRA will be compared in conjunction with other considerations, such as Ecological Health, Safety and Greenhouse Gas when identifying the most appropriate Management Option for the CWS.

1. INTRODUCTION

This Comparative Health Risk Assessment (CHRA) has been prepared by Ramboll Environ Australia Pty Ltd (Ramboll Environ) on behalf of Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to inform the Capped Waste Stockpile Waste Management Options Analysis (the Management Options Analysis) for submission to the NSW Environmental Protection Authority (EPA). This CHRA was prepared to assess the implications to human health from the identified Management Options for the Capped Waste Stockpile (CWS) at the former Hydro Aluminium Kurri Kurri aluminium smelter located at Hart Road Loxford (the Smelter).

1.1 Background

The objective of the Management Options Analysis relevant to this CHRA is to prepare a report for submission to the NSW EPA that provides a detailed assessment of the options considered for the the management of the wastes within the CWS (the Management Options).

The rational for, and background to, the identified Management Options is detailed in **Section 2** and **Section 3** of the Management Options Analysis. Six options (Management Options 2 to 7) have been identified for the management of the wastes within the CWS and for comparison against a do nothing scenario. These Management Options are the subject of the Management Options Analysis and this CHRA. All Management Options include the demolition and removal of Smelter structures, however this is not assessed as part of the Management Options Analysis. A brief description of the CWS Management Options is presented in **Table C1.1**.

Table C1.1: Capped Waste Stockpile Waste Management Options

Option	Description	Outline
1	Do Nothing	The CWS would remain in its current location, with no improvement works. Ongoing groundwater, leachate and gas monitoring would occur at the CWS. Visual inspections would also be required to identify any faults in the capping layer. Long-term management and maintenance would comprise vegetation cover maintenance such as mowing, weed and tree/deep rooted plant removal and cap repairs as required. Future land use surrounding the CWS would be as per the 'Rezoning Master Plan' illustrated on **Figure C1, Appendix C1**.
2	Containment Cell	Removal of the CWS and onsite transport of materials for placement in an onsite Containment Cell. This would involve ongoing long term monitoring and maintenance of the Containment Cell for leachate, gas and any visual changes.
3	Sorting of Recyclables from the CWS and Treatment of Non-Recyclables Placed in Containment Cell	Removal of the CWS and onsite transport of materials for placement in an onsite Containment Cell. Potentially recyclable materials from the CWS (steel and carbon) would be sorted, cleaned, validated and make available for recycling. Non-recyclable materials from the CWS would be crushed prior to being treated to comply with the Chemical Control Order (CCO) and placement in the onsite Containment Cell. The ongoing maintenance and monitoring of the onsite Containment Cell would be as per Management Option 2.
4	Treatment of All Material within Containment Cell	Removal of the CWS and placement of all materials in the onsite Containment Cell with layers of lime interlayered with the placed CWS material. This option does not include any recycling or sorting of material. The ongoing maintenance and monitoring of the onsite Containment Cell would be as per Management Option 2.
5	Offsite Disposal of CWS to Licensed Waste Facility in NSW	Removal of the CWS, separation of the steel for cleaning and recycling and transport of the remaining waste offsite to a licensed waste management facility/facilities in NSW. Treatment to comply with the COO would occur at the receiving facility. There would be ongoing maintenance and monitoring at the receiving waste management facility/facilities.
6	Offsite Disposal of CWS to Tellus Facility	Removal of the CWS material, separation of the steel for cleaning and recycling and heat treatment of the remaining material to 600 °C (in an onsite purpose built facility) prior to transportation offsite via road and rail to a salt mine facility in the Northern Territory. The receiving facility would dispose of the CWS material without further treatment. There would be ongoing maintenance and monitoring at the receiving waste management facility.
7	Onsite Destruction (Plasma Gasification) of CWS Material	Removal of the CWS material, separation of the steel for cleaning and recycling with the remaining waste material being subject to an onsite plasma gasification process to remove fluorides and cyanides. By-products of the plasma gasification process would include vitrified rock (slag) and elemental metal which would theoretically be suitable for a beneficial re-use.

1.2 CHRA Objectives

The objectives of this CHRA are to assess the potential for unacceptable human health risks posed to onsite and offsite human receptors that may result from potential contact with or exposure to chemicals (including asbestos) arising from the Management Options for the CWS.

The CHRA also assesses the potential health risk via a number of 'additional scenarios' for each Management Option that includes all potential exposure pathways that have a lower probability of occurring (refer to **Section 7.3.3**).

The risk estimates generated for each Management Option will be compared in conjunction with other considerations, such as Ecological Health, Safety, Greenhouse Gas and Technology Risk, when identifying the most appropriate Management Option for the CWS. These results will contribute to the comparative assessment of the Management Options for the CWS to assist Hydro and NSW regulators in determining the Management Option with the most appropriate outcomes.

1.3 CHRA Methodology

This CHRA was undertaken in accordance with the Australian guidance for conducting human health risk assessment as outlined in enHealth (2012) *Environmental Health Risk Assessment, Guidelines for assessing human health risks from environmental hazards*. *Commonwealth of Australia*.

Health Risk Assessment (HRA) is used to inform and assist decision-makers in managing chemical exposure issues with careful consideration of site-specific circumstances. It is used to estimate, in a way that is adequately protective of health, the potential for chemical exposures to represent a risk of adverse effects on the health of populations potentially exposed to it. Since the goal is to inform decision-makers regarding safe choices and approaches to chemical usage or management, HRA intentionally does not attempt to establish an upper limit of exposure above which adverse effects are expected, but conversely, employs criteria adjusted so that they are expected to be safe for foreseeably exposed groups, including sensitive subgroups. In other words, comparisons are made to criteria known to be safe, not exposure levels reflecting a threshold at which effects are expected. Margins of safety are built into the process to achieve this. HRA in this form cannot serve as a means to evaluate health conditions reported by individuals and, thus, is not a substitute for evaluation by a medical professional for individuals concerned about their specific health status.

HRA in this context is achieved by protectively projecting the dose that individuals might receive through exposure scenarios that reflect the nature of chemical use and how humans can come in contact with the chemicals. These include incidental exposure to impacted soil, sediment and/or water as a result of everyday activities, consumption of food items containing the chemicals, and direct contact to chemical products. This estimated dose can then be compared against doses that are derived to be protective against any adverse impacts to health, as published by authoritative bodies and health protection agencies. These comparison doses are chosen specifically based upon the most sensitive type of potential effects for the chemical.

Where potential health risks could not be assessed quantitatively due to absence of analytical concentrations (for example asbestos exposure) this CHRA utilised qualitative risk assessment approaches which is described in **Section 7.1.3**.

This CHRA also assesses the potential health risk associated with a number of different 'additional scenarios' for each Management Option that are considered to have a lower likelihood of occurring. The methodology for assessing the potential health risk for these additional scenarios was in accordance with the enHealth (2012) methodology described above.

The risk assessment process adopted for this CHRA follows the enHealth (2012) guidance, and is illustrated in **Flowchart 1** on page 15.

1.3.1 Analysis of Uncertainty

Inherent in each step of the risk assessment process are uncertainties that may ultimately affect the final risk estimates and conclusions. Uncertainties may exist in many areas including the information used to characterise chemical usage and distribution, estimation of potential exposures and derivation of toxicity criteria. In general, uncertainties may result in either an over or under-estimation of risks. However, in conducting a HRA, where uncertainties are recognised, a protective approach and assumptions are adopted in order that the final results are expected to overestimate rather than underestimate potential exposures and risks.

A discussion of the uncertainties in this CHRA for the Management Options Analysis is discussed after each corresponding section throughout the report.

1.4 CHRA Report Structure

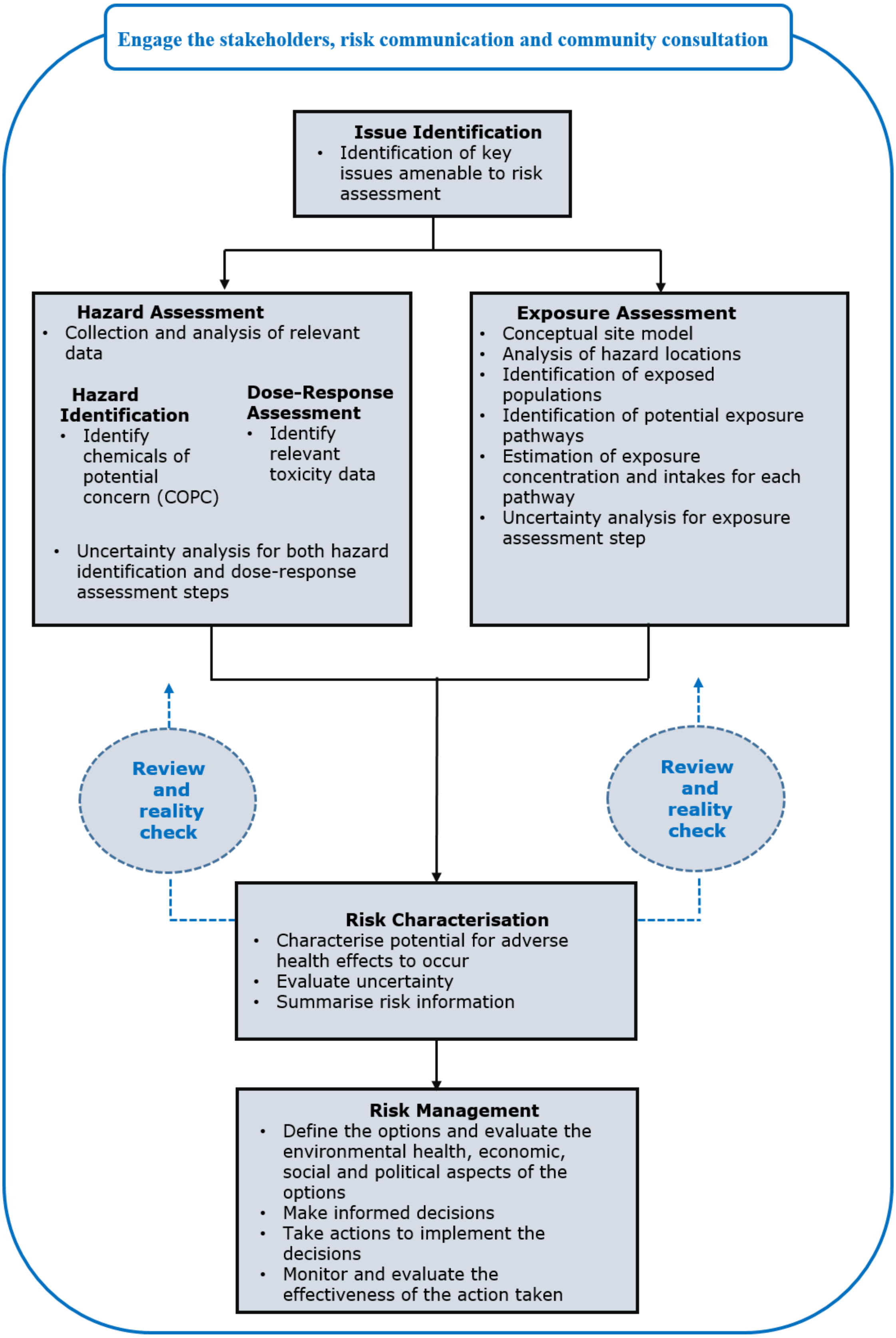
This CHRA follows the guidance described in **Section 1.3** and the CHRA process illustrated in **Flowchart 1** on page 10, and this CHRA report has been structured to reflect these risk assessment stages including:

- Section C2: Site Setting
- Section C3: Issue Identification
- Section C4: Data Collection and Evaluation (including Conceptual Site Model)
- Section C5: Exposure Assessment
- Section C6: Hazard Assessment (Hazard Identification & Dose-Response Assessment)
- Section C7: Risk Characterisation
- Section C8: Conclusions
- Section C9: Limitations
- Section C10: References

Supporting information used to form conclusions in this CHRA is provided in the following Appendices:

- Appendix C1: Figures
- Appendix C2: Air Quality Study
- Appendix C3: Tables
- Appendix C4: Algorithms
- Appendix C5: Toxicological Profiles
- Appendix C6: Model inputs and risk estimates
- Appendix C7: Model inputs and risk estimates for additional scenarios

Flowchart 1: Environmental Health Risk Assessment Model (enHealth, 2012).



2. SITE SETTING

Site description information presented in this section is considered relevant for the CHRA when identifying the exposure scenarios likely to result from the different Management Options.

2.1 Site Layout and Description

2.1.1 Onsite

The Smelter is located on Hart Road, Loxford near Kurri Kurri in New South Wales, Australia. The area of land owned and managed by Hydro (the Hydro Land) incorporates the former Smelter area (the Smelter Site) and the surrounding buffer zone, comprising approximately 2,000 ha.

The Smelter Site is located approximately 3 km north of the Kurri Kurri central business district central business district, approximately 10 km south of the Maitland central business district and approximately 33 km to the northwest of the Newcastle CBD at Hart Road in Loxford, NSW within the Cessnock local government area.

The Hydro Land surrounding the Smelter Site includes bushland, grazing land, rural residences and recreational facilities. The Hunter Expressway passes through the south-western corner of the Hydro Land, and the South Maitland Railway passes through the eastern section of the Hydro Land.

The CWS located within the Smelter Site which is accessed through one main entrance located on the southern boundary off Hart Road.

The CWS is a repository of waste arising during the operations of the aluminium smelter and includes Spent Pot Liner (SPL), anodes, scrubber bags, concrete, brick, bulky waste, fines and other smelter wastes. The CWS is located near the eastern boundary of the Smelter and adjacent to the surrounding Hydro owned buffer land. The CWS was maintained as an uncapped bunded waste repository prior to being capped with clay under development consent in the mid 1990's. At this time, impacts to vegetation in the buffer zone downgradient of the CWS were observed. Leachate from the CWS was also known to have impacted on groundwater and investigations commenced to investigate the extent of groundwater impact. These investigations identified that leachate impacted groundwater likely originated from the northeast corner of the CWS and extended approximately 250 m northeast. The CWS and associated leachate impacted groundwater were identified as Area of Concern (AEC) 1 in the Phase 2 Environmental Site Assessment completed by Ramboll Environ in 2012 (Ramboll Environ, 2012a).

The location of the CWS within the Smelter is illustrated on **Figure C2, Appendix C1**.

2.1.2 Offsite

The Smelter is surrounded by the following features:

- *Surface water features*: Swamp Creek, Black Waterholes Creek and several smaller creeks are tributaries of Wentworth Swamp, and are located to the north of the CWS. Swamp Creek is approximately 180 m to the east of the southeast corner of the Smelter and flows in a northerly direction in the east of the Hydro Land. Swamp Creek varies in width but is up to 10 m wide within the Hydro Land. Water depth is unknown. Swamp Creek flows through Weston and Loxford before flowing through Wentworth Swamp, which is a network of low lying areas between Maitland and Loxford connected by Swamp Creek. Black Waterholes Creek flows in a northerly direction in the northwest of the Hydro Land. An unnamed watercourse is located approximately 45 m to the west of the Site and is a tributary to Black Waterholes Creek. Other small ephemeral watercourses and low lying areas are located to the east of the Smelter Site and drain to Swamp Creek. Surface water from the Swamp Creek eventually flows into Wallis Creek which discharges to the Hunter River near Maitland, approximately 15 km northeast of the Smelter.

  Swamp Creek runs roughly north-south along the boundary between the vegetated buffer zone to the west and the predominantly cleared agricultural land to the east. In its natural state the creek would be considered ephemeral; however, treated effluent is discharged directly into Swamp Creek from the Kurri Kurri Wastewater Treatment Works located 2.5 km upstream from the investigation area and diffuse runoff occurs from surrounding agricultural and urban areas. The main remnant vegetation and mangrove species include *Angophora bakeri, Corymbia gummifera, Eucalyptus agglomerata, Eucalyptus resinifera, Eucalyptus parramattensis subsp. decadens, Eucalyptus fibrosa, Eucalyptus punctata, Eucalyptus racemosa,* and *Eucalyptus capitellata*, she-oak (*Casuarina*), swamp mahogany (*Eucalyptus robusta*) trees, and a prominent groundcover of soft leaved herbs and grasses (DECC 2007, Bell 2004).

A semi-permanent dam is located to the east of the CWS (adjacent to Swamp Creek), which collects surface water runoff from the Smelter. This dam and aforementioned surface water features are accessible to the public. The location of these surface water features is illustrated on **Figure C3**, **Appendix C1**.

- *Residential*: the CWS is approximately 440 m to the north of the nearest sensitive receptor, which is a rural residence owned by Hydro. The nearest rural residence not owned by Hydro is approximately 500 m to the southeast, and the next nearest property is approximately 750 m to the southeast. There are approximately 24 rural residences within a 1 km radius of the Smelter, of which 15 residences are on Hydro land. The nearest residential area to the Smelter is Weston, which is approximately 1.8 km to the southwest.
- *Recreational*: the Kurri Kurri Speedway and the Kurri Kurri Junior Motorcycle Club facility are approximately 500 m to the east of the CWS. Anecdotal information suggests that users of this facility often access the vegetated area east of the CWS, in the area with known groundwater impacts due to CWS leachate. It is also understood that recreational users have the potential to visit the semi-permanent dam to the east of the CWS, which collects surface water runoff from the Smelter.
- *Educational Facilities*: the Kurri Kurri TAFE is located approximately 1.5 km to the southeast of The Site and Kurri Kurri High School is approximately 1.9 km to the southeast of the Smelter.
- *Health Care Facilities*: the Kurri Kurri Family Medical Centre is located approximately 3 km south of the Smelter. The Royal Freemason's Benevolent Institute Masonic Village/Nursing Home Kurri Kurri is located 3.6 km south/southwest of the Smelter.
- *Subsurface Utilities*: information provided by Hydro indicates that subsurface electrical conduits and irrigation channels are present to the north and northeast of the CWS. According to the current 'Proposed Hydro Land Rezoning Plan' (**Figure C1, Appendix C1**), the area immediately down-gradient of the CWS location will be zoned for 'Heavy Industrial', 'Environmental Conservation' and 'Rural Landscape'. The 'Heavy Industrial' zoning would likely result in the installation of additional subsurface utilities.

The location of the Smelter in relation to the offsite surroundings is presented in **Figure C4, Appendix C1**.

2.2 Geology

2.2.1 Capped Waste Stockpile Geology

The CWS geology has been discussed in Ramboll Environ (2016a). Field work undertaken for the CWS characterisation reported that topsoil extends to approximately 0.5 m, overlying up to 1.1 m of clay capping material. Clays were underlain by gravels comprising the gas collection layer. Topsoil, clays and gravels were not observed to contain waste materials. The depth of fill within the CWS was approximately 12 meters below ground surface (m bgs), with the exception of MW201 where fill was encountered down to approximately 10.5 m bgs.

Table C2.1 provides a general description of material encountered during the installation of soil boreholes within the CWS. Location of the boreholes is illustrated on **Figure C5, Appendix C1**.

Table C2.1: Subsurface Geology Beneath the CWS

Depths (m bgs)	Lithology
0 – 0.5	Topsoil, SAND, brown, fine to medium grained, moist
0.5 – 1.6	CLAY, red and grey mottled, medium plasticity, dry (stockpile cap)
1.6 – 1.8	Gravel, dark grey / black, fine to medium grained (gas buffer layer)
1.8 – 12	Carbon, spent potlining (85 %), bath (5 %), and other material such as steel and clay (10 %)
>12	A mixture of sands and clays. Clays encountered were generally stiff with medium to high plasticity

2.2.2 Offsite Down-Hydraulic Gradient Geology

Geology encountered down-hydraulic gradient of the CWS consists of a complex interbedded quaternary sediments which comprises estuarine muds (high plasticity clay), fluvial channel sands (fine grained and coarse grained sands), sandy levee deposits (clayey sand/ sandy clay) and high energy flood deposits (coarse grained quartz sand). The shallow aquifer close to the monitoring wells installed offsite (refer to **Figure C6**, **Appendix C1**) has been delineated as an elongate and sinuous sand lens approximately 50 m wide and 250 m in length extending to the north east of the CWS. The shallow sand aquifer is surrounded vertically and horizontally by a discontinuous clay aquitard.

2.3 Hydrogeology

2.3.1 Site Hydrogeology

Groundwater was encountered within only four of the six groundwater monitoring wells installed through the CWS in November 2016 (Ramboll Environ, 2016a). Groundwater was limited within the CWS and in most cases was present just above the waste and natural surface interface. The reported depths to groundwater were 12.19 m bgs (MW202), 13.21 m bgs (MW203), 12.49 m bgs (MW204), and 12.45 m bgs (MW206). MW201 and MW205 were found to be dry during the sampling event.

The inferred direction of groundwater flow is discussed in Ramboll Environ (2017) and is reported to be northeast towards Swamp Creek.

2.3.2 Offsite Hydrogeology

A shallow (approximately 2 m bgs) semi-continuous sand aquifer within the Buffer Zone has been impacted by leachate originating from the eastern side of the CWS which is characterised by high pH (>9), elevated electrical conductivity (>5000 µS/cm), elevated fluoride (>200 mg/L) and total cyanide (>6 mg/L) concentrations and is brown in colour.

The shallow sand aquifer has been delineated as an elongate and sinuous sand lens approximately 50 m wide and 250 m in length extending to the northeast of the CWS. The shallow sand aquifer is surrounded vertically and horizontally by a discontinuous clay aquitard that has been less impacted by leachate in close proximity to the plume and not impacted by leachate at a distance from the plume.

The configuration of the aquifer is a result of the nature of the deposition of sediments within a former estuary during periods of sea level rise and fall. The location of the plume within the semi-continuous shallow sand aquifer constrained by the surrounding discontinuous clay aquitard suggests that the movement of the leachate groundwater plume is limited by the geology. The complexly interbedded Quaternary sediments comprise estuarine muds (high plasticity clay), fluvial channel sands (fine grained and coarse grained sands), sandy levee deposits (clayey sand/ sandy clay) and high energy flood deposits (coarse grained quartz sand).

The shallow nature of the semi-continuous sand aquifer results in the exfiltration of leachate impacted groundwater within topographically low areas of the Hydro Land and following high rainfall events. The impacts of exfiltration are observed on the eastern edge of the plume where dieback of vegetation has occurred (southern and northern vegetation impact areas). Brown coloured seepage is observed and evaporation of exfiltrated groundwater has left a white salt crust on surface soils in this area. The high electrical conductivity of the exfiltrated groundwater (up to 15,000 µS/cm) exceeds the limit (300 µS/cm) at which conditions are generally too saline for plant growth (ANZECC, 2000).

The location of the offsite monitoring wells is illustrated on **Figure C6, Appendix C1**.

2.4 Drainage and Flood Potential

There are five storage ponds located at the Smelter. Surface water from the Smelter is directed to these storage ponds via open channels and some concrete subsurface drainage lines. Surface water ponds known as 'East' and 'West' are pumped to the North Dams where excess surface water is discharged to an irrigation area under licence from the EPA (Environment Protection Licence (EPL) No. 1548). Surface water dams were constructed by excavation into the residual underlying extremely weathered bedrock.

Ex-filtrated leachate impacted groundwater has been observed to become overland flow discharging along a surface water flowpath to a small dam. During periods of high rainfall surface water within this dam is able to flow through a culvert structure to a larger dam which discharges to Swamp Creek (Ramboll Environ, 2017).

Currently, an active leachate interception trench placed at the toe of the CWS is intercepting leachate from below the CWS and diverting it to the East Surge Pond. Further down-gradient, a passive leachate interception trench intercepts groundwater following rain events and diverts this groundwater to the East Surge Pond. Surface water quality data from the East Surge Pond and North Dams are monitored for pH, fluoride and cyanide. Data from 2014 monitoring indicates that pH is neutral at 6.5 to 7 in both dams, fluoride concentrations have varied between 5.6 mg/L and 20 mg/L in the East Surge Pond and 14.8 mg/L to 18 mg/L in North Dam. Free cyanide concentrations are generally less than the laboratory detection limit. These fluoride concentrations are elevated compared to background levels, which is likely due to the flow of stormwater past the anode waste pile (located to the northwest of the CWS) prior to pumping to the North Dam.

The location of these surface water features and the overland flow path directions is illustrated on **Figure C3, Appendix C1**.

2.5 Groundwater Abstraction Wells

According to the NSW Department of Primary Industries – Water (DPI Water), there are 17 licensed groundwater abstraction wells located within the Hydro land. However, these registered wells are either for monitoring purposes or have been decomissioned. The other registered wells are outside a 2 km radius of the Hydro land and are registered for stock watering and irrigation purposes (NSW DPI Water, 2017).

3. ISSUE IDENTIFICATION

The Issue Identification process is intended to establish the context for the CHRA by a process of identifying the concerns of the stakeholders that need to be addressed, such as 'what is causing the identified concern?" and "why is the concern an issue?". It is a process of communication between stakeholders in the study, and its scope and complexity depends upon the scale of the subject of the study and the issues being dealt with.

3.1 Project Stakeholders

As outlined in **Section 1.1**, the purpose of the Management Options Analysis is to provide the NSW EPA with a detailed assessment of the options considered for the remediation of the CWS. A detailed discussion of the relevant consultation undertaken to date with the NSW EPA is provided in **Section 4.2** of the Management Options Analysis.

3.2 Risk Management Decisions

The results from this CHRA will contribute to the identification of the most suitable approach to be taken for the management/remediation of the CWS.

3.3 Nature of the Problem

In 2016, a Human Health Risk Assessment (HHRA) was prepared by Ramboll Environ to inform an EIS for submission to the Department of Planning and Environment (the Department) for the demolition and remediation of the Smelter Site. The data considered included predicted air quality, noise and vibration results likely to be generated by the Project. The HHRA assessed potential offsite and onsite human health risks associated with:

- demolition of Smelter structures;
- remediation of surface soil impacts;
- construction of a new onsite containment cell;
- excavation and disposal of CWS material into onsite containment cell;
- leachate and groundwater treatment; and
- monitoring and management of the new onsite containment cell.

Potential health risks were identified in the Ramboll Environ (2016) HHRA for onsite personnel exposed to groundwater beneath the CWS, and measures to be included in a Work Health and Safety Management Plan were recommended to mitigate these health risks.

The aim of this current CHRA is to compare the potential health risks associated with each Management Option for the CWS (refer to **Section 1.1**), and to identify which Management Option presents the lowest health risk. The risk estimates generated for each Management Option will be compared in conjunction with other considerations, such as Ecological Health, Safety, Greenhouse Gas and Technology Risk when identifying the most appropriate Management Option. The exposure scenarios assessed in the 2016 HHRA are similar to Management Option 2, with the exception of demolition and surface soil remedial activities which are not considered in any of the Management Options exposure scenarios.

3.3.1 Additional scenarios

This CHRA also assesses the potential health risk associated with a number of different 'additional scenarios' for each Management Option that are considered to have a lower likelihood of occurring. The 'additional scenarios' are detailed in **Section 7.3.4** for each Management Option and include exposure scenarios associated with potential failures in technology or as a result of human error. For example extreme weather events which may increase erosion, surface water runoff and/or leachate from the CWS or onsite containment cell; or a truck containing CWS material overturning onsite or offsite.

Consideration of health risks associated with the 'additional scenarios' was undertaken to provide the Project stakeholders information regarding potential health risks that could occur however unlikely the probability of the event was considered to be. The CHRA estimated health risks for these additional scenarios assuming that they occurred as a single isolated event. In the Management Options Analysis, the assessed health risks of the additional scenarios are to be scaled in accordance with their assigned likelihood and used to inform the total risk associated with each of the Management Options.

3.4 CHRA Dimensions

This CHRA assesses the potential health risks to onsite (Works personnel) and offsite sensitive receptors (i.e. residents and other sensitive receptors) due to activities that would be associated with the Management Options for the CWS. This CHRA does not assess the potential health risks due to 1) demolition and removal of Smelter structures or 2) the remediation of onsite surface soil because these activities will occur for each Management Option and therefore the potential health risks will be the same regardless of which Management Option is chosen.

It should be noted that this CHRA does not assess the potential cumulative health risk should the demolition, surface soil remediation and CWS remediation (including containment cell construction) occur concurrently.

This CHRA does not assess the potential health risk due to noise and vibration (applicable for Management Options 2-7) generated from the Management Options because:

- The HHRA prepared by Ramboll Environ (2016) reported that the noise and vibration impacts from Option 2 for onsite and offsite receptors are within WHO (1999) health-based guidelines and no exceedances would occur within standard hours of the morning and afternoon, outside standard hours in the evening (i.e. 6 pm-10 pm except under "worst-case" weather conditions such as temperature inversion) and outside standard hours in the night time (i.e. 10 pm-6 am). This scenario included the activities described in **Section 3.3**. Due to the nature of the onsite activities for Option 3 – 7 it is expected that potential noise levels would be consistent with or below those forecast for Option 2.
- It is assumed that during remediation of the CWS (Management Options 2-7) noise reduction measures would comply with the sleep disturbance criteria under the NSW EPA *Interim Construction Noise Guideline* (DEC, 2009), which develops receptor-specific sleep disturbance criteria based on the existing background noise levels.
- The Noise and Vibration Impact Assessment (VIPAC, 2016) prepared for the Environmental Impact Statement for Option 2 concluded that offsite traffic noise impact would be insignificant as the predicted increase between the existing and future traffic (and therefore noise levels) is extremely low. The internal noise levels at the properties assessed in the 2016 HHRA (using data from the Noise and Vibration Impact Assessment) were predicted to be below the applicable maximum internal noise level limits, which would not be expected to cause any awakening reactions to occupants and would be unlikely to cause sleep disturbance impacts. It is expected that offsite traffic movements, and therefore offsite traffic noise, for Options 3 through 7 would be at a consistent or lower rate than that predicted for Option 2, albeit over a longer time period.
- Based on the HHRA (2016) findings, it is unlikely that any vibration impacts generated by the operation of remediation equipment would give rise to annoyance at the closest sensitive receptor.

The CHRA will be undertaken in accordance with relevant NSW and Australian guidance for performing human health risk assessments as described in **Section 1.3**.

Predictive air quality, gas monitoring data, soil, groundwater and surface water data are used in this CHRA to assess potential health risks. **Table C3.1** summarises a comparative analyses of the CHRA dimensions of the Management Options.

Table C3.1: CHRA Dimensions Comparison between Management Options

CHRA Dimension	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Consideration of onsite Works personnel	Yes [a]	Yes	Yes	Yes	Yes	Yes	Yes
Consideration of offsite receptors due to impacted groundwater	Yes [b]	No[c]	No[c]	No[c]	No[c]	No[c]	No[c]
Consideration of offsite receptors surrounding the CWS and containment cell	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consideration of receptors at, and surrounding, offsite disposal facility	No	No	No	No	Yes	Yes	No

Note:

a) The Do Nothing scenario onsite personnel represent workers who undertake groundwater monitoring of the CWS leachate

b) Assumes leachate will continue to migrate downgradient from the CWS

c) Assumes offsite groundwater impacts attenuate once the CWS is removed and that the onsite containment cell or offsite receiving facility are designed to prevent leachate leakage.

4. DATA COLLECTION AND EVALUATION

4.1 Data Considered in the CHRA

Data from previous and parallel environmental investigations have been collated and analysed and the results have been utilised to form conclusions regarding the potential health risks. These potential health risks are presented in this CHRA. The data which have been considered are:

- Onsite and offsite particulate/vapour data (predicted in a parallel air quality study undertaken for this CHRA and presented in **Appendix C2**);
- Onsite CWS gas monitoring data (from monitoring wells, soil vapour wells and CWS gas vents);
- Onsite and offsite groundwater and surface water quality monitoring data;
- CWS soil data; and
- CWS material inventory (which includes asbestos).

4.2 Previous Environmental Investigations Considered in this CHRA

A summary of the objectives, scope and conclusions of the relevant works previously completed by Ramboll Environ at the Smelter, and surrounding areas, considered within the CHRA is discussed below.

4.2.1 ENVIRON (2012) Environmental Site Assessment, Alcan Mound

Objective: to assess the behaviour of the impacted groundwater plume migrating from the CWS via an investigation of aquifer characteristics, groundwater quality and extent of leachate impacts to soil and surface waters.

Scope: review previous environmental and geotechnical reports provided by Hydro from the site library and analyse data gaps; install one large diameter (100 mm) well close to the northeast corner of the CWS; pump the aquifer and monitor the recovery of the water table in adjacent wells using data loggers; perform a pre- and post-pump test sampling of groundwater and surface water; collect and analyse surface soil samples from a total of five locations at two depths from the two areas of vegetation impact for analysis of pH, fluoride (total and soluble), and cyanide.

Conclusions: exfiltration of the plume to the ground surface has not resulted in cyanide contamination in shallow soils. Fluoride concentrations within soil exceed the preliminary screening criteria for agricultural use and as such, further evaluation was recommended to develop a site-specific fluoride assessment criteria. A dam located down gradient of the plume and immediately up gradient of Swamp Creek is collecting and containing surface water with elevated fluoride concentrations. Fluoride concentrations within Swamp Creek were reported at background levels up stream of the Smelter and slightly elevated downstream. Exposure pathways were identified for receptors, and recommendations were made to further assess the potential human and ecological offsite risk.

4.2.2 ENVIRON (2012b) Phase 2 Environmental Site Assessment

Objective: evaluate soil and groundwater concentrations that may represent a risk to human health at the Smelter, and human health and the environment in the surrounding Hydro land. Fieldworks were conducted during site operations and were considered to be a preliminary investigation.

Scope: review historical and background data; site inspections; drilling of 31 boreholes; installation of 21 groundwater monitoring wells; collection of 14 sediment, 45 surface soil and 28 groundwater samples; and soil and groundwater laboratory analysis.

Conclusions: the investigations identified 10 areas of potential environmental concern including the CWS, the Anode Waste Pile, East Surge Pond and associated drainage lines, Diesel Spray Area, Carbon Plant, Glen Ayr Drift, clay borrow pit, fluoride in soil and groundwater and aluminium in groundwater.

4.2.3 ENVIRON (2013a) Preliminary Screening Health Risk Assessment

Objective: develop preliminary screening level guidelines that are protective of human health for fluoride and aluminium under a range of current and possible future site uses.

Scope: the Health Risk Assessment was qualitative and involved a desktop evaluation of toxicity reference values for fluoride and aluminium, identified source exposure pathways and mechanisms and development of preliminary screening levels based on the compound's toxicity and the possible exposure routes.

Conclusions: preliminary screening levels for aluminium and soluble fluoride were developed for residential, recreational and industrial soil, and surface water assuming recreational use. It was conservatively assumed that soluble fluoride and aluminium are 100% bioavailable in soil and fluoride levels in drinking water are at the maximum target levels. The preliminary screening levels for fluoride are based on 'soluble fluoride' and not 'total fluoride'.

4.2.4 ENVIRON (2013b) Phase 1 Environmental Site Assessment

Objective: identify, review and report on the potential for historic and current site contamination.

Scope: review historical reports relating to land use and operations at the Smelter and Hydro land; review of historical aerial photographs; detailed site walk over; interview with Smelter environmental manager; and review of historical environmental investigations conducted since 2000.

Conclusions: Smelter operations on the Smelter Site and in the Hydro Buffer Zone have potentially resulted in impacts to soil and water. ENVIRON previously completed a number of investigations at the Smelter that identified and investigated potential areas of concern. Areas of potential concern identified previously and as part of this in-depth historical review have been listed in an Environmental Issues Register for Hydro land. This Environmental Issues Register is a live document used to document the issue identification and close out process and also to record new issues should they arise.

4.2.5 ENVIRON (2015a) Phase 2 Environmental Site Assessment (ESA), Additional Investigations

Objectives: complete Stage 2 of the Phase 2 ESA to build upon the results of Stage 1 in understanding the potential for soil and groundwater contamination at the site to impact on the use of the site for commercial/industrial land use. The initial Stage 1 phase of work was completed in November 2012.

Scope: review previous investigations and identify data gaps; soil sampling at five areas of concern and five new potential areas of environmental concern; install seven new groundwater wells at three areas of concern; sample new and existing 17 groundwater wells; and analysis of soil and groundwater samples for metals, fluoride, polycyclic aromatic hydrocarbons (PAHs) and cyanide. Based on these results, refine the conceptual site model, identify additional site investigations and assess areas requiring remediation.

Conclusions: PAH impacts (primarily benzo(a)pyrene (BaP)) to surface soils was identified in seven areas due to contamination in the fill material, which was not identified to extend into the underlying alluvial sands and not impact groundwater. Lateral delineation of soil contamination and hotspots was recommended prior to remediation efforts. Development of a Remediation Action Plan was recommended to develop remediation and validation plans for each of the seven areas identified with PAH soil impacts. It was acknowledged that remediation is likely to occur following or during demolition of the buildings on the Smelter.

4.2.6 ENVIRON (2015b) Capped Waste Stockpile, 12 Month Groundwater Monitoring Report

Objectives: monitor the groundwater leachate plume down-gradient of the CWS and compare the current status of the plume to historical data to assess its stability.

Scope: conduct five groundwater monitoring events at the leachate plume associated with the CWS between July 2013 and November 2014. Each groundwater monitoring event included the sampling and analysis of groundwater from 25 wells located on five sections along the length of the leachate plume down-gradient of the CWS. Groundwater samples were analysed for soluble fluoride, cyanide and aluminium. Field measurements of physio-chemical properties including pH.

Conclusions:

- Groundwater drawdown around the interception trench has occurred since the commissioning of the trench in May 2014.
- Fluoride concentrations are responding to the leachate interception trench with suggestions that undiluted leachate is being drawn into the trench, and concentrations beyond the trench are starting to decrease.
- Fluoride concentrations in the deep aquifer remain low and this aquifer appears un-impacted by leachate.
- Continued quarterly groundwater monitoring was recommended.

4.2.7 Ramboll Environ (2016a) Capped Waste Stockpile Assessment

Objectives: provide a preliminary assessment of the composition of the CWS and the soil and groundwater conditions beneath the stockpile.

Scope: drill six boreholes within the CWS. Log, photograph, sample and analyse materials encountered for waste characterisation. Sample and analyse soils beneath the CWS. Convert the boreholes to groundwater monitoring wells. Sample the groundwater and analyse the results. An additional 24 samples were analysed from the same 2015 core samples (held onsite since the 2015 investigation) and analysed in March 2017.

Conclusions:

- The depth of the fill material in the six boreholes ranged between approximately 10.5 and 12 m bgs. The natural soils underlying the wastes generally comprised a mixture of clays and sands. Clays encountered during the works were considered to be firm to very stiff.
- Elevated gas concentrations of carbon monoxide (CO), ammonia, and methane (CH_4) were detected within the CWS. Oxygen deficient concentrations as low as 3.2 % were also detected. Health and safety considerations for the identified gas were recommended for any work intrusive works.
- The fill material encountered during the drilling works was generally dry, indicating that the current CWS cap is effective at reducing infiltration through the wastes. Leachate impacted groundwater was encountered within the underlying natural soils in four of the six groundwater monitoring wells installed.
- Soil sampling detected asbestos fibres in three of the six boreholes. It was recommended that health and safety considerations for asbestos is made prior to any disturbance of the fill material within the CWS, as well as transporting, and/or crushing the material.
- Chemical analysis of the waste materials for contaminants of concern classified the materials as 'Hazardous' and 'Special' waste on the basis of elevated total and leachable fluorides, total PAHs and asbestos fibre content.
- Impacts to underlying natural soils are limited to shallow PAH impacts extending to less than 1.0 m in to underlying soils.

4.2.8 Ramboll Environ (2016b) Landfill Gas Monitoring Protocol

Objectives: assess monthly for a 12 month period the gas concentrations in twelve on site gas monitoring locations (VT1-VT12), six groundwater monitoring wells (MW201-MW206) and for landfill gases CH_4, carbon dioxide (CO_2), CO, oxygen and hydrogen sulphide (H_2S) and ammonia (CH_4) as well as the rate of gas emission at each location.

Scope: collect gas samples from gas vents (VT01-12), monitoring wells (MW201-MW206) and vapour wells (VW01-VW06); analyse gas samples for CH_4, CO_2, CO, oxygen and H_2S and ammonia; prepare a monthly report and update gas monitoring datasheet.

Conclusions: interpretation of the most recent set of gas data collected on 28 April 2017 concluded that:

- Within the gas vents 1) ammonia concentrations generally fluctuate both temporarily and spatially with the highest concentrations recorded at VT5, VT6 and VT7, 2) CO and H_2S are elevated and fluctuate overtime, and 3) CO_2 and CH_4 concentrations are low and have generally reduced overtime.
- Within the monitoring wells 1) positive air flow was recorded in all the wells, and oxygen concentrations represented ambient air levels, 2) ammonia concentrations consistently elevated (>900 ppm) for the last three monitoring events at MW201 and concentrations in the other five wells fluctuated over the sampling period between 25 ppm and >900 ppm, and 3) concentrations of H_2S, CO, CH_4 and CO_2 were fairly consistent between monitoring events.
- Within the vapour wells 1) low oxygen, CH_4 and CO_2 concentrations were consistently measured in the vapour wells across all sampling events, 2) ammonia concentrations were consistently elevated in VW05 and VW06, and were detected above the detection limit for all wells and sampling events, and 3) elevated H_2S concentrations were consistently measured over the six sampling events with no decreasing or increasing trend observed.

4.2.9 Ramboll Environ (2017) Capped Waste Stockpile, 2016 Annual Groundwater Monitoring Report

- *Objectives*: collect water quality data to inform the behaviour of the groundwater plume migrating from the CWS.
- *Scope*: collect groundwater samples and measure depth to water in the offsite wells illustrated on **Figure C6**, **Appendix C1**); perform a field analysis for physico-chemical parameters including pH, temperature, electrical conductivity (EC), redox and dissolved oxygen; and laboratory analysis of groundwater samples for soluble fluoride, total and free cyanide, and total aluminium. The groundwater data collected by Ramboll Environ from the first monitoring event for 2017 was also considered in the data set.
- *Conclusions*:
  - Groundwater flow was interpreted to be north to northeast in both the shallow and deeper parts of the aquifer. This was consistent with historical observations.
  - The leachate interception trench has been non-operational since 14 March 2016 when the discharge rate dropped to 0 L/minute. Groundwater levels on Section 1 (see **Figure C6, Appendix C1**) reportedly had not recovered.
  - pH and fluoride concentrations in shallow wells were similar to previous sampling events, with an increasing or stable trend in Section 1 wells, and a decreasing or stable trend in wells further down gradient.
  - Monitoring well W2D recorded the highest impacts in the deep aquifer along Section 1. Fluoride concentrations in this well more than doubled over the 14 monitoring events from 682 mg/L to 1700 mg/L.
  - Fluoride concentrations in the deep aquifer down-gradient of Section 1 remain low, indicating a semi-continuous connection between the shallow and deeper aquifer.
  - Groundwater data from the two new pairs of shallow and deep wells adjacent to Swamp Creek, the nearest surface water receptor, showed no impact from the leachate plume. This result was anticipated based on the location of high plasticity clays, through which the leachate plume cannot move, between the location of the leachate plume and Swamp Creek.
  - Monitoring of groundwater and operation of the toe leachate interception trench was proposed to continue until remediation of the CWS is completed.

4.3 Data Quality and Quantity

During preparation of this CHRA, Ramboll Environ relied upon information presented in the reports listed in **Section 4.2** all of which were conducted and/or verified by Ramboll Environ. The majority of these studies are field-based and laboratory-based projects which adhered to field and laboratory quality control/quality assurance protocols outlined in:

- NEPM (2013) Schedule B2, Guideline on Site Characterisation.

- NEPM (2013) Schedule B3, Guideline on Laboratory Analysis of Potentially Contaminated Soils.

Due to the nature of the data available, this CHRA has set out to incorporate assumptions corresponding to a near-"worst-case' exposure scenario when evaluating potential health risks to onsite Workers and offsite sensitive receptors, including protective toxicity reference values and exposure parameters. This approach is considered to account for any limited or variable quality of the data available for use in the CHRA. A discussion of the information gaps in the available data for use in this CHRA is provided in **Section 4.4**.

4.4 Data Gaps

An assessment of the data gaps identified for conducting this CHRA is presented in **Table C4.1**.

Table C4.1 Data Gaps

Data Gap	Potential Significance	Manner in which data gap is addressed in the CHRA
Limited groundwater data (four samples collected in November 2015) beneath the CWS is available to characterise potential health risks associated with exposure to groundwater for onsite workers.	The potential to underestimate health risks from groundwater exposure due to limited analytical concentrations.	The maximum reported groundwater concentration beneath the CWS is adopted to estimate potential health risk due to groundwater exposure. These concentrations were also compared to groundwater data collected immediately down-gradient (for which there is a larger database) to ensure that the maximum chemical concentrations are considered in this CHRA.
Limited surface water samples have been collected in the offsite area of Swamp Creek and Wentworth Swamp to reliably characterise the temporal and spatial surface water concentrations.	Potential to underestimate health risks from surface water exposure during recreational activities in the offsite down-hydraulic gradient area.	Groundwater concentrations reported down-hydraulic gradient of the CWS, in the Swamp Creek/Wentworth Swamp area, are used to assess potential health risks from surface water. Groundwater in the offsite area is shallow (refer to **Section 2.3.2**), and may come to the surface during periods of flood, and where shallow groundwater intersects with surface water features (refer to **Section 2.4**).
The concentration of dust likely to be generated via remediation of the CWS is unknown.	Works personnel have the potential to inhale contaminated dust during the remedial works. Dust generated also have the potential to be transported offsite where sensitive receptors such as residents have the potential to inhale dust particles.	Dust concentrations were modelled by Ramboll Environ for this CHRA in a parallel study. The methodology and results are presented in **Appendix C2.**
Offsite groundwater samples were analysed for 'total' aluminium concentrations. Concentrations of 'dissolved' aluminium is unknown in offsite groundwater samples.	Health risks due to aluminium exposure should be assessed based on 'dissolved' aluminium concentrations which are available for uptake into the body. Aluminium	Assessment of potential health risks due to aluminium exposure in groundwater for offsite receptors will be undertaken by using onsite

	is reported to be 'insoluble in water' and use of 'total' aluminium to estimate health risks would be overly conservative (ATSDR, 2008).	'dissolved' aluminium concentration reported beneath the CWS.
The relative proportions of aromatic and aliphatic hydrocarbons within the reported TPH mixture is unknown.	Aromatic and aliphatic hydrocarbons have different toxicity reference values. Assuming all TPH is present as aromatic hydrocarbons would likely overestimate potential health risk. Conversely, assuming all TPH is present as aliphatic hydrocarbons would likely underestimate potential health risk.	In the absence of site-specific information, this CHRA assessed potential health risk due to TPH exposure twice. Once assuming all TPH is present as aliphatic hydrocarbons, and once assuming all TPH is present as aromatic hydrocarbon. This is recognised as a conservative approach.

4.5 Conceptual Site Model

A conceptual site model (CSM) is a site-specific qualitative description of the source(s) of contamination, the pathway(s) by which chemicals (and asbestos) may migrate through environmental media, and the human populations that may potentially be exposed. This relationship is commonly known as a Source-Pathway-Receptor (SPR) linkage. Where one or more elements of the SPR linkage are missing, the exposure pathway is considered to be incomplete and no further assessment is required.

4.5.1 Human Receptors

The human receptors of concern for this CHRA are onsite and offsite receptors surrounding the Smelter site, and the offsite disposal facilities in NSW (Management Option 5) and the Northern Territory (Management Option 6).

- *Onsite receptors*:
  - Adult Workers employed to monitor the CWS (Do Nothing).
  - Adult Workers employed to remediate the CWS (Management Options 2-7)
  - Adult Workers employed to monitor the proposed Containment Cell (Management Options 2, 3 and 4)
  - Adult and child recreational users (Management Options 2, 3 and 4): according to the 'Rezoning Master Plan' (refer to **Figure C1, Appendix C1**) the area that would comprise the proposed containment cell would be zoned for Heavy Industrial (IN3). However it is understood that the proposed containment cell surface would be grassed (with no overlying buildings) and entry will not be restricted via fencing. Consequently, adult and child recreational users would have the potential to enter the future proposed containment cell area given that the adjacent future land use would be zoned Environmental Conservation (E2).
- *Current offsite receptors*: when identifying the specific offsite human receptors for consideration in this CHRA, Ramboll Environ considered the same receptor groups as the Ramboll Environ (2016) HHRA. These receptors are located within a four kilometre radius of the Smelter site. For the air quality assessment, potential health risks were assessed for the most sensitive human receptor which was considered to be the receptor location where predicted particulate concentrations, generated from the CWS management/remediation, were the highest (as predicted by the parallel air quality study prepared for this CHRA, **Appendix C2**).
  - *Offsite residents*: child and adult residents who live within the vicinity of the Smelter site, or the offsite disposal facilities in NSW and the Northern Territory.

    - *Offsite recreational users*: children and adults who use passive and active recreational facilities such as the down-gradient Swamp Creek area, parks, golf clubs and sporting venues.
    - *Offsite sensitive receptors*: children and adults that use or reside in facilities such as childcare centers, educational facilities, places of worship, aged care facilities, immunocompromised and medical facilities.
    - *Offsite intrusive maintenance workers*: adult workers who dig a trench in the down-gradient area from the CWS for the purpose of maintaining services such as subsurface utilities.
- *Future offsite receptors (Do Nothing option only)*: according to the 'Rezoning Master Plan' (refer to **Figure C1, Appendix C1**) the area that currently comprises the CWS, and the area down hydraulic-gradient (in the direction of the CWS leachate plume), would be zoned Heavy Industrial (IN3) and Environmental Conservation (E2). Consequently, future offsite receptors would comprise:
    - Future intrusive maintenance workers who have the potential to work in these areas to undertake maintenance works on subsurface utilities.
    - Adult and child recreational users in the Environmental Conservation area down gradient from the CWS.

The location of the offsite receptors considered in this CHRA is summarised on **Table C4.2** and illustrated on **Figure C4, Appendix C1**.

Table C4.2: Offsite Human receptors

Service Receptor	Address	Distance from onsite	Direction from onsite
Educational Facilities			
Hunter TAFE [R3]	McLeod Road, Kurri Kurri	1.4	Southeast
Kurri Kurri High School [R5]	Deakin and Standford Streets, Kurri Kurri	1.8	South/ southeast
Child-Care Facility			
Kurri Early Childhood Centre [R18]	107 Lang Street, Kurri Kurri	2.6	South/ southeast
Medical facility			
Kurri Kurri Family Medical Centre [R13]	312 Lang Street, Kurri Kurri	3	South
Aged–Care Facility			
RFBI Kurri Kurri Masonic Village/Nursing Home [R17]	Hospital Road, Kurri Kurri	3.6	South/ southwest
Nearest Residential Property			
Private dwelling [R6]	685 Old Maitland Road, Bishops Bridge	4	North
Hydro-owned dwelling [R8]	464 Cessnock Road, Gillieston Heights	2.8	Northeast
Private dwelling [R9]	20 Bowditch Avenue, Loxford	1.0	East
Private dwelling [R10]	6 Dawes Avenue, Loxford	0.5	Southeast
Hydro-owned dwelling [R12]	Scales Avenue (Lot 444, DP755231), Loxford	0.35	South
Private dwelling [R14]	78 Hart Road, Loxford	0.8	Southwest
Private dwelling [R15]	103 Bishops Bridge Road, Sawyers Gully	0.7	West
Private dwelling [R16]	78 Lumby Land, Sawyers Gully	1.8	Northwest

Nearest Recreational Facility			
Hydro-owned Cricket Pitch Park, used by Scout clubs [R2]	Dawes Avenue, Loxford	0.15	Southwest
Kurri Kurri Speedway [R1]	73-81 Dickson Road, Loxford	0.2	West
Places of Worship			
Church of Christ [R19]	134 Maitland Street, Kurri Kurri	2.5	North

4.5.2 Health Impact Source

The health impact sources assessed in this CHRA includes:

- Soil impacts within the CWS
- Particulates and vapours generated from remediation of the CWS (Management Options 2 to 7)
- Groundwater impacts beneath and down-hydraulic gradient of the CWS
- Surface water impacts down-hydraulic gradient of the CWS
- Smelter waste material (including asbestos) within the CWS
- Gas emissions from the CWS

The term 'soil' is used throughout this CHRA to describe the CWS material however in this context this term is interchangeable with 'waste'.

The 'health impact source' is identified by comparison of observed chemical(s) of potential concern (CoPC) concentrations in the media of concern (soil, groundwater, and particulates) against conservative generic screening criteria, termed "Tier 1 assessment criteria". A potential 'source' is identified when the CoPC concentration is reported to be present in the environmental media at concentrations above Tier 1 assessment criteria which have been derived based on protection of human health. Further assessment of the CoPC that exceed the Tier 1 assessment criteria is undertaken in the Tier 2 CHRA.

Assessment of the 'health impact source' for particulates, soil, groundwater, surface water, vapour emissions and materials within the CSW is provided below; in addition to the adopted Tier 1 assessment criteria for each 'health impact source'.

Total vs Soluble Groundwater Concentration Considerations

Total cyanide concentrations represents the amount of free cyanide (such as the cyanide ion (CN^-) and hydrogen cyanide (HNC)) and other cyanide metal complexes. 'Free' cyanide represents the concentration which is available for uptake into the body and is more appropriate than 'total' cyanide concentrations in HHRA (NEPM Schedule B7, Appendix A1, 2013). Therefore, when 'free' cyanide was analysed the assessment of potential health risk due to cyanide exposure is assessed using the 'free' cyanide concentration.

This approach was also undertaken for fluoride and aluminium whereby the soluble fluoride and dissolved aluminium concentrations, and not the total fluoride and total aluminium concentrations, were considered in this CHRA.

4.5.2.1 Soil Impacts Sources

Thirty-eight soil samples, from six locations, were collected by Ramboll Environ within the CWS during environmental investigations conducted in October, November and December 2015; and the results are reported in Ramboll Environ (2016a). An additional 24 samples were analysed from the same 2015 core samples (held onsite since the 2015 investigation) and analysed in March 2017.

The CWS soil data are presented in **Table C1** and **Table C2**, **Appendix C3**. The location of the soil bores is presented on **Figure C5**, **Appendix C1**. The additional 24 soil samples were also analysed for 11 organochlorine pesticides, 12 herbicides, 24 phenolic compounds and 54 halogenated aliphatics/aromatics; however all these concentrations were below the laboratory limit of reporting (between 0.1 and 10 mg/kg) and are therefore the results are not included on **Table C2, Appendix C3**.

Site-wide soil data not collected from the CWS was not considered in this CHRA because for the purpose of this assessment only soil within the CWS would be disturbed during remediation of the CWS (Management Options 2 to 7). Many of the soil samples were labelled as 'bulk waste' from the CWS and for the purpose of this CHRA these samples are considered to represent a 'soil source'.

The CWS reported soil concentrations were compared against appropriate 'residential' land use Tier 1 assessment criteria because this is considered to be the most sensitive land use potentially exposed to airborne soil-derived dust (i.e. offsite residents).

The residential Tier 1 assessment criteria adopted for soil in this CHRA included:

- NEPM (2013) Health Investigation Levels (HIL) for 'low density residential land use', HIL-A
- Site-specific fluoride and aluminium soil assessment criteria for 'residential land use', derived by ENVIRON (2013)
- US EPA Regional Screening Levels (RSLs) for 'residential soil'.

The Tier 1 assessment criteria adopted in this CHRA are presented in **Table C1** and **Table C2**, **Appendix C3** and

A summary of the CoPCs in soil that exceeded the residential Tier 1 criteria is provided in **Table C4.3.** Since the BaP NEPM (2013) HIL assessment criteria is based on eight carcinogenic PAHs and their toxic equivalents (potency relative to BaP), all eight carcinogenic PAHs will be considered in this CHRA when assessing potential health risk.

The additional 24 soil samples analysed in March 2017 from the CWS were analysed for total fluoride, and when assessing potential health risks soluble fluoride concentrations is more appropriate (refer to **Section 6**). Therefore, only the soil samples analysed for soluble fluoride were considered in this CHRA.

Table C4.3: Maximum Soil Concentrations in CWS exceeding the Tier 1 Assessment Criteria (mg/kg)

Chemical	No. of samples considered	Maximum Concentration (mg/kg)	Average Concentration (mg/kg)	95% Upper Confidence Concentration (mg/kg)[e]	Tier 1 Assessment Criteria (mg/kg)
Aluminium	13	103,000	17,065	30,267	100,000[b]
Fluoride (soluble)	25	21,100	5,050	**14,304**	440[b]
Naphthalene	62	8.5	2.4	2.9	3[a]
Benzo(a)pyrene TEQ^	82	1210	177	**238.2**	3[a]
Benzo(a)pyrene	72	832	135	**176.4**	
Benz(a)anthracene	73	731	125.5	**162.2**	-[c]
Chrysene	74	626	106.3	**136.6**	-[c]
Benzo(b+j)fluoranthene	72	1330[d]	230.2	**297**	-[c]
Benzo(k)fluoranthene	70	1330[d]	234.9	**305.1**	-[c]
Indeno(1,2,3-c,d)pyrene	70	442	67.9	**87.8**	-[c]
Dibenzo(a,h)anthracene	67	116	24.4	**31.17**	-[c]
Benzo(g,h,i)perylene	70	528	72.9	**93.92**	-[c]
Arsenic	57	850	72.7	**151.5**	100
Lead	65	820	168.5	290.4	300
TRH >C10 - C16 less Naphthalene (F2)	31	180	107.5	**119.7**	110*
TRH >C16-C34	59	14000	4,169	**5,988**	4500^

Notes:
a NEPM (2013) Health Investigation Level for 'low density residential land use', HIL-A.
b Site-specific concentration in soil for residential land use (Environ, 2013)
c NEPM (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equivalents, therefore when the BaP TEQ HIL is exceeded all eight carcinogenic PAHs are assessed.
d Value represents the highest value where the laboratory reports the sum of benzo(b+j) and benzo(k)fluoranthene only (only applicable for the December 2015 samples).
e UCL concentration calculated using the US EPA ProUCL v5.1
^ TEQ: benzo(a)pyrene toxic equivalent

Considering the size of the data set, the 95% upper confidence limit concentration was used during the Tier 1 soil screening exercise. Based on the Tier 1 screening results, an assessment of potential health risk associated with soluble fluoride, eight carcinogenic PAHs, arsenic and total recoverable hydrocarbons (TRH) <C_{10}-C_{34} is assessed further in this CHRA.

4.5.2.2 Particulates and Vapours Generated from CWS Remediation

Air borne particulates and vapours are likely to be generated from a number of sources during remediation of the CWS (Management Options 2 to 7). Some of the compounds emitted would remain in vapour form, others would be released in particulate form, and other compounds could form particles after being emitted or by adhering to existing particles. Emissions from the Management Options would include products of combustion, fugitive dust or particulate matter (PM), ammonia, cyanide and a range of organic compounds including PAHs.

Table C4.4 summarises the particulate sources for each of the Management Options. Air borne particulates are not considered to be generated for Do Nothing scenario because the CWS will remain *in situ*, and is assumed to be covered in grass/vegetation which will limit the potential for air borne dust to be generated.

Table C4.4: Particulate and Vapour Sources for Capped Waste Stockpile Management Options

Activity Considered	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Excavate and remove CWS	N/A	✓	✓	✓	✓	✓	✓
Construction of onsite containment cell[1]	N/A	✓	✓	✓	X	X	X
Construction of offsite containment cell	N/A	X	X	X	✓	X	X
Placement of CWS material in truck for offsite disposal	N/A	X	X	X	✓	✓	X
Placement of CWS in onsite/offsite containment cell	N/A	✓	✓	✓	✓	X	X
Placement of lime material in containment cell with CWS material	N/A	X	✓	✓	✓	X	X
Capping of onsite/offsite containment cell	N/A	✓	✓	✓	✓	X	X
Sorting of recyclables from CWS and treatment of non-recyclables	N/A	X	✓[2]	X	✓[2]	✓[2]	✓[2]
Transportation and disposal of CWS to offsite waste disposal facility	N/A	X	X	X	✓	✓	X
Transportation and disposal of CWS to onsite treatment facility	N/A	X	X	X	X	X	✓
Remediation of haul road between CWS and onsite containment cell[3]	N/A	✓	✓	✓	X	X	X
Operation of Water Treatment Plant	✓	✓[4]	✓[4]	✓[4]	✓[4]	✓[4]	✓[4]

Note: N/A means 'Not Applicable' because the CWS material remains *in situ* and covered with grass/vegetation.

1. Particulates can be generated during vegetation clearance, excavation of soil and operation of machinery such as trucks, tractors and grousers.
2. Particulates can be generated during the crushing of non-recyclable materials in preparation for disposal.
3. Remediation of haul road comprises removal of the top layer of soil, and placement into the onsite containment cell.
4. Water treatment plant will be operated only during CWS removal and while the onsite/offsite containment cell is open.

Ramboll Environ estimated particulate and vapour concentrations predicted to be emitted during activities undertaken for each Management Option and this CHRA examined the potential acute and chronic onsite/offsite health risks from these predicted particulate and vapour emissions. The methodology and results are provided in **Appendix C2**. Particulate concentrations were predicted at the human receptor locations presented in **Table C4.2**.

Local air quality impacts were assessed using a 'Level 2' assessment approach, in accordance with the NSW EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA, 2005), as follows:

- Emissions were estimated for Management Option related activities.
- Dispersion modelling was used to predict onsite and offsite Ground Level Concentrations (GLCs) for key pollutants from each Management Option.
- Cumulative impacts were assessed, taking into account the combined effect of existing baseline air quality and other neighbouring sources of emissions.

The intention of the air quality modelling was to capture the worst case 24-hour period of operational activity and then combine this with all likely meteorological conditions that would be experienced throughout a calendar year to predict maximum impacts. The worst case scenario was assumed to be the period involving concurrent:

- CWS material excavation and processing;
- Haulage of CWS material to the onsite/offsite treatment/disposal facilities; and
- Placement in the treatment/disposal facilities.

The following constituents were included in the air quality modelling either because they are known constituents of combustion (emitted from machinery) or they were detected in CWS soil above the Tier 1 residential assessment criteria described in **Section 4.5.2.1**:

- Particulates: deposited dust, total suspended particles (TSP), PM_{10} and $PM_{2.5}$.
- Combustion emissions: nitrogen dioxide (NO_2), sulfur dioxide (SO_2), CO, benzene, toluene, ethylbenzene, xylenes, naphthalene and phenol.
- Metals: arsenic and lead.
- PAHs, including all eight carcinogenic PAHs.
- Inorganic gases: ammonia, fluoride, cyanide, hydrogen sulfide (H_2S).

Predicted particulate and vapour concentrations were generated for a number of averaging periods including annual, 24-hour, 8-hour periods and 1-hour period. The highest 1-hour, 8-hour or 24-hour average ground level concentrations (GLCs) predicted at each of the offsite human receptors were adopted for the assessment of acute exposure. The annual average GLCs were adopted for the assessment of chronic exposure.

The predicted cumulative maximum 'work area' concentrations were considered to represent the air quality onsite workers would be exposed to during the Management Options activities. This area was considered to be approximately 14 hectares. When assessing the offsite sensitive receptors, Ramboll Environ considered the residential property that had the highest predicted particulate and vapour concentrations (maximum cumulative value). This residence was located 500 m to the southeast at 6 Dawes Avenue, Loxford. This property returned higher dust concentrations than properties closer to the site due to factors relating to spatial distribution of particulates around the Smelter Site and the general northwest-southeast alignment of the prevailing wind direction (**Appendix C2**).

The predicted dust concentrations were screened against appropriate health-based air quality guidelines including:

- NSW EPA (2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Department of Environment and Conservation (NSW).
- NEPC (2003) National Environment Protection (Ambient Air Quality) Measure, National Environmental Protection Council.

- World Health Organization (WHO) (2000) Air Quality Guidelines for Europe, 2nd Edition, 2000. World Health Organization Regional Publications, European Series, No. 91.
- Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) adopted.
- United States Environmental Protection Agency (US EPA) Integrated Risk Information System (IRIS). In absence of available Tier 1 screening criteria (reference concentration), toxicity value for the compound was adopted.
- Office of Environment Health Hazard Assessment (OEHHA), California Environmental Protection Agency (CalEPA).
- Provisional Peer-Reviewed Toxicity Values (PPRTV) Oak Ridge National Laboratory. Value obtained from US EPA Regional Screening Levels website.

Where available, acute Tier 1 assessment criteria were compared against the predicted acute air quality data, and similarly for the chronic screening criteria against the chronic (or annual) predicted air quality data. Results of the Tier 1 screening assessment for the acute and chronic particulate and vapour data is presented in **Table C12** to **Table C15**, **Appendix C3**.

Results from the Tier 1 screening assessment showed that the particulate and vapour concentrations predicted to occur for each Management Option were below the acute and chronic assessment criteria. Therefore, the assessment of potential health risk due to exposure to particulates and vapour that would occur during remediation of the CWS will not be considered further in this CHRA.

4.5.2.3 Groundwater Impact Sources

The major source of groundwater impact considered in this CHRA is via the seepage of leachate from the CWS through the soil layers and into the groundwater. Groundwater monitoring wells have been installed through the CWS (onsite wells) and down-hydraulic gradient of the CWS (offsite wells). The location of these wells is illustrated on **Figure C6, Appendix A1**.

When identifying the groundwater CoPCs for this CHRA, the onsite and offsite groundwater data were screened against the following health-based Tier 1 assessment criteria:

- Site-specific assessment criteria for soluble fluoride and aluminum as reported in ENVIRON (2013).
- National Health and Medical Research Council (NHMRC) (2016) *Australian Drinking Water Guidelines 6*, National Water Quality Management Strategy. Australian Government. Version 3.3.
- NHMRC (2008) Guidelines for Managing Risks in Recreational Water. This guideline allows the health-based drinking water guidelines to be adjusted for a recreational exposure scenario that is considered to ingest 10% of the daily drinking water ingestion rate. This is considered to more accurately represent the exposure scenario to be encountered for onsite workers and offsite recreational users of Swamp Creek and Wentworth Swamp. Drinking water guidelines set for aesthetic and/or taste threshold reasons were not adjusted.
- WHO (2008*) Petroleum Products in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality*.
- United States Environmental Protection Agency (US EPA) *Regional Screening Level (RSL) Resident Tapwater*, published online (May 2016).

Onsite CWS Monitoring Wells

In November 2015, six groundwater monitoring wells were installed by Ramboll Environ within the CWS to depths between 10.5 m bgs and 14 m bgs, to target groundwater conditions beneath the CWS material (Ramboll ENVIRON, 2016a). Groundwater was collected from only four wells (MW201, MW203, MW204 and MW206) on 11 November 2015 as the remaining two wells were reportedly dry. Groundwater has only been sampled from these wells once since their installation and this information was used in the CHRA to assess potential health risk to onsite workers.

This approach assumes that the November 2015 reported groundwater concentrations are representative of the worst-case conditions beneath the CWS (refer to **Table C4.1**).

The onsite CWS groundwater analytical concentrations, and adopted Tier 1 assessment criteria, are presented in **Table C3, Appendix C3.** A summary of the chemicals that exceeded the Tier 1 assessment criteria is presented in the **Table C4.5**.

Table C4.5 CWS Groundwater Concentrations Exceeding Assessment Criteria (mg/L)

Chemical	Maximum Groundwater Concentration (mg/L) (well ID)	Tier 1 Assessment Criteria (mg/L)[b]
Fluoride (soluble)	**1880** (MW202)	1.5[c]
Benzo(a)pyrene	**0.0096** (MW206)	0.0001[a]
Benz(a)anthracene	**0.0092** (MW206)	0.001 [a]
Benzo(b+j)fluoranthene	**0.0123** (MW206)	0.001 [a]
Benzo(k)fluoranthene	**0.0039** (MW206)	0.001 [a]
Indeno(1.2.3.cd)pyrene	**0.007** (MW206)	0.001 [a]
Dibenz(a.h)anthracene	**0.0017** (MW206)	0.0001 [a]
Naphthalene[d]	**0.058** (MW206)	0.017
TPH (C_6-C_9)	**0.33** (MW206)	0.01

Notes:

a) NHMRC (2016) states that "Data are inadequate to set guidelines for other PAHs, however comparative carcinogenic potency can be used to determine an approximate risk when complex mixtures of PAHs are present in drinking water". Toxicity equivalence factors from NEPM (2013) are adopted.

b) Value represents the adopted health-based Drinking Water criteria adjusted by a factor of 10, as recommended by NHMRC (2008) for exposure to groundwater not ingested for potable drinking water purposes.

c) Site-specific soluble fluoride criteria for recreational land use (Environ, 2013a).

d) Naphthalene value represents concentration derived using EP080:BTEXN laboratory method.

e) Concentration from well MW206 is the highest value reported between the parent sample and duplicate sample.

Concentrations of chloride, sodium and sulfate exceeded the NHMRC (2016) aesthetic and/or taste threshold drinking water criteria; no health-based drinking water value is provided. Consequently, consideration of health impacts due to chloride, sodium and sulfate groundwater will not be undertaken further in this CHRA.

A review of the information provided in **Table C4.5** identifies that the following chemicals requires further assessment in this CHRA for onsite exposure to groundwater:

- fluoride (soluble);
- TPH C_6-C_9;
- naphthalene; and
- PAHs including benzo(a)pyrene, benz(a)anthracene, benzo(b+j)fluoranthene, benzo(k)fluoranthene, indeno(1.2.3.cd)pyrene and dibenz(a.h)anthracene.

Offsite Monitoring Wells Down-Hydraulic Gradient of the CWS

The leachate plume originating from the CWS has been monitored via a network of 25 monitoring wells installed down-hydraulic gradient of the CWS, and data from 14 monitoring events between July 2013 and March 2017 has been reviewed during preparation of this CHRA. In the offsite well network, 17 wells target shallow (≤2 m bgs) groundwater, and 11 wells target deeper (≥5 m bgs) groundwater. In 2016, two additional shallow wells (G5, G6) and two additional deep wells (F5, F6) were installed adjacent to Swamp Creek, the nearest surface water receptor. The locations of the offsite groundwater monitoring wells is illustrated on **Figure C6, Appendix C1.**

Offsite groundwater samples were analysed for soluble fluoride, free cyanide, total aluminium and pH; other parameters such as BTEX, TPH and PAH were either not detectable or below the adopted assessment criteria and therefore were not routinely analysed for. The analytical results obtained between July 2013 and March 2017 are presented in **Table C4** (shallow data) and **Table C5** (deep data), **Appendix C3**.

A review of this information indicates that the leachate plume is alkaline (pH> 9), has elevated electrical conductivity, elevated soluble fluoride and total aluminium; and has migrated approximately 250 m northeast into the Hydro land. These concentrations have fluctuated overtime with no clear increasing or decreasing trend. The majority of impacts have been detected in the wells which target the shallow aquifer, however impacts have also been detected in the deeper wells located close to the CWS.

Soluble fluoride and free cyanide concentrations were not reported above the Tier 1 assessment criteria in the monitoring wells installed in Swamp Creek located between 450 m and 550 m east from the CWS.

The maximum, average and 95% upper confidence limit (UCL) groundwater concentrations reported in the shallow and deep wells located down-hydraulic gradient from the CWS are summarised in **Table C4.6**.

Table C4.6: Offsite Groundwater Concentrations Down Gradient of the CWS (mg/L)

Chemical[a]	Number of samples considered	Maximum Concentration (mg/L)	Average Concentration (mg/L)	95% Upper Confidence Concentration (mg/L)[f]	Health-Based Groundwater Criteria (mg/L)
Shallow Wells					
Soluble Fluoride	148	1100	265.8	357.1	1.5[b]
Free Cyanide	83	11	0.19	0.77	0.8[c]
Total Aluminium	146	1200	50	93.9	9[b]
pH		10.71[d]/6.77[e]	8.55[d]/5.0[e]	8.7[d]	6.5-8.5
Deep Wells					
Soluble Fluoride	119	1700	145.8	305.4	1.5[b]
Free Cyanide	72	0.88	0.04	0.09	0.8[c]
Total Aluminium	117	110	5.3	9.9	9[b]
pH	122	10.42	6.6	6.8	6.5-8.5

Notes:

a) Concentrations reported between July 2013 and March 2017 from monitoring wells down gradient from the CWS and Swamp Creek.
b) Site-specific assessment criteria derived in Environ (2013a) for soluble fluoride and soluble aluminium. Refer to **Section 4.1Table C4.1** for a discussion of aluminium concentrations.
c) NHMRC (2016) Drinking water guideline adjusted for incidental ingestion in accordance with NHMRC (2008) recommendations.
d) pH value from down-gradient wells excluding Swamp Creek (n = 150)
e) pH value from Swamp Creek (n = 4)
f) UCL concentration calculated using the US EPA ProUCL v5.1. Where the concentration was below the laboratory limit of reporting (LOR), the LOR concentration was used in the calculations. Where the LOR was elevated above the maximum reported concentration, this LOR value was omitted from the dataset due to its potential to misrepresent the dataset.

There is a potential for direct contact with groundwater by offsite receptors should groundwater be exposed to the surface (for example during periods of flood, see **Section 2.4**), and at surface water features such as the semi-permanent dam in the Swamp Creek area. The potential future health risks due to exposure from groundwater impacts migrating offsite will therefore be assessed further in this CHRA. This exposure scenario is only expected to occur for the Do Nothing scenario when the CWS will remain in place, and therefore the generation of groundwater impacts down-gradient will be an ongoing scenario.

Consequently the potential health risks due to exposure to soluble fluoride in offsite groundwater down-hydraulic gradient of the CWS will be assessed further in this CHRA.

4.5.2.4 Surface Water Impact Sources Down-Hydraulic Gradient of the CWS

Surface water samples were collected at ten locations from the northern (DZ2) and southern (DZ1) vegetated impact area, an ephemeral dam (SW8), the semi-permanent dam (SW3), the southern portion of Wentworth Swamp (SW7) and Swamp Creek (SW1, SW2 and SW4-SW6) in August 2012 and September 2012 (Environ, 2012). Additional surface water samples were collected in March 2013 at the Black Water Hole Creek, and from Swamp Creek in September 2014 and June 2016 by Ramboll Environ. The location of these surface water features are illustrated on **Figure C3**, **Appendix C1**.

A total of 25 surface water samples were collected and samples were analysed for soluble fluoride, cyanide (total and free) and total aluminium. A summary of the surface water analytical concentrations is presented in **Table C6** and **Table C7** (Black Water Hole Creek), **Appendix C3**.

The surface water data were screened against the following health-based assessment criteria:

- National Health and Medical Research Council (NHMRC) (2016) *Australian Drinking Water Guidelines 6*, National Water Quality Management Strategy. Australian Government.
- NHMRC (2008) Guidelines for Managing Risks in Recreational Water. This guideline was adopted as it allows the health-based drinking water guidelines to be adjusted for a recreational exposure scenario that is considered to ingest 10% of the daily drinking water ingestion rate. This is considered to more accurately represent the exposure scenario to be encountered for onsite workers and offsite recreational users of Swamp Creek and Wentworth Swamp. Drinking water guidelines set for aesthetic and/or taste threshold reasons were not adjusted.
- Site-specific assessment criteria for fluoride and aluminum as reported in ENVIRON (2013).

Analytical concentrations of soluble fluoride, cyanide (total and free) and total aluminium were above the adopted Tier 1 assessment criteria for fluoride in locations SW8, DZ1 and DZ2 and cyanide (locations SW5, SW8 and DZ1). This data suggests that the movement of the leachate groundwater plume is limited by the geology as discussed in **Section 2.2** and **Section 2.3.**

Considering the area of Swamp Creek and Wentworth Swamp (i.e. > 1800 m^2, see **Section 2.1.2**), a limited number of samples have been collected to characterise surface water concentrations both temporarily and spatially (refer to **Table C4.1**). Therefore, as a conservative approach, this CHRA will assume that concentrations reported in groundwater down-gradient of the CWS in the Swamp Creek/vegetated area are exposed to the surface and available for direct exposure to offsite receptors. This is a potential exposure scenario during periods of flood and when surface water mixes with shallow groundwater. This exposure scenario is only applicable for the Do Nothing scenario which assumes that the CWS will remain *in-situ* indefinitely.

4.5.2.5 Smelter Waste in the CWS

Spent potlining was placed in the CWS up until 1992, after which the spent potlining waste was stored in an on-site environmentally secure storage facility comprised of purpose-built sheds. Spent potlining, when in contact with moisture, has the potential to produce flammable, toxic and explosive gasses (e.g. ammonia, hydrogen, $CH_4$and phosphine). Spent potlining is a waste generated during aluminium smelting and is subject to the "*Chemical Control Order (CCO) in Relation to Aluminium Smelter Wastes Containing Fluoride and/or Cyanide*" under the *Environmentally Hazardous Chemicals Act 1985*.

At the Smelter, between 1969 and 1992 the process used to remove spent potlining from a pot involved the use of water to soak the pot linings. This resulted in the spent potlining cracking and breaking up, making it easier to remove, transport and stockpile. The use of water also created a reaction between the sodium, carbides and nitrides in the spent potlining to form sodium carbonate, hydrogen, CH_4 and ammonia.

Information from Dames and Moore (1992) *Environmental Impact Statement, Upgrades to Waste Storage Facilities at the Alcan Australia Limited Kurri Kurri Smelter* indicates that the gas generation rate is initially rapid for the three major gases of ammonia, hydrogen and CH_4, with the liberation of hydrogen and CH_4 ceasing within a matter of hours. Ammonia continues to be generated for a longer time period. This soaking process is likely to have released the majority of any harmful gasses from the spent potlining waste prior to disposal into the CWS.

The use of water in the breakup of the pot lining, the subsequent storage in a stockpile open to rain water and the rapid gas generation rate indicates that the spent potlining stored in the CWS is likely to have exhausted its gas generation potential.

Aside from spent potlining, the following materials are understood to have been stockpiled in the CWS:

- Asbestos
- Lead-based paint
- Carbon Plant shot blast refuse, including grit and dust
- Carbon Plant dust collector product
- Collar mix (coke, pitch) spillage
- Carbon Plant floor sweepings
- Packing coke oversize
- Contaminated bath
- Rotary breaker oversize
- Pot lining mix (hot ramming paste)
- Rodding mix (including anthracene oil)
- Stud joining mix
- Pitch spills/ pencil pitch
- Aluminium swarf
- Scrap aluminium billets
- Anode cover material
- Butt from spent anodes
- Ahead of schedule anodes
- Dross
- Pot bottom aluminium
- General rubbish, including plastic, wood and steel

The majority of these materials are associated with the Carbon Plant, which produces carbon anodes from liquid pitch and coke. The main chemical of concern for these materials is PAHs associated with pitch, coke and anodes which have a low solubility in water and are unlikely to generate leachable concentrations.

Soil samples in the CWS were collected to characterise waste in the CWS (refer to **Section 4.5.2.1**); therefore potential health risks due to exposure to Smelter waste in the CWS is considered via these soil concentrations.

Presence of Asbestos

Nineteen soil samples were analysed for the presence/absence of asbestos fragments from the soil samples collected in 2015 (refer to **Section 4.5.2.1**). Of the 19 sail samples, six were identified as containing asbestos fragments. Amosite asbestos fibres were reported in samples between depths of 6.0 and 9.8 m bgs. Chrysotile asbestos fibres were also reported in one soil sample at 7.0 m bgs as shown in **Table C8** in **Appendix C3**.

A qualitative approach will be adopted in this CHRA to assess the potential health risks due to exposure to waste materials (including friable asbestos) in the CWS for both onsite workers and offsite sensitive receptors. Refer to **Section 7.1.3** which details the qualitative method adopted.

4.5.2.6 Gas Emissions from the CWS

Gas emissions from the CWS have been monitored for ammonia, phosphine (arsine), hydrogen cyanide (HCN), hydrogen sulphide (H_2S), CH_4 and hydrogen since 1996, via three different types of techniques:

- *Gas vents (VT01-VT12)*: 12 vents were installed in 1996 through the CWS into the 150 mm thick gas-accumulating gravel layer beneath the clay cap (i.e. imported, clean, unbound gravel containing less than 5% fines and having a permeability less than $1x10^{-3}$cm/sec). Data collected from 27 sampling events between February 1996 and February 2017 were considered in this CHRA, and are reported in Ramboll Environ (2016a and 2016b).
- *Groundwater monitoring wells (MW201-MW206)*: six groundwater monitoring wells were installed in November 2015 through the CWS down to depths between 10.5 m bgs and 14 m bgs. The gas data from these wells represent vapour emanating from the groundwater benath the the CWS. Data collected from six monitoring events between December 2016 and March 2017 were considered in this CHRA, and are reported in Ramboll Environ (2016b).
- *Vapour wells (VW01-VW06)*: six vapour wells were installed in December 2016 through the CWS down to depths between 1.6 and 1.95 m bgs into the 150 mm thick gas-accumulating gravel layer beneath the clay cap. Data collected from six monitoring events between December 2016 and March 2017 were considered in this CHRA, and are reported in Ramboll Environ (2016b).

The location of the gas vents, groundwater monitoring wells and vapour wells are illustrated on **Figure C5, Appendix C1.**

Gas Vent Data

Vapour from the gas vents were collected and analysed *in situ* using kitagawa gas detection tubes for ammonia and a GA-500 landfill gas analyser for phosphine/arsine, HCN, H_2S, CH_4 and hydrogen. The data collected from the gas vents is presented in **Table C9, Appendix C3.** A review of this data indicates that:

- Gas data collected between 1996 and 2012 indicated that gases such as phosphine/arsine, and hydrogen cyanide are either not present in the CWS or are present at very low concentrations below the laboratory limit of reporting. Consequently, there were not recorded in subsequent monitoring events conducted after 2012.
- Ammonia concentrations generally fluctuate both temporarily and spatially, with an average and maximum concentration of 326 ppm and 5500 ppm, respectively.
- Hydrogen and CH_4 concentrations have reduced overtime.
- Prior to December 2016, H_2S concentrations were not detected on the GA-500 landfill gas analyser. Since this time, concentrations have generally decreased with an average and maximum concentration of 18.2 ppm and 200 ppm, respectively.

The maximum and average gas concentrations recorded in the gas vents are presented in **Table C4.7**.

Table C4.7 CWS Gas Concentrations from Gas Vents between 1996 and 2017

Chemical	Maximum Concentration	Average Concentration
Ammonia	5500 ppm	326.3 ppm
Phosphine/Arsine	<0.1 ppm	<0.1 ppm
Hydrogen cyanide (HCN)	<1 ppm	<1 ppm
Hydrogen sulphide (H_2S)	445 ppm	85.7 ppm
Hydrogen	4.2 %	0.53 %
Methane	6.4 %	0.74 %

Notes:
1. Data from 27 sampling events

Monitoring Well Data

Between December 2016 and April 2017, gas samples were collected from six groundwater wells installed through the CWS (MW201-MW206) over six monitoring events. Vapour samples were collected and analysed *in situ* using kitagawa gas detection tubes for ammonia and a GA-500 landfill gas analyser for hydrogen sulphide (H_2S), carbon monoxide (CO), oxygen (O_2), CO_2 and CH_4. The gas data collected from the monitoring wells is presented in **Table C10, Appendix C3**. A review of this data indicates that:

- The highest concentrations for H_2S, CO and CH_4 were recorded in February 2017 at location MW201.
- Ammonia was not sampled in December 2016, January 2017 and March 2017 but was sampled in the three subsequent monitoring events. Ammonia concentrations consistently exceeded the kitagawa gas detection tubes maximum concentration (>900 ppm) for the last three monitoring events at MW201. Ammonia concentrations in the other five wells fluctuated over the sampling period between 25 ppm and >900 ppm.
- High oxygen concentrations representing ambient air concentrations were generally recorded in all six monitoring wells.

The maximum and average gas concentrations from the CWS monitoring wells are presented in **Table C4.8**.

Table C4.8 CWS Gas Concentrations from Monitoring Wells between 2016 and 2017

Chemical	Maximum Concentration	Average Concentration
Ammonia	200 ppm	104 ppm
Hydrogen sulphide (H_2S)	445 ppm	86 ppm
Methane	0.6%	0.1%
Carbon dioxide	1.2%	0.2%
Carbon monoxide	1402 ppm	128 ppm
Oxygen	21.9 %	14%

Notes:
1. Concentrations represent the 'stabilised' measurement.
2. Data from six sampling events

Vapour Well Data

Between December 2016 and April 2017, gas samples were collected from six vapour wells installed through the CWS (VW01-VW06) over six monitoring events. Vapour samples were collected and analysed *in situ* using kitagawa gas detection tubes for ammonia and a GA-500 landfill gas analyser for hydrogen sulphide (H_2S), carbon monoxide (CO), oxygen (O_2), carbon dioxide (CO_2) and CH_4. The gas data collected from the monitoring wells is presented in **Table C11, Appendix C3**. A review of this data indicates that:

- Low oxygen, CH_4 and CO_2 concentrations were consistently measured in the vapour wells across all sampling events.
- Ammonia was not sampled in December 2016, January 2017 and March 2017 but was sampled in the three subsequent monitoring events. Ammonia concentrations were consistently elevated in VW05 and VW06, and were detected above the detection limit for all wells and sampling events.
- Hydrogen sulfide concentrations were also consistently measured over the six sampling events with no decreasing or increasing trend observed.

The maximum and average gas concentrations from the CWS vapour wells are presented in **Table C4.9**.

Table C4.9 CWS Gas Concentrations from Vapour Wells between 2016 and 2017

Chemical	Maximum Concentration	Average Concentration
Ammonia	500 ppm	161 ppm
Hydrogen sulphide (H_2S)	325 ppm	149 ppm
Methane (CH_4)	1.4%	0.5%
Carbon dioxide (CO_2)	0.8 %	0.13%
Carbon monoxide (CO)	1227 ppm	235 ppm
Oxygen	2.6 %	0.29 %

Notes:

1. Concentrations represent the 'stabilised' measurement.
2. Data from six sampling events

Exposure to vapour within the CWS is expected to occur during Management Options 2-7 when the CWS clay cap is removed and the material is disturbed during removal. Gas data from the gas vents, monitoring wells and vapour wells were used to predict ambient air concentrations likely to be experienced by onsite Workers and offsite sensitive receptors during removal of the CWS (refer to **Section 4.5.2.2**). Therefore potential health risks due to exposure from vapours released during removal of the CWS is considered in the assessment of potential health risks from 'particulates and vapours'.

Another potential exposure pathway to vapours generated by the CWS material is via outdoor inhalation should a person be in close proximity to gas vents installed through the CWS and/or proposed Containment Cell. This includes monitoring workers and the community (refer to **Section 4.5.1**). As shown in **Table C4.10**, a comparison of the gas vent data/outdoor air concentration against ambient air standards shows that the likely outdoor gas concentrations due to emissions from the gas vents is below human health air quality standards. Consequently, assessment of this exposure scenario will not be considered further in this CHRA.

Table C4.10 Comparison of CWS gas Concentrations against Air Quality Standards

Chemical	*In situ* Average Concentration (mg/m³)	Predicted Outdoor Air Concentration (mg/m³)	Air Quality Standard (mg/m³)
Ammonia	227.29	0.011[1]	0.069[2]
Hydrogen sulphide (H_2S)	119.46	0.006[1]	0.004[3]

Notes:

1. A soil gas to outdoor air attenuation factor of 0.00005 was applied which represents the sub-slab to indoor air value adopted by CRC CARE (2011) for hydrocarbons (i.e. 0.005) with an additional two orders of magnitude to account for the additional attenuation processes in outdoor air and the very low flow rates reported in the CWS air vents (refer to **Tables C9-C11**, **Appendix C3**).
2. ATSDR value for chronic exposure.
3. NSW EPA (2005) hydrogen sulfide impact assessment criteria for a population of ~10 people.

4.5.3 Exposure Pathways

In order for a human receptor to be exposed to a chemical contaminant derived from a site, there should be an exposure pathway linking the source of contamination and the exposed population. An exposure pathway describes the course a chemical or physical agent takes from the source to the exposed individual and generally includes the following elements (USEPA, 1989):

- Source and mechanism of chemical release;
- Retention or transport medium (or media where chemicals are transferred between media);
- Point of potential human contact with the contaminated media; and
- Exposure route (e.g. ingestion, inhalation) at the point of exposure.

A detailed assessment of the potential exposure pathways for the receptors identified in Section **4.5.1** is presented in **Section 4.5.3.1**.

4.5.3.1 Source-Pathway-Receptor Linkages Summary

An analysis of the source-pathway-receptor linkages for the human receptor groups identified in **Section 4.5.1** is presented in:

- **Table C4.11**, onsite CWS Workers (Do Nothing and Management Options 2-7)
- **Table C4.12**, onsite Containment Cell Workers (Management Options 2, 3, and 4)
- **Table C4.13**, onsite recreational receptors at the proposed Containment Cell (Management Options 2, 3 and 4)
- **Table C4.14**, offsite recreational receptors (Do Nothing scenario only)
- **Table C4.15**, offsite intrusive maintenance workers (Do Nothing scenario only)

Table C4.11 Source-Pathway-Receptor Linkages for Onsite Capped Waste Stockpile Workers

Exposure Scenario	Complete SPR-Linkage? Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Justification
Impacted Soil in CWS								
Dermal contact and incidental ingestion of soil	X	✓	✓	✓	✓	✓	✓	Onsite personnel would have the potential to directly contact soil during removal of CWS. Personnel undertaking minor cap repairs (Do Nothing) assumed not to come into contact with CWS material, only the cap material of the CWS. Soil-derived dust and vapour concentrations were below Tier 1 assessment criteria. Assumed permanent grass cover for the Do Nothing scenario, and therefore no dust from the CWS material would be generated.
Soil-derived dust and vapour inhalation	X	X	X	X	X	X	X	
Impacted Groundwater beneath CWS								
Dermal Contact	✓	✓	✓	✓	✓	✓	✓	Onsite workers would have the potential to incidentally ingest or have dermal contact with contaminated groundwater during monitoring works (Do Nothing) or during removal of the CWS material (Management Options 2-7). Volatile hydrocarbons were reported in groundwater above the Tier 1 assessment criteria. Outdoor inhalation of vapours derived from groundwater impacts for the maintenance/monitoring worker (Do Nothing) is considered to be negligible.
Incidental Ingestion	✓	✓	✓	✓	✓	✓	✓	
Outdoor inhalation of vapours within CWS trench	X	✓	✓	✓	✓	✓	✓	
Potable Ingestion	X	X	X	X	X	X	X	Groundwater beneath the project site is not used for potable purposes.
Materials in the CWS								
Inhalation of asbestos fibres	X	✓	✓	✓	✓	✓	✓	Onsite workers would have the potential to be exposed to asbestos and CWS material during removal of the CWS (Management Options 2-7). Exposure via asbestos fibre inhalation will be assessed qualitatively. Personnel undertaking minor cap repairs (Do Nothing scenario) assumed not to come into contact with CWS material, only the cap material of the CWS.
Exposure to CWS materials	X	✓	✓	✓	✓	✓	✓	

Exposure Scenario	**Complete SPR-Linkage?**							
	Do Nothing	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**	**Option 7**	**Justification**
Inhalation of gas via vents installed through CWS	✓	X	X	X	X	X	X	Ammonia and H_2S gas detected in vents that are installed through the CWS (refer to **Table C4.7**). Monitoring workers have the potential to inhale the gasses during monitoring/maintenance activities associated with the Do Nothing scenario.

Table C4.12 Source-Pathway-Receptor Linkages for Onsite Containment Cell Monitoring Workers (Management Options 2, 3 and 4)

Exposure Scenario	Complete SPR-Linkage?							Justification
	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	
Impacted Soil in Containment Cell								
Dermal contact and incidental ingestion	X	X	X	X	X	X	X	Proposed Containment Cell design would include a capping layer with topsoil and grass restricting direct contact to soil placed in the Containment Cell. Management Options 5, 6 and 7 do not include consideration of an onsite Containment Cell.
Soil-derived dust and vapour inhalation	X	X	X	X	X	X	X	
Impacted Groundwater Beneath Containment Cell								
Dermal contact and incidental ingestion	X	✓	✓	✓	X	X	X	Onsite workers would have the potential to incidentally ingest or have dermal contact with groundwater leachate during monitoring works in the leachate capture system (Management Options 2, 3 and 4).
Potable Ingestion	X	X	X	X	X	X	X	Groundwater beneath the proposed Containment Cell would not be used for potable purposes.
Materials in the Containment Cell								
Exposure to CWS materials including asbestos	X	X	X	X	X	X	X	Proposed Containment Cell design would include a capping layer with topsoil and grass restricting direct contact to material placed in the Containment Cell.
Inhalation of gas via vents installed in Containment Cell	X	X	X	X	X	X	X	Predicted ammonia and H_2S outdoor air concentrations are below the adopted human health air quality standards (refer to **Table C4.10**).

Table C4.13 Source-Pathway-Receptor Linkages for Onsite Recreational Receptors to Containment Cell (Management Options 2, 3 and 4)

Exposure Scenario	Complete SPR-Linkage?							Justification
	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	
Impacted Soil in proposed Containment Cell								
Dermal contact and incidental ingestion of soil	X	X	X	X	X	X	X	Future containment cell design would comprise a capping layer with topsoil and grass that would prevent direct contact with CWS material.
Soil-derived dust and vapour inhalation	X	X	X	X	X	X	X	Onsite Containment Cell is not proposed for Management Options 5-7.
Impacted Groundwater beneath proposed Containment Cell								
Dermal Contact	X	X	X	X	X	X	X	Future containment cell design would comprise a capping layer with topsoil and grass that would prevent direct contact to groundwater. No groundwater monitoring wells would be installed in proposed Containment Cell. Access to leachate capture system would be restricted to employees only.
Incidental Ingestion	X	X	X	X	X	X	X	
Outdoor inhalation of vapours within CWS trench	X	X	X	X	X	X	X	
Potable Ingestion	X	X	X	X	X	X	X	Groundwater beneath the project site is not used for potable purposes.
Materials in the proposed Containment Cell								
Exposure to Containment Cell materials including asbestos	X	X	X	X	X	X	X	Proposed Containment Cell design would include a capping layer with topsoil and grass restricting direct contact to material placed in the Containment Cell.
Inhalation of gas via vents installed in Containment Cell	X	X	X	X	X	X	X	Predicted ammonia and H_2S outdoor air concentrations are below the adopted human health air quality standards (refer to **Table C4.10**).

Table C4.14 Source-Pathway-Receptor Linkages for Offsite Recreational Receptors

Exposure Scenario	Complete SPR-linkage?							
	Do Nothing	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**	**Option 7**	**Justification**
Impacted Soil from CWS								
Dermal contact and incidental ingestion of soil	X	X	X	X	X	X	X	Offsite receptors would not have access to soil within the CWS.
Soil-derived dust and vapour inhalation	X	X	X	X	X	X	X	Predicted airborne particulate and vapour concentrations at the nearest sensitive offsite receptor was below the Tier 1 assessment criteria for acute and chronic exposure (refer to **Section 4.5.2.2)**. Assumed permanent grass cover for the Do Nothing scenario, and therefore no dust would be generated.
Atmospheric deposition on roof catchments used to collect rainwater	X	X	X	X	X	X	X	Predicted total suspended particulates and deposited dusts were below Tier 1 assessment criteria for acute and chronic exposures (refer to **Section 4.5.2.2)**.
Impacted Groundwater down gradient of CWS								
Dermal Contact	✓	X	X	X	X	X	X	Impacted groundwater beneath and down-gradient of the CWS has been identified (refer to **Section 4.5.2.3**). Offsite receptors have the potential for exposure to groundwater in Swamp Creek and/or adjacent vegetated areas during periods of flood and where groundwater intersects surface water.
Incidental Ingestion	✓	X	X	X	X	X	X	
Potable Ingestion	X	X	X	X	X	X	X	Groundwater beneath, and down gradient of the CWS is not used for potable purposes in offsite areas (refer to **Section 2.5**).
Outdoor inhalation of vapours	X	X	X	X	X	X	X	No volatile CoPCs were identified in the offsite groundwater. Free cyanide has the potential to generate hydrogen cyanide gas, however gas monitoring in the CWS did not detect hydrogen cyanide gas above the detection limit of 1 ppm

Exposure Scenario	Complete SPR-linkage?							Justification
	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	
								(see **Section 4.5.2.6**) and therefore the generation of hydrogen cyanide gas is unlikely.
Indoor inhalation of vapours	X	X	X	X	X	X	X	No buildings are located in the offsite area of concern down-hydraulic gradient from the CWS.
Direct contact and incidental ingestion within trenches	✓	X	X	X	X	X	X	Service trenches could potentially be installed down-gradient to maintain subsurface utilities as part of the Rezoning Master plan (refer to **Section 4.5.1**). Given the shallow (<2m bgs) groundwater depth there is a potential for groundwater to intersect a maintenance workers trench.
Materials in the CWS								
Inhalation of asbestos fibres	X	X	X	X	X	X	X	Exposure to offsite receptors due to generation of airborne asbestos fibres during management of the CWS is considered negligible.
Exposure to CWS materials	X	X	X	X	X	X	X	

Table C4.15 Source-Pathway-Receptor Linkages for Offsite Intrusive Maintenance Workers

Exposure Scenario	Complete SPR-linkage?							Justification
	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	
Impacted Soil from CWS								
Dermal contact and incidental ingestion of soil	X	X	X	X	X	X	X	Offsite receptors would not have access to soil within the CWS.
Soil-derived dust and vapour inhalation	X	X	X	X	X	X	X	Predicted airborne particulate and vapour concentrations at the nearest sensitive offsite receptor was below the Tier 1 assessment criteria for acute and chronic exposure. Assumed permanent grass cover for the Do Nothing scenario, and therefore no dust would be generated.
Atmospheric deposition on roof catchments used to collect rainwater	X	X	X	X	X	X	X	Predicted total suspended particulates and deposited dusts were below Tier 1 assessment criteria for acute and chronic exposures.
Impacted Groundwater down gradient of CWS								
Potable Ingestion	X	X	X	X	X	X	X	Groundwater beneath, and down gradient of the CWS is not used for potable purposes in offsite areas (refer to **Section 2.5**).
Outdoor inhalation of vapours	X	X	X	X	X	X	X	No volatile CoPCs were identified in the offsite groundwater. Free cyanide has the potential to generate hydrogen cyanide gas, however gas monitoring in the CWS did not detect hydrogen cyanide gas above the detection limit of 1 ppm (see **Section 4.5.2.6**) and therefore the generation of hydrogen cyanide gas is unlikely.
Indoor inhalation of vapours	X	X	X	X	X	X	X	No buildings are located in the offsite area of concern down-hydraulic gradient from the CWS.

Exposure Scenario	Complete SPR-linkage? Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Justification
Direct contact and incidental ingestion within trenches	✓	X	X	X	X	X	X	Service trenches could potentially be installed down-gradient to maintain subsurface utilities as part of the Rezoning Master plan (refer to **Section 4.5.1**). Given the shallow (<2m bgs) groundwater depth there is a potential for groundwater to intersect a maintenance workers trench.
Materials in the CWS								
Inhalation of asbestos fibres	X	X	X	X	X	X	X	Exposure to offsite receptors due to generation of airborne asbestos fibres during management of the CWS is considered negligible.
Exposure to CWS materials	X	X	X	X	X	X	X	

4.5.4 CSM Summary

A summary of the source-pathway-receptor linkages that will be assessed further in this CHRA is provided in **Table C4.16**.

Table C4.16: Conceptual Model Summary

Exposure Pathway	Onsite CWS Workers	Onsite Monitoring Workers[b]	Offsite Recreational Receptors[c]	Offsite Intrusive Maintenance Worker
Dermal contact and incidental ingestion of soil	✓ (Options 2-7)	X	X	X
Dermal contact and incidental ingestion of groundwater	✓ (Options 2-7)	✓ (Do Nothing and Options 2-4)	✓ (Do Nothing)	✓ (Do Nothing)
Inhalation of vapours within the CWS excavation from groundwater	✓ (Options 2-7)	X	X	X
Exposure to asbestos	✓ (Options 2-7)[a]	X	X	X

Notes:
✓ Indicates a potential exposure pathway is present which will be assessed further in the CHRA
X Indicates a potential exposure pathway is not considered to be present, and will not be assessed further in the CHRA
a) Potential health risks are assessed qualitatively for the asbestos exposure scenario.
b) Monitoring workers for the CWS (Do Nothing) and proposed Containment Cell (Options 2-4)
c) Adult and child recreational users of the Swamp Creek area located down hydraulic gradient of the CWS (Do Nothing scenario)
d) Adult workers who undertake intrusive activities to maintain already installed subsurface utilities located in the down gradient area of the CWS (Do Nothing scenario)

4.5.5 Conceptual Site Model Uncertainty

The CSM described in **Section 4.5** outlines the contamination sources, exposure pathways and receptors for onsite and offsite sensitive receptors that have been assessed in this CHRA. A discussion of the uncertainties associated with the CSM is presented below.

- *Receptor uncertainty*: there is low uncertainty regarding the human receptors for the various Management Options because the Management Options Analysis is applicable to the onsite activities that will be carried out by adult workers. The most sensitive offsite human receptor of concern was identified as a child resident who lives at the residential dwelling that had the highest predicted site-derived dust concentration, for 365 days per year for 30 years. These exposure scenarios are considered to be the most sensitive scenario which adequately addresses any receptor uncertainty.
- *Source uncertainty*: there is moderate uncertainty regarding the contamination source that is assessed in this CHRA because:
  - Site-derived dust concentrations at the nearest offsite receptor were predicted using modelling techniques. However, conservative and EPA approved assumptions were used during the modelling with the aim of reducing any uncertainty in the predicted dust concentrations (**Appendix C2**). This CHRA also used the maximum cumulative dust concentration predicted offsite to assess chronic and acute health risks to the nearest resident.
  - Limited groundwater data were available to characterise chemical concentrations in groundwater beneath the CWS. To account for this limited information, the maximum groundwater concentrations in the CWS were used to assess the potential health risks to onsite workers. The onsite groundwater concentrations were also compared to groundwater data collected immediately down-gradient (for which there is a larger database) to ensure that the maximum chemical concentrations were considered in this CHRA. The maximum CWS soil and soil gas were also used to estimate soil-derived dust and vapour concentrations in the Air Quality Study (**Appendix C2**).
  - Limited surface water samples have been collected in the offsite area of Swamp Creek and Wentworth Swamp to reliably characterise the temporal and spatial surface water concentrations. Therefore, groundwater concentrations reported down-hydraulic gradient of the CWS, in the Swamp Creek/Wentworth Swamp area, were used to assess potential health risks from surface water. Groundwater in the offsite area is shallow (refer to **Section 2.3.2**), and may come to the surface during periods of flood, and where shallow groundwater intersects with surface water features (refer to **Section 2.4**).
  - When assessing potential health risks due to water exposure, the ‘soluble’ or ‘free’ concentration should be considered because adopting the ‘total’ concentration will result in an overly conservative health risk estimate. Therefore, concentrations of soluble fluoride, soluble aluminum and free cyanide were considered in this CHRA when estimating potential health risks.
  - There is uncertainty regarding the relative proportions of aliphatic and aromatic hydrocarbons within the reported TPH groundwater and soil mixture. In the absence of site-specific information this CHRA assessed potential health risks twice, once assuming all TPH is present as aliphatic fractions and once assuming all TPH is present as aromatic fractions. This approach would overestimate any health risks.
- *Exposure pathway uncertainty*: there is moderate uncertainty regarding the exposure pathways adopted for the CHRA because:
  - The onsite remediation exposure scenario includes activities that are assumed to occur during remediation of the CWS (Management Options 2-7) or monitoring/maintenance of the CWS (Do Nothing). These exposure scenarios assumed that workers will be wearing boots, long pants and long sleeved shirts; with face and hands exposed. In reality, the onsite workers are likely to have greater protection via the use of air conditioned machinery and personal protective equipment such as gloves and respiratory protection; therefore health risks are likely to be overestimated. This CHRA also assesses the

potential health risk associated with a number of different 'additional scenarios' for each Management Option that are considered to have a lower likelihood of occurring (refer to **Section 7.3.3**).

- There is low uncertainty for the offsite sensitive receptor exposure pathways because it was conservatively assumed a child recreational user would play in a surface water body in the Swamp Creek area every weekend, and have direct exposure to the surface water.
- There is moderate uncertainty regarding the identification of rainwater tanks in the vicinity of the Smelter Site because not all properties were visited to inspect the presence of rainwater tanks. To compensate for this uncertainty, the CHRA has taken a conservative approach and assumed that the residential property with the highest predicted dust concentration had a rainwater tank.

5. EXPOSURE ASSESSMENT

Exposure assessment involves the estimation of the magnitude, frequency, extent and duration of exposures to contaminants, and identifies exposed populations and particularly sensitive sub-populations. The exposure assessment process involves:

- Identification of exposed populations;
- Identification of potential exposure pathways;
- Estimation of exposure concentrations for each pathway; and
- Estimation of contaminant intakes for each pathway for a range of scenarios.

5.1 Human Behavioural and Lifestyle Assumptions

Human behavioural and lifestyle assumptions adopted in the CHRA were obtained from site-specific information, and where missing, from the following Australian and international resources:

- NEPM (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1)
  - Schedule B4, Site-Specific Health Risk Assessment Methodology.
  - Schedule B7, Derivation of Health-Based Investigation Levels.
- US EPA (2011) Exposure Factors Handbook: 2011 Edition.

The human behavioural and lifestyle assumptions adopted in this CHRA are presented in **Table C5.1** (onsite CWS workers), **Table C5.2** (onsite proposed Containment Cell workers), **Table C5.3** (offsite recreational receptors) and **Table C5.4** (offsite intrusive maintenance workers).

The health risk assessment process is designed to consider an individual who has reasonable maximum exposure i.e., the highest exposure that is reasonably expected to occur at a site. When considering an adult worker in a construction or maintenance scenario, is it common practice in Australia to assume that the worker is wearing boots, full-length pants and long-sleeve shirt; with hands and face exposed to soil and/or groundwater (NEPM, 2013). Personal protective equipment (PPE) such as gloves and face shields do not always provide 100% protection against exposure to chemicals due to (but not limited to):

- improper application of PPE due to inadequate instruction and training of workers;
- incorrect choice of PPE for the chemical exposure;
- careless behaviour of the user;
- wearing poorly maintained or malfunctioning PPE; and
- ill-fitting respirators that may also contain the incorrect filter for the chemical exposure.

It is for these reasons listed above that the health risk assessment process does not take into account the application of PPE to reduce exposure during construction or maintenance work other than clothing and footwear which covers the body, arms, legs and feet. This approach is considered to be suitably health-protective for the maximally exposed individual.

Ramboll Environ has taken this into account when selecting the human behavioural assumptions for the onsite CWS worker and onsite proposed Containment Cell worker. These workers are considered to wear boots, long-sleeved shirts and long pants with hands and face exposed to soil and groundwater.

Table C5.1: Onsite CWS Worker Human Behavioural and Lifestyle Assumptions

Parameter	Onsite Personnel	Source
Exposure duration (years)	Do Nothing (30) Option 2 (1.6) Option 3 (5.5) Option 4 (1.6) Option 5 (6.1) Option 6 (17.0) Option 7 (7.2)	Do Nothing: NEPM (2013) Commercial. Options 2-7: represents the duration of tasks that would result in exposure to CWS material and groundwater beneath the CWS for each Management Option.
Carcinogenic averaging time (days)	25,550	Assumes 365 days per year for 70 years (NEPM, 2013)
Body weight (kg)	70	NEPM (2013), adult value.
Direct Contact with Groundwater/Surface Water from CWS		
Exposure frequency (days/year)	4 (Do Nothing) 240 (Options 2-7)	Do Nothing: Assumes an ongoing, 1 day per quarter groundwater monitoring. Option 2-7: Assume 5 days per week with 4 weeks holiday
Exposure time for dermal contact (hour/day)	1	Assumes contact with water for 1 hour per day
Exposed skin surface area (cm^2)	1,450	Hands and 25% of head value from Table 3.2.3 (enHealth, 2012)
Incidental ingestion rate (L/day)	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25mL/hr for >15yrs whilst swimming
Inhalation of Vapours derived from Groundwater Impacts within the CWS Excavation (Options 2-7 only)		
Exposure time spent in a the CWS excavation (hrs)	8	Assumes an 8 hour working day

Direct Contact with Impacted Soil in CWS		
Exposed skin surface area (cm^2)	1,450	Hands and 25% of head value from Table 3.2.3 (enHealth, 2012)
Soil to skin adherence (mg/cm^2)	0.6	enHealth (2012) 50^{th} percentile for pipe layers (wet soil)
Exposure frequency to soil (days/year)	240 (Options 2-7)	Option 2-7: Assumes 5 days per week with 4 weeks holiday per year. Note, minor cap repairs associated with the Do Nothing scenario assumes no direct contact with CWS material, only the cap material of the CWS.
Soil ingestion rate (mg/day)	25	NEPM (2013) for commercial land use. Conservative assumption considering personal protective equipment will be worn during remediation activities that will limit the amount of soil incidentally ingested.

Table C5.2: Onsite Proposed Containment Cell Human Behavioural and Lifestyle Assumptions (Options 2, 3 and 4)

Parameter	Monitoring Worker	Source
Carcinogenic averaging time (days)	25,550	Assumes 365 days per year for 70 years (NEPM, 2013)
Body weight	70	NEPM (2013) adult value
Exposure duration (years)	30	NEPM (2013) commercial/industrial value
Exposure frequency (days/year)	4	Assumes an ongoing, 1 day per quarter monitoring of the leachate capture system.
Water ingestion rate (L/day)	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25 mL/hr for >15yrs whilst swimming
Skin surface area (cm^2)	1,450	Hands and 25% of head value from Table 3.2.3 (enHealth, 2012)
Exposure time (hours)	1	Conservative assumption

Table C5.3: Offsite Recreational Human Behavioural and Lifestyle Assumptions (Do Nothing scenario)

Parameter	Adult	Child	Source
Averaging time (carcinogens)	25,550	25,550	Assumes 365 days per year for 70 years (NEPM, 2013)
Body weight	70	15	NEPM (2013) adult and child value
Direct Contact with Surface Water			
Exposure duration (years)	29	6	NEPM (2013) Exposure duration for a recreational receptor.
Exposure frequency (days/year)	104	104	Assumes every weekend.
Exposure time (hours)	1	1	Assumes hand and feet are wet for a total of one hour per exposure event.
Event frequency for dermal exposure to surface water (events/day)	1	1	Assumes a child/adult visit the surface water body in the Swamp Creek area once per day.
Surface water ingestion rate (L/day)	0.013	0.025	Based on 50% of the recommended approximate average water ingestion rate while swimming of 50 mL/hr and 25 mL/hour for children aged ≤15 years, and adults ≥ 15 years, respectively (enHealth, 2012).
Skin surface area (cm^2)	6700	2700	Mean total skin surface area for the feet, hands, forearms and lower legs for an adult (Table 3.2.3) and 3-6yrs old child (Table 3.2.5) (enHealth, 2012).

Table C5.4: Offsite Intrusive Maintenance Worker Human Behavioural and Lifestyle Assumptions (Do Nothing Scenario)

Parameter	Adult	Source
Averaging time (carcinogens)	25,550	Assumes 365 days per year for 70 years (NEPM, 2013)
Body weight	70	NEPM (2013) adult and child value
Direct Contact with Surface Water		
Exposure duration (years)	30	NEPM (2013) exposure duration for commercial/industrial land use
Exposure frequency (days/year)	20	Assumes four weeks work for major repair work
Exposure time for dermal contact (hour/day)	1	Conservative assumption
Event frequency for dermal exposure to surface water (events/day)	1	Assumes 1 hour exposure to water each day.
Surface water ingestion rate (L/day)	1,450	Hands and 25% of head value from Table 3.2.3 (enHealth, 2012). Assumes worker is wearing boots, long pants and long sleeved shirt.
Skin surface area (cm^2)	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25 mL/hr for >15yrs whilst swimming

5.1.1 Human Exposure Parameter Uncertainty

Risk assessment requires the adoption of several assumptions relating to human behaviour and characteristics in order to assess potential human exposure. However the exposure scenario for each of the Management Options has a degree of uncertainty associated with it. To account for this uncertainty, the assumptions used for the onsite and offsite receptors were conservative and developed to provide an estimate of reasonable maximum exposures rather than the actual exposures. For example, during remediation of the CWS it was conservatively assumed that adult workers would have their hands and face exposed to groundwater whereby they have the potential to incidentally ingest groundwater (via splashing) and touch groundwater with their hands. In reality, remediation workers would comply with health and safety protocols which include wearing gloves and respiratory protection.

This approach tends to overestimate the associated risks because it is highly unlikely that this level of exposure could occur during remediation/monitoring of the CWS and therefore this conservatism, or over prediction, of risk is considered to have more than catered for potential exposure uncertainty in the risk assessment. Uncertainty in the assessment is, therefore, taken into account by erring on the side of over estimation and health protection.

5.2 Exposure Point Concentrations

An exposure point concentration (EPC) is the estimation of the concentration of the source contaminant in the medium that the population is exposed to, at the location where exposure is predicted to occur. EPCs are identified for each site-impacted ‘exposure unit’, which is defined as the area throughout which a receptor moves and encounters an environmental medium for the duration of exposure. Typically, an individual receptor is assumed to be equally exposed to media within all portions of the exposure unit over the time frame of the risk assessment, which is often an overly conservative assumption.

There are a number of options for choosing the value to use as the EPC, and the most appropriate method will depend on the data set and site-specific exposure scenarios. These options include:

- *Maximum observed contaminant concentration*: this is often the most conservative option and is commonly used for groundwater sources where trends are poorly defined.
- *Mean concentration*: this is suitable for use as an EPC provided that it adequately represents the source being considered, and hotspot areas are not ignored. The mean value is more representative of the source as a whole, and may provide a better estimation of the actual concentration that a population would be exposed to over a period of time.
- *95% upper confidence limit (UCL) of the arithmetic mean contaminant concentration*: this provides a 95% confidence level that the true population mean will be less than, or equal to, this value. This is useful as an EPC in accounting for uncertainty in whether the data set is large enough for the mean to provide a reasonable measure of tendency.

For this CHRA, where data were limited (such as onsite groundwater) the maximum reported concentration was adopted. Where a sufficient data set was available (such as offsite groundwater) the 95% UCL concentration was adopted at the EPC.

Modelling methodology was used to estimate vapour concentrations emanating from groundwater impacted by naphthalene and TPH C_6-C_9 within the CWS excavation (Management Options 2-7). The modelling methodology, assumptions and results are described in **Section 7**.

5.2.1 Adopted exposure Point Concentrations

The soil EPCs presented in **Table C5.5** represent the 95% UCL soil concentration which exceeded the 'low density residential' land use criteria (refer to **Table C4.3**). Potential health risks to onsite personnel who undertake CWS remedial activities (Management Options 2-7) is assessed using these soil concentrations. Since the relative proportions of aliphatic and aromatic fractions within the TPH mixture is unknown, the CHRA assessed the TPH twice, once assuming TPH is present as aromatic fractions and once assuming TPH is presented as aliphatic fractions. This is considered to be a conservative approach, and likely to overestimate potential health risks.

Table C5.5: Soil Exposure Point Concentrations (mg/kg) for onsite CWS workers (Management Options 2-7)

Chemical	Soil EPC (mg/kg)
Fluoride (soluble)	14,304
Benzo(a)pyrene	176.4
Benz(a)anthracene	162.2
Chrysene	136.6
Benzo(b+j)fluoranthene	297
Benzo(k)fluoranthene	305.1
Indeno(1,2,3-c,d)pyrene	87.8
Dibenzo(a,h)anthracene	31.2
Benzo(g,h,i)perylene	93.9
Arsenic	151.5
TRH>C10-C16 less Naphthalene (F2)	119.7
TRH >C16-C34	5988

The onsite and offsite groundwater EPCs are summarised in **Table C5.6** and **Table C5.7,** respectively. Due to the limited onsite dataset, the onsite EPCs represents the maximum reported concentration in groundwater beneath the CWS. The offsite fluoride EPC represents the 95% UCL concentration in the shallow wells located offsite down gradient of the CWS.

Since the relative proportions of aliphatic and aromatic fractions within the groundwater TPH mixture is unknown, the CHRA assessed TPH twice, once assuming all TPH is present as aromatic fractions and once assuming TPH is present at aliphatic fractions. This is considered to be a conservative approach, and likely to overestimate potential health risks.

Table C5.6: Groundwater Exposure Point Concentrations (mg/L) for Onsite CWS and Proposed Containment Cell Workers

Chemical	Groundwater EPC Onsite workers (mg/L)
Fluoride (soluble)	1880
Benzo(a)pyrene	0.0096
Benz(a)anthracene	0.0092
Benz(b+j)fluoranthene	0.0123
Benzo(k)fluoranthene	0.0039
Indeno(1.2.3.cd)pyrene	0.007
Dibenz(a.h)anthracene	0.0017
Naphthalene	0.058
TPH (C6-C9) aliphatic	0.33
TPH (C6-C9) aliphatic	0.33

Table C5.7: Groundwater Exposure Point Concentrations (mg/L) for Offsite Receptors (Do Nothing only)

Chemical	Groundwater EPC Offsite Receptors (mg/L)
Soluble fluoride	357.1

5.2.1.1 Groundwater-Derived Vapour Estimation within the CWS Trench

Estimation of groundwater-derived vapour concentrations within the CWS excavation was undertaken using the Virginia Department of Environmental Quality ("DEQ") service trench model ("vrp38" spreadsheet). The modelling considers vapour emanating from a dissolved phase hydrocarbon source. The modelling approach is based upon a combination of a vadose zone model to estimate volatilisation of vapour from contaminated groundwater into a trench, and a box model to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere to estimate the EPC for air in a maintenance trench.

Table C5.8 presents the parameters adopted during vapour modelling for the intrusive maintenance workers trench.

Table C5.8 CWS Excavation Vapour Modelling Assumptions

Parameter	Value Adopted	Comment
Depth to groundwater (cm)	0	Groundwater assumed to seep into CWS, direct contact therefore possible
Trench height (m)	5	
Trench length (m)	10	Conservative, actual CWS excavation likely to be larger
Trench width (m)	10	
Air exchange in trench (h^{-1})	360	VDEQ recommended value when the depth of the trench is less than the trench width
Fraction of floor through which groundwater can enter	0.9	Assumes the CWS intersects the groundwater
Water temperature (ºC)	22.2	Average (*n*=4) stabilised temperature recorded during the groundwater sampling event in November 2015 at the CWS (Ramboll Environ, 2016a).

The groundwater-derived vapour EPCs within the CWS excavation, that were estimated using the modelling methodology described above, are summarised in **Table C5.9**.

Table C5.9: Groundwater-Derived Vapour EPC within the CWS Excavation.

Chemical	Groundwater-Derived Vapour EPC within the CWS excavation (mg/m^3)
Naphthalene	1.02E-03
TPH C6-C9 aliphatic	6.78E-03
TPH C6-C9 aromatic	7.16E-03

5.3 Estimation of chemical Intakes

The chemical intakes are estimated for each receptor, chemical and pathway separately, and the methodology follows that described in NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1), Schedule B4, Site-Specific Health Risk Assessment Methodology*. The equations used to estimate chemical intake are presented in **Appendix C4** for the following exposure pathways:

- Inhalation of groundwater-derived vapour generated during remediation of the CWS;
- Incidental ingestion of groundwater;
- Dermal contact with groundwater;
- Dermal contact with soil; and
- Incidental ingestion of soil.

6. HAZARD ASSESSMENT

Hazard assessment is typically divided into two stages: hazard identification; and dose-response assessment. The hazard identification stage is a qualitative description of the capacity of a contaminant or agent to cause harm. The dose-response assessment includes the selection of appropriate toxicity criteria from a hierarchy of published and reliable sources.

6.1 Hazard Identification

The hazard identification process provides a means in which to consider the capacity of a specific agent to produce adverse health or environmental effects. Hazard identification comprises the initial part of the toxicity assessment process involving the consideration of the types of adverse health effects that might be caused by a given agent and uncertainty analysis of toxicological data.

The hazard identification assessment is generally restricted to those compounds that were found to be present at the site in excess of the relevant Tier 1 assessment criteria which were:

- Arsenic
- Asbestos
- Naphthalene
- Polycyclic aromatic hydrocarbons (including benzo(a)pyrene and related carcinogenic compounds)
- Soluble fluoride
- Total petroleum hydrocarbons

A review of the toxicological effects and available toxicity data for PAHs (including benzo(a)pyrene) and arsenic was undertaken during development of the NEPM (2013) soil heath investigation levels; and this information is published in Schedule B7, Appendix A1 and Appendix A2. With the exception of benzo(a)pyrene, the toxicity data used during derivation of the HILs were also adopted in this CHRA.

In January 2017, the US EPA published the findings of their toxicological review for benzo(a)pyrene which considered more recent toxicological data than what was available when the HILs were derived (US EPA, 2017). The benzo(a)pyrene toxicological data recommended by US EPA is considered to be a more current review of toxicity data not previously considered when the HILs were developed, and therefore are more appropriate for use in this CHRA.

The toxicological profiles for asbestos, soluble fluoride, naphthalene and TPH are provided in **Appendix C5**. The soil dermal absorption factor (DAF), oral bioavailability and gastrointestinal absorption factor (GAF) adopted for each chemical in this CHRA is presented in **Table C6.1**.

The physico-chemical parameters for each chemical assessed in this CHRA is provided in **Appendix C6**.

Table C6.1 Absorption and Bioavailability Chemical Properties for the CHRA

Chemical	Soil Dermal Absorption Factor (DAF) (unitless)	Oral Bioavailability (B) (%)	Gastrointestinal Absorption factor (GAF) (unitless)
Arsenic	0.005[a]	80%[a]	1[a]
Benz(a)anthracene	0.06[a]	100%[a]	1[a]
Benzo(a)pyrene	0.06[a]	100%[a]	1[a]
Benzo(b)fluoranthene	0.06[a]	100%[a]	1[a]
Benzo(g,h,i)perylene	0.06[a]	100%[a]	1[a]
Benzo(k)fluoranthene	0.06[a]	100%[a]	1[a]
Chrysene	0.06[a]	100%[a]	1[a]
Dibenz(a,h)anthracene	0.06[a]	100%[a]	1[a]
Fluoride (soluble)	0.001[e]	100%[e]	1[e]
Naphthalene	0.1[b]	100%[d]	1[c]
TRH Aliphatic >C6-C10	0.2[b]	100%[d]	1[c]
TRH Aliphatic >C10-C16	0.2[b]	100%[d]	1[c]
TRH Aliphatic >C16-C34	0.2[b]	100%[d]	1[c]
TRH Aromatic >C6-C10	0.2[b]	100%[d]	1[c]
TRH Aromatic >C10-C16	0.2[b]	100%[d]	1[c]
TRH Aromatic >C16-C34	0.2[b]	100%[d]	1[c]

Notes
a) NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure.
b) CCME (2008) Canadian council of Ministers of the Environment, Standard for petroleum Hydrocarbons in Soil, January.
c) The Risk Assessment Information System (RAIS) database, accessed May 2017
d) US EPA (2004) Risk Assessment Guide for Superfund, Part E, Supplemental Guidance for Dermal Risk Assessment
e) Chavoshi, E., *et al*. (2011) "Health risk assessment of fluoride exposure in soil, plants, and water at Isfahan, Iran." *Human and Ecological Risk Assessment* 17.2: 414-430.

The objective of the dose-response assessment is to identify the toxicity values for each CoPC to be used for the quantification of human health risk. The numerical values derived from toxicity dose-response studies are referred to collectively as toxicity values. There are two basic approaches for the dose-response assessment that have been developed on the basis of the way in which chemicals cause toxicity: 1) threshold toxicity, and 2) non-threshold toxicity.

6.1.1 Threshold Toxicity

Threshold toxicity is exhibited by chemicals where there is an exposure level below which no toxic effect is thought to occur. Threshold substances are generally considered to include most non-carcinogenic chemicals and non-genotoxic carcinogens, however some carcinogenic chemicals act by both threshold and non-threshold toxicological modes of action (such as benzene).

Potential health effects that are assessed on the basis of a threshold dose response utilise a threshold value which is typically termed an acceptable or tolerable daily intake (ADI or TDI) or a reference dose (RfD) (expressed as mg of chemical/kg of body weight/day). For the purpose of this assessment, the threshold value adopted has been termed a TDI. A TDI is a chemical intake below which it is considered unlikely that adverse effects would occur in human populations, including sensitive sub-groups (such as the very young or elderly). Hence, the TDI relates to intakes from all sources, the site related impacts as well as background intakes (where relevant).

For inhalation exposures, the threshold value is typically termed a tolerable concentration in air (TC) or reference concentration (RfC) (expressed as mg of chemical/cubic meter of air), which is an estimate of a continuous inhalation exposure concentration to people (including sensitive subgroups) that is likely to be without risk of deleterious effects during a lifetime.

Exceedence of the threshold level does not imply that adverse effects will occur, as there are a number of uncertainties and safety factors incorporated into the threshold value, rather that exposure needs to be further evaluated.

6.1.2 Non-Threshold Toxicity

Non-threshold toxicity is exhibited by chemicals where there is considered to be no dose below which no adverse effect will occur. Genotoxic carcinogens comprise this group and they can potentially cause carcinogenesis at any level of exposure, with the probability of carcinogenesis increasing with dosage. These chemicals are therefore assessed on the basis of a non-threshold dose-response relationship.

The assessment of potential health effects associated with genotoxic carcinogens requires the use of non-threshold toxicity values. The values available are essentially the slope of the cancer dose-response curve for the chemical (based on relevant studies and approaches to extrapolate effects from high doses to low doses) and are termed either a cancer slope factor ("CSF") or an inhalation unit risk ("IUR"). The CSF (expressed as $(mg/kg/day)^{-1}$), or IUR (expressed as $(\mu g/m^3)^{-1}$) is used to estimate the probability of an individual developing cancer at some point in a lifetime as a result of a specific exposure.

6.2 Dose-Response Assessment

6.2.1 Adopted Dose-Response Values

The threshold and non-threshold dose-response values published in the follow guidance were adopted in this CHRA:

- NEPM (2013) Schedule B7, Appendix A1, The Derivation of HILs for Metals and Inorganics.
- NHMRC (2016) Australian Drinking Water Guidelines 6, Version 3.3 Updated November 2016
- United States Environmental Protection Agency, Online Integrated Risk Information System (IRIS) database, accessed May 2017.
- Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for Naphthalene, 1-methylnaphthalene and 2-methylnaphthalene, August 2005.
- Total Petroleum Hydrocarbon Criteria Working Group Series (1997), Volume 4 – Development of Fraction Specific Reference Doses and Reference Concentrations for Total Petroleum Hydrocarbons (TPH).

The dose-response values adopted for this CHRA are presented in **Table C6.2.**

Table C6.2: Adopted Dose-Response Values

Chemical	Threshold Values		Non-Threshold Values	
	RfD (mg/kg-day)	RfC (mg/m^3)	SF oral $(mg/kg\text{-}day^{-1})$	IUR (mg/m^3)
Ammonia	-	0.069[d]	-	-

Arsenic	0.02[a]	0.01[a]	-	-
Benzo(a)pyrene	0.0003[b]	2.0E-06[b]	1.0[b]	0.143[a]
Benz(a)anthracene	-	-	0.1[f]	0.0143[f]
Benzo(b)&(k)fluoranthene	-	-	0.1[f]	0.0143[f]
Benzo(g,h,i)perylene	-	-	0.01[f]	0.00143[f]
Chrysene	-	-	0.01[f]	0.00143[f]
Dibenz(a,h)anthracene	-	-	1.0[f]	0.143[f]
Indeno(1,2,3-c,d)pyrene	-	-	0.1[f]	0.0143[f]
Fluoride (soluble)	0.04[e]	-	-	-
Hydrogen Sulfide	-	0.028[d]	-	-
Naphthalene	0.02[b]	0.003[b]/[d]		
TPH C_6-C_9 aliphatic	5.0[c]	18.4[c]	-	-
TPH C_6-C_9 aromatic	0.04[c]	0.2[c]	-	-
TPH C_{10}-C_{16} aliphatic	0.1[c]	1.0[c]	-	-
TPH C_{10}-C_{16} aromatic	0.04[c]	0.2[c]	-	-
TPH C_{16}-C_{34} aliphatic	2.0[c]	not volatile	-	-
TPH C_{16}-C_{34} aromatic	0.03[c]	not volatile	-	-

Notes:
RfD: reference dose
RfC: reference concentration
SF: slope factor
IUR: inhalation unit risk

a) NEPM (2013) Schedule B7, Appendix A1
b) US EPA IRIS Online Database (accessed May 2017)
c) TPH (1997) Volume 4 – Development of Fraction Specific Reference Doses and Reference Concentrations for Total Petroleum Hydrocarbons (TPH)
d) ATSDR Toxicological Profile
e) NHMRC (2016) Australian Drinking Water Guidelines 6, Version 3.6 Updated November 2016
f) Toxic equivalency factors relative to benzo(a)pyrene adopted to derive toxicity value as per recommendations in NEPM (2013) Schedule B1, Guideline on Investigation Levels for Soil and Groundwater.

6.2.2 Background Exposure

Background levels of contamination comprise chemical concentrations present in the environment as a result of everyday activities or natural sources. These chemicals may be present in food, air, water and consumer products and represent the non-site sources of contamination exposure. This is commonly referred to as background exposure which should be taken into account during the assessment of potential human health risk.

Background exposure is only applied to threshold contaminants (i.e. non-carcinogens) because intakes of non-threshold contaminants (i.e. carcinogens) are considered on the basis of an increase in risk, which is irrespective of background exposure. The allocation of background exposure is undertaken on a chemical-specific basis by applying a factor (%) to the threshold toxicity reference value (TRV or Reference Dose), as illustrated in the equation below:

$$TRV\ (adjusted\ for\ background\ exposure) = (1 - Background\ (\%))\ x\ TRV$$

In cases where background exposure is considered to be essentially negligible (contributing to less than 5% of the threshold TRV), no background exposure has been applied. Where background exposure is considered to comprise greater than 50% of the threshold TRV, the background exposure is considered to be 50% of the TRV.

The allocation of the TRV to background exposure for the chemicals assessed in this CHRA is presented in **Table C6.3**

Table C6.3: Background Exposure Adopted for Non-Carcinogenic Chemicals

Chemical	Oral (%)	Inhalation (%)	Source
Arsenic	50	0	NEPM (2013)
Fluoride	10	0	ENVIRON (2013a) Preliminary Screening CHRA
Naphthalene	0	0	CRC CARE (2011)
TPH C_6-C_{16}	10	10	CRC CARE (2011)
TPH C_{16}-C_{34}	10	0	CRC CARE (2011)

6.3 Hazard Assessment Uncertainty

In general, the available scientific information is insufficient to provide a thorough understanding of all of the potential toxic properties of chemicals to which humans may be exposed. It is necessary, therefore, to extrapolate these properties from data obtained under other conditions of exposure and involving experimental laboratory animals. This may introduce two types of uncertainties into the risk assessment:

- Those related to extrapolating from one species to another; and
- Those related to extrapolating from the high exposure doses, usually used in experimental animal studies, to the lower doses usually estimated for human exposure situations.

The majority of the toxicological knowledge of chemicals comes from experiments with laboratory animals, although there may be interspecies differences in chemical absorption, metabolism, excretion and toxic response. There may also be uncertainties concerning the relevance of animal studies using exposure routes that differ from human exposure routes. In addition, the frequent necessity to extrapolate results of short-term or subchronic animal studies to humans exposed over a lifetime has inherent uncertainty.

In order to adjust for these uncertainties, toxicity reference values incorporate safety factors that may vary from 10 to 10,000. The US EPA assumes that humans are as sensitive to carcinogens as the most sensitive animal species. The policy decision, while designed to minimise the potential for underestimating risk, introduces the potential to overestimate carcinogenic risk. Conversely, it also does not allow for the possibility that humans may be more sensitive than the most sensitive animal species.

The toxicity reference values adopted in this CHRA (illustrated on **Table C6.2**) have included additional safety factors. For example, the naphthalene TRV recommended by the US EPA IRIS database was derived by dividing an oral 90-day rat gavage study No-Observed-Adverse-Effect-Level (NOAEL) of 71 mg/kg body weight per day, but an uncertainty factor of 3000 (10 to extrapolate from rats to humans, 10 to protect sensitive humans, 10 to extrapolate from subchronic to chronic exposure, and 3 for database deficiencies including lack of chronic oral exposure studies and 2-generation reproductive toxicity studies).

7. RISK CHARACTERISATION

Risk characterisation is the final step in the risk assessment process whereby information gathered and derived from the hazard assessment and exposure assessment are combined to derive numerical estimates of risk to human health. Conclusions reached during the risk characterisation process conveys the nature and existence of (or lack of) human health risks in a manner useful for decision makers.

7.1 Methodology

7.1.1 Chemical Threshold Risks

Non-carcinogenic or threshold risks are estimated in the form of Hazard Quotients ("HQs"), which are estimated for the dermal/oral pathways and the inhalation pathways as described below.

Oral/Dermal Pathways

$$Hazard\ Quotient\ (HQ) = \frac{Mean\ Daily\ Intake\ (MDI)\ \left(\frac{mg}{kg}\ day\right)}{Tolerable\ Daily\ Intake\ (TDI)\ \left(\frac{mg}{kg}\ day\right)}$$

Inhalation Pathways (dust and vapour)

$$Hazard\ Quotient\ (HQ) = \frac{Exposure\ Adjusted\ Air\ Concentration\ \left(\frac{\mu g}{m^3}\right)}{Tolerable\ Air\ Concentration\ \left(\frac{\mu g}{m^3}\right)}$$

Since an individual might be exposed to a substance or combination of substances via several exposure pathways, the HQs (for multiple exposure pathways and a combination of chemicals) can be summed to calculate an overall risk level, or Hazard Index (HI), as described below.

$$Hazard\ Index\ (HI) = \Sigma\ Hazard\ Quotients$$

It is important however to consider the reasonable exposure pathways combinations and to assess whether it is likely that the same individual would consistently face the reasonable maximum exposure by more than one pathway. Although often a conservative process, this procedure can be used to assess the additivity of effects from concurrent exposure to a mixture of chemicals.

7.1.2 Chemical Non-Threshold Risks

Carcinogenic or non-threshold risks are estimated in the form of Increased Lifetime Cancer Risks ("ILCR") which are estimated for the dermal/oral pathways and the inhalation pathways as illustrated below.

Oral/Dermal Pathways

$$ILCR = Chronic\ Daily\ Intake\ \left(\frac{mg}{kg}day\right) \times\ Slope\ Factor\ \left(\frac{mg}{kg}day\right)^{-1}$$

Inhalation Pathways (dust and vapour)

$$ILCR = Exposure\ Adjusted\ Air\ Concentration\ \left(\frac{\mu g}{m^3}\right) \times Inhalation\ Unit\ Risk\ \left(\frac{\mu g}{m^3}\right)^{-1}$$

Estimates from all pathways are summed to produce a total ILCR for each contaminant. ILCRs are evaluated against acceptability criteria set *a priori* to the risk assessment process, termed Maximum Acceptable Risk Levels ("MARLs").

7.1.3 Asbestos Exposure Risk

The 'Asbestos Health Risk' value is influenced by:

- the number of activities that disturb soil CWS material (defined as a 'soil disturbance event'), and therefore potentially generate airborne asbestos fibres that can be inhaled; and
- the expected duration (years) of each soil disturbance event.

Each soil disturbance event is allocated an 'Asbestos Health Risk' value of 0.5 in accordance with the definitions described in **Table C7.1**. The Asbestos Health Risk Value is then multiplied by the expected duration of each soil disturbance event (years).

Table C7.1 Asbestos Exposure Risk Definitions

Soil Disturbance Event	Asbestos Health Risk Value
Soil in CWS is excavated and loaded onto truck	0.5
Soil is transported and placed in onsite/offsite storage treatment facility	0.5
Haul road between CWS and onsite/offsite containment cell is scraped and placed into onsite/offsite containment cell	0.5
Sorting of CWS recyclable material	0.5
Cleaning of steel and carbon recyclable materials	0.5
Additional cleaning of steel recyclable materials	0.5
Additional cleaning of carbon recyclable materials	0.5
Crushing of fines and crushable materials	0.5
Pug Mill lime treatment of crushed fine materials	0.5

7.2 Risk Acceptability Criteria

The MARL for non-carcinogenic risk is a HI of one (NEPM, 2013). A HI of less than one indicates that the estimated level of exposure is below that at which health risks are expected to occur. Should the HI exceed one then the 'risk driving' compounds and pathways need to be considered in more detail (such as segregating the pathways and/or different chemicals).

For non-threshold (carcinogenic) chemicals, the incremental lifetime cancer risk estimates for each receptor have been compared to an acceptable carcinogenic risk level of 1 in 100,000 (1×10^{-5}) in accordance with NEPM (2013) guidelines. Similar to the threshold risk MARL, a carcinogenic risk level greater than 1 in 100,000 implies that health risks are low and acceptable, and a carcinogenic risk level less than 1 in 100,000 indicates the potential for unacceptable health risks and further investigation is required.

7.3 Summary of Health Risk Estimates

7.3.1 Quantitative Health Risk Estimates

The quantitative health risk estimates for each Management Option is provided in **Appendix C6**. A summary of the health risk estimates for each Management Option is presented in **Table C7.2** and **Table C7.3** for the threshold and non-threshold compounds, respectively.

7.3.1.1 Threshold Health Risks

- Do Nothing scenario:
  - Threshold health risks for onsite workers who conduct monitoring of the CWS leachate were low and acceptable with a HI of 0.07.
  - Health risks were similarly low for future offsite maintenance workers undertaking repairs on subsurface utilities where groundwater enters a trench.

    - Unacceptable health risks were identified for offsite recreational receptors who have the potential to incidentally ingest fluoride in surface water during recreational play in surface water bodies in the Swamp Creek area. These potential health risks assume that fluoride concentrations in surface water are similar to groundwater concentrations down gradient of the CWS, and that the CWS material remains *in-situ*.
- Management Options 2-7:
    - Management Options 2-7 had the same HI value because the only parameter that differed between these exposure scenarios was the exposure duration (measured in years) which is irrelevant when estimating the dose for threshold chemicals because it is both a numerator and denominator (refer to algorithms presented in **Appendix C4**).
    - Potentially unacceptable threshold health risks were identified via the incidental ingestion of groundwater (driven by fluoride concentrations) and dermal contact with groundwater (driven by benzo(a)pyrene concentrations) during removal of the CWS material.
    - Threshold risks for the other exposure pathways (direct contact with soil and vapour inhalation with the CWS excavation) were considered to be low and acceptable.
    - Threshold health risks for onsite workers who conduct monitoring of the proposed onsite Containment Cell leachate were low and acceptable with a HI of 0.07.

7.3.1.2 Non-Threshold Health Risks

- Do Nothing scenario:
    - Non-threshold health risks for onsite workers who conduct monitoring of the CWS leachate were low and acceptable.
    - No carcinogenic chemicals were detected in offsite groundwater above the adopted health-based Tier 1 assessment criteria. Consequently, offsite carcinogenic health risks for the offsite receptors associated with the Do Nothing scenario were not generated.
- Management Options 2-7:
    - Non-threshold health risks for onsite workers who conduct monitoring of the proposed onsite Containment Cell leachate were low and acceptable.
    - Potentially unacceptable carcinogenic health risks were identified for Management Options 2-7 with estimates ranging between 1 in 50,251 (Management Options 2 and 4) and 1 in 4762 (Management Option 6). Dermal contact with benzo(a)pyrene in groundwater was identified to be the risk driving compound and exposure pathway for Management Options 2-7.
    - The Management Options with longer project durations had higher non-threshold risks. Consequently, Management Option 6 (approximately 17 year duration) had the highest carcinogenic health risks compared to Management Options 2 and 4 (1.6 year duration) which assumed the shortest duration for remediation of the CWS.

7.3.2 Qualitative Health Risk Estimates for Asbestos

Table C16 in **Appendix C3** presents the results of the asbestos qualitative risk assessment in accordance with the methodology outlined in **Section 7.1.3**. A summary of the asbestos health risk estimates for each Management Option is presented in **Table C7.4.** The health risk estimates were greater for the Management Options involving more soil disturbance activities (such as Management Option 3) and for Management Options with a longer overall project duration (such as Management Option 6).

Table C7.2: Summary of Hazard Indices (HI)

Exposure Pathway	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Onsite Adult Exposure (CWS remediation worker)							
Dermal contact with soil	-	0.67	0.67	0.67	0.67	0.67	0.67
Incidental ingestion of soil	-	0.30	0.30	0.30	0.30	0.30	0.30
Incidental ingestion of groundwater	0.04	2.21	2.21	2.21	2.21	2.21	2.21
Dermal contact with groundwater	0.03	2.06	2.06	2.06	2.06	2.06	2.06
Inhalation of groundwater-derived vapour within CWS excavation	-	0.08	0.08	0.08	0.08	0.08	0.08
Total Onsite HI (CWS worker)	**0.07**	**5.32**	**5.32**	**5.32**	**5.32**	**5.32**	**5.32**
Onsite Adult Exposure (proposed Containment Cell monitoring worker)							
Dermal contact with groundwater	-	0.03	0.03	0.03	-	-	-
Incidental ingestion of groundwater	-	0.04	0.04	0.04	-	-	-
Total Onsite HI (Containment cell monitoring worker)	-	**0.07**	**0.07**	**0.07**	-	-	-
Offsite Exposure (child recreational user)							
Dermal contact with surface water	0.5	-	-	-	-	-	-
Incidental ingestion of surface water	4.2	-	-	-	-	-	-
Total Offsite HI (child recreational)	**4.7**	-	-	-	-	-	-
Offsite Exposure (future intrusive maintenance worker)							
Dermal contact with surface water	0.01	-	-	-	-	-	-
Incidental ingestion of surface water	0.03	-	-	-	-	-	-
Total Offsite HI (Maintenance worker)	**0.04**	-	-	-	-	-	-

Notes:

a) Acceptable risk level of 1.0 was adopted (NEPM, 2013)

a) – indicates that a carcinogen was not considered in the exposure pathway because either no carcinogenic compounds exceeded the adopted Tier 1 assessment criteria or the exposure scenario was not appropriate for the Management Option.

Table C7.3: Summary of Increased Lifetime Cancer Risk Estimates (ILCRs)

Exposure Pathway	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Onsite Adult Exposure (CWS remediation worker)							
Dermal contact with soil	-	3.3E-06	1.1E-05	3.3E-06	1.3E-05	3.5E-05	1.5E-05
Incidental ingestion of soil	-	1.6E-06	5.5E-06	1.6E-06	6.0E-06	1.7E-05	7.1E-06
Incidental ingestion of groundwater	4.9E-09	1.6E-08	5.4E-08	1.6E-08	6.0E-08	1.7E-07	7.0E-08
Dermal contact with groundwater	4.6E-06	1.5E-05	5.1E-05	1.5E-05	5.7E-05	1.6E-04	6.7E-05
Inhalation of groundwater-derived vapour within CWS excavation	-	-	-	-	-	-	-
Total ILCR (CWS worker)	**4.6E-06 (1:217,391)**	**1.99E-05 (1:50,251)**	**6.79E-05 (1:14,728)**	**1.99E-05 (1:50,251)**	**7.53E-05 (1:13,280)**	**2.10E-04 (1:4762)**	**8.89E-05 (1:11,249)**
Onsite Adult Exposure (proposed Containment Cell monitoring worker)							
Incidental ingestion of groundwater	-	4.88E-09	4.88E-09	4.88E-09	-	-	-
Dermal contact with groundwater	-	4.64E-06	4.64E-06	4.64E-06	-	-	-
Total ILCR (Containment cell monitoring worker)	-	**4.64E-06**	**4.64E-06**	**4.64E-06**	-	-	-

Notes:

b) An acceptable cancer risk level of 1 in 100,000 was adopted in accordance with NEPM (2013) recommendations

c) – indicates that a carcinogen was not considered in the exposure pathway because either no carcinogenic compounds exceeded the adopted Tier 1 assessment criteria or the exposure scenario was not appropriate for the Management Option.

Table C7.4 Asbestos Exposure Risk Estimates

Soil Disturbance Event	Do Nothing	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Soil in CWS is excavated and loaded onto truck	-	0.42	1.62	0.42	0.63	1.97	1.97
Soil is transported and placed in onsite/offsite storage or treatment facility	-	0.42	1.90	0.44	2.82	8.73	3.12
Haul road between CWS and onsite/offsite containment cell is scraped and placed into onsite/offsite containment cell	-	0.04	0.04	0.04	0.05	-	-
Sorting of CWS recyclable material	-	-	1.62	-	0.75	0.63	0.63
Cleaning of steel and carbon recyclable materials	-	-	1.70	-	0.48	0.48	0.48
Additional cleaning of carbon recyclable materials	-	-	1.55	-	-	-	-
Additional cleaning of steel recyclable materials	-	-	0.48	-	-	-	-
Crushing of fines and crushable materials	-	-	1.66	-	1.97	1.97	1.97
Pug Mill lime treatment of crushed fine materials	-	-	1.38	-	1.64	-	-
Total Asbestos Exposure Risk Estimate	**0**	**0.88**	**11.94**	**0.90**	**8.34**	**13.79**	**8.17**

7.3.3 Health Risk Estimates for Additional Scenarios

As described in **Section 1.3**, this CHRA also considered a number of additional scenarios that could occur for each Management Option, however unlikely the probability of the event occurring was considered to be. When estimating the potential health risk associated with these additional scenarios, it was assumed that they occurred as a single isolated event.

A description of the additional scenarios for each Management Option is described in **Table C7.5**. The Health Risk Estimates were calculated for each additional event in accordance with the methodology outlined in **Section7.1**. When estimating the potential health risk for each additional event, the EPCs used to represent the soil, groundwater and surface water source were the same as the EPCs described in **Section 0**.

The exposure modelling inputs and health risk estimates for the additional scenarios are provided in **Appendix C7**, and the results are summarised in **Table C7.5**.

Table C7.5 Health Risk Estimates for Additional Single Exposure Events

Event ID	Single Exposure Event	Hazard Index	Non-Threshold Risk	Asbestos Exposure Risk
	Do Nothing			
Do Nothing_AEE1	Leachate requires removal and treatment for three years. Involves groundwater/subsurface leachate extraction and treatment through a treatment plant (on or off site).	6.59	4.82E-05 (1:20,747)	0
Do Nothing_AEE2	Moderate repairs to cap (2% -<10% cap surface)	5.86E-02	2.55E-07 (1:3,921,569)	3.85E-02
Do Nothing_AEE3	Community access capped waste stockpile	Health risks not applicable, capping layer would prevent direct access to CWS material.		
Do Nothing_AEE4	Future construction on surrounding properties encounters leachate and gas	0.28	7.74E-08 (1:12,919,897)	0
Do Nothing_AEE5	Complete remediation consistent with Management Option 2 in response to cap failure; changing regulation; monitoring shows impacts of significance; development around cell required.	5.32	1.99E-05 (1:50,251)	0.88
Do Nothing_AEE6	Gas migration to surrounding buildings following future development of the site	11.8	0	0
Do Nothing_AEE7	Leachate reaches downstream receptors. Leachate requires removal and treatment. Involves groundwater/subsurface leachate extraction and treatment through a treatment plant (on or offsite) with an assumed duration of three years.	30.10*	1.61E-04 (1:6,211)	0
Do Nothing_AEE8	Major stockpile failure as a result of seismic event/major climate event	33.40*	6.80E-05 (1:14,706)	0.5
	Management Option 2			
Opt 2_AEE1	Heavy rainfall causes leachate discharge to onsite surface water	3.17E-02	7.74E-08 (1:12,919,897)	0
Opt 2_AEE2	Minor repairs to cap (<2% cap surface)	1.46E-02	6.37E-08 (1:15,698,587)	9.62E-03

Opt 2_AEE3	Heavy rainfall causes erosion and sediment loss offsite during works.	Health risks not applicable, erosion of containment cell limited to surface soil. CWS material remains *in-situ*.		
Opt 2_AEE4	Heavy rainfall causes leachate discharge offsite to surface water	30.10*	5.36E-05 (1:18,657)	0
Opt 2_AEE5	Moderate repairs to cap (2-<10% cap surface)	5.86E-02	2.55E-07 (1:3,921,569)	3.85E-02
Opt 2_AEE6	Truck turnover spilling contaminated load onsite	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
Opt 2_AEE7	Leachate tanker spills/overtops	4.73E-02	1.09E-07 (1:9,174,312)	0
Opt 2_AEE8	Containment cell leaks causing leachate migration to groundwater	30.10*	5.36E-05 (1:18,657)	0
Opt 2_AEE9	Major cap repair (10-<20%)	0.35	1.53E-06 (1:6,53,595)	0.23
Opt 2_AEE10	Major Containment Cell failure as a result of seismic event/major climate event	33.40*	6.80E-05 (1:14,706)	0.5
	Management Option 3			
Opt 3_AEE1	Minor repairs to cap (<2% cap surface)	1.46E-02	6.37E-08 (1:15,698,587)	9.62E-03
Opt 3_AEE2	Heavy rainfall causes erosion and sediment lost offsite during works	Health risks not applicable, erosion of containment cell limited to surface soil. CWS material remains *in-situ*.		
Opt 3_AEE3	Carbon material containing asbestos is pulverised	0	0	9.62E-03
Opt 3_AEE4	Heavy rainfall causes leachate discharge to offsite surface water	30.10*	5.36E-05 (1:18,657)	0
Opt 3_AEE5	Asbestos containing material is sent to recycler	0	0	9.62E-03
Opt 3_AEE6	Asbestos containing materials are distributed to consumer in recycled products	0	0	9.62E-03
Opt 3_AEE7	Recyclable carbon material has no end user	Health risks not applicable		
Opt 3_AEE8	Recyclable steel material has no end user due to asbestos risk	Health risks not applicable		
Opt 3_AEE9	Leachate activates lime which crystallises and clogs leachate capture system resulting in increased gas emissions due to water content	1.89E-03	0	0

Opt 3_AEE10	Moderate repairs to cap (2-<10% cap surface)	5.86E-02	2.55E-07 (1:3,921,569)	3.85E-02
Opt 3_AEE11	Truck turnover spilling contaminated load onsite	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
Opt 3_AEE12	Leachate tanker spills/overtops	4.73E-02	1.09E-07 (1:9,174,312)	0
Opt 3_AEE13	Containment cell leaks causing leachate migration to groundwater (assume no fluoride concentrations)	5.37*	5.36E-05 (1:18,657)	0
Opt 3_AEE14	Major cap repair (10-<20%)	0.35	1.53E-06 (1:65,3,595)	0.23
Opt 3_AEE15	Treatment with lime does not reduce leachable F concentration	Health risks not applicable, assumes leachate is confined within the containment cell		
Opt 3_AEE16	Major Containment Cell failure as a result of seismic event/major climate event	33.40*	6.80E-05 (1:14,706)	0.5
	Management Option 4			
Opt 4_AEE1	Heavy rainfall causes leachate discharge to onsite surface water	3.17E-02	7.74E-08 (1:12,919,897)	0
Opt 4_AEE2	Minor repairs to cap (<2% cap surface)	1.46E-02	6.37E-08 (1:15,698,587)	9.62E-03
Opt 4_AEE3	Heavy rainfall causes erosion and sediment lost offsite during works	Health risks not applicable, erosion of containment cell limited to surface soil. CWS material remains *in-situ*.		
Opt 4_AEE4	Heavy rainfall causes leachate discharge to offsite surface water	30.10*	5.36E-05 (1:18,657)	0
Opt 4_AEE5	Treatment with lime does not reduce leachable F concentration	Health risks not applicable, assumes leachate is confined within the containment cell		
Opt 4_AEE6	Leachate activates lime which crystallises and clogs leachate capture system resulting in increased gas emissions due to water content	1.89E-03	0	0
Opt 4_AEE7	Moderate repairs to cap (2-<10% cap surface)	5.86E-02	2.55E-07 (1:3,921,569)	3.85E-02

Opt 4_AEE8	Truck turnover spilling contaminated load onsite	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
Opt 4_AEE9	Leachate tanker spills/overtops	4.73E-02	1.09E-07 (1:9,174,312)	0
Opt 4_AEE10	Containment cell leaks causing leachate migration to groundwater (assume no fluoride concentrations)	5.37*	5.36E-05 (1:18,657)	0
Opt 4_AEE11	Major cap repair (10-<20%)	0.35	1.53E-06 (1:653,595)	0.23
Opt 4_AEE12	Major Containment Cell failure as a result of seismic event/major climate event	33.40*	6.80E-05 (1:14,706)	0.5
	Management Option 5			
Opt 5_AEE1	Heavy rainfall event causes erosion and sediment lost offsite at receiving facility	2.58E-01	6.75E-07 (1:1,481,481)	9.62E-03
Opt 5_AEE2	Leachate reacts with other waste leachate within the larger cell	45.2[b]	5.36E-04 (1:1866)[b]	0
Opt 5_AEE3	Minor repairs to cap (<2% cap surface)	1.46E-02	6.37E-08 (1:15,698,587)	9.62E-03
Opt 5_AEE4	Heavy rainfall causes erosion and sediment lost offsite during works	Health risks not applicable, erosion of containment cell limited to surface soil. CWS material remains *in-situ*.		
Opt 5_AEE5	Heavy rainfall causes leachate discharge to offsite surface water	30.10*	5.36E-05 (1:18,657)	0
Opt 5_AEE6	Community access containment cell location and exposed to gas	7.08E-04	0	0
Opt 5_AEE7	Space for landfill insufficient	Health risks not applicable		
Opt 5_AEE8	Financial assurance for long term management insufficient or has lower regulatory requirement – government assistance required	Health risks not applicable		
Opt 5_AEE9	Asbestos containing material is sent to recycler	0	0	9.62E-03
Opt 5_AEE10	Asbestos containing materials are distributed to consumer in recycled products	0	0	9.62E-03
Opt 5_AEE11	Recyclable steel material has no end user due to asbestos risk	Health risks not applicable		

Opt 5_AEE12	Leachate activates lime which crystallises and clogs leachate capture system resulting in increased gas emissions due to water content	1.89E-03	0	0
Opt 5_AEE13	Moderate repairs to cap (2-<10% cap surface)	5.86E-02	2.55E-07 (1:3,921,569)	3.85E-02
Opt 5_AEE14	Truck spills contaminated load on public road	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
Opt 5_AEE15	Leachate tanker spills/overtops	4.73E-02	1.09E-07 (1:9,174,312)	0
Opt 5_AEE16	Containment cell leaks causing leachate migration to groundwater (assume no fluoride concentrations)	5.37*	5.36E-05 (1:18,657)	0
Opt 5_AEE17	Treatment with lime does not reduce leachable F concentration	Health risks not applicable, assumes leachate is confined within the containment cell		
Opt 5_AEE18	Major Containment Cell failure as a result of seismic event/major climate event	33.40*	6.80E-05 (1:14,706)	0.5
Opt 5_AEE19	Major cap repair (10-<20%)	0.35	1.53E-06 (1:653,595)	0.23
Opt 5_AEE20	Truck turn over spilling contaminated load onsite	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
	Management Option 6			
Opt 6_AEE1	Heavy rainfall causes leachate discharge to offsite surface water	30.10*	5.36E-05 (1:18,657)	0
Opt 6_AEE2	Heavy rainfall causes erosion and sediment lost offsite during works	Health risks not applicable		
Opt 6_AEE3	Gas build up in salt cavity of flammable/toxic gases (cavity not vented)	6.43	0	0
Opt 6_AEE4	Asbestos containing material is sent to recycler	0	0	9.62E-03
Opt 6_AEE5	Asbestos containing materials are distributed to consumer in recycled products	0	0	9.62E-03
Opt 6_AEE6	Recyclable steel material has no end user due to asbestos risk	Health risks not applicable		
Opt 6_AEE7	Truck spills contaminated load on public road	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03

Opt 6_AEE8	Train derailment causing spillage	0.22*	8.94E-07 (1:1,118,568)	9.62E-03
Opt 6_AEE9	Groundwater seepage to salt cavity	4.27	2.32E-04 (1:4,310)	0
Opt 6_AEE10	Extreme weather event occurs during transport or transitory storage causing damage to containers and bags and uncontrolled release in air and water	1.67*	3.47E-06 (1:288,184)	9.62E-03
Opt 6_AEE11	Landfill leaks causing impact to groundwater or surface water	Health risks not applicable. Depth (>800m) and surrounding geology of the containment cell provides a vertical separation and barrier of ~400m between waste material and overlying groundwater system. See Note c for further information.		
Opt 6_AEE12	Leachate tanker overtops onsite	4.73E-02	1.09E-07 (1:9,174,312)	0
Opt 6_AEE13	Truck spills contaminated load onsite	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
Opt 6_AEE14	Material interacts with co-disposed waste	45.2*[b]	5.36E-04 (1:1866)[b]	0
	Management Option 7			
Opt 7_AEE1	Heavy rainfall event causes leachate discharge to offsite surface water	30.10*	5.36E-05 (1:18,657)	0
Opt 7_AEE2	Plant delays due to heterogeneity of material feed	Health risks not applicable		
Opt 7_AEE3	Heavy rainfall causes erosion and sediment lost offsite during works	Health risks not applicable		
Opt 7_AEE4	Asbestos containing material is sent to recycler	0	0	9.62E-03
Opt 7_AEE5	Asbestos containing materials are distributed to consumer in recycled products	0	0	9.62E-03
Opt 7_AEE6	Recyclable steel material has no end user due to asbestos risk	Health risks not applicable		
Opt 7_AEE7	Slag end product requires landfilling	Health risks not applicable		
Opt 7_AEE8	Truck turn over spilling contaminated load onsite	8.79E-03	3.82E-08 (1:26,178,010)	9.62E-03
Opt 7_AEE9	Plasma gasification plant gas leak occurs	1.82E-02	0	0

Opt 7_AEE10	Plasma gasification plant explodes	Unacceptable health risk potentially resulting in immediate death. This scenario is assessed in the Worker Risk Assessment (Appendix D of The Management Options Analysis).		
Opt 7_AEE11	Leachate tanker spills/overtops	4.73E-02	1.09E-07 (1:9,174,312)	0

Notes:

a) * indicates that the exposure event includes assessment of a recreational (adults and children) and commercial/industrial (adults only) exposure scenario. The risk estimates presented are for the child recreational receptor which represents the most sensitive human receptor, and hence worst-case health risk estimates.

b) The hazard index represents the total calculated hazard index which is increased by 50% to account for any additive toxicity effects caused by the unknown chemicals in the co-disposed waste and leachate. Similarly the ILCR is increased by an order of magnitude to account for any increased carcinogenic toxicity effects due to additive effects.

c) Chapter 8 (Groundwater) of the Proposed Chandler Facility Environmental Impact Statement reports that "*Contamination of groundwater arising from the storage of waste in the underground repository is unlikely to pose a groundwater contamination risk given the natural permeability of the Chandler Formation halite resource. In addition, the depth of the proposed Changer salt mine and deep geological repository in comparison to known groundwater systems provides a vertical separation and barrier of about 400 m. This comprises low permeability overburden material between the waste repository and the nearest overlying groundwater system*".

7.4 Risk Characterisation Uncertainty

Uncertainties can be introduced into the risk characterisation stage of a CHRA when risk estimates are added for multiple chemicals across multiple exposure pathways. In some situations, chemicals may not affect similar target organs, may not act via similar mechanisms, or may interact in ways that are not additive. As a result, adding risk estimates may not appropriately reflect the potential risks associated with multiple chemical exposures. Similarly, the risks posed by a chemical following exposure via different pathways may differ in ways that are not adequately reflected by simple addition of the risk estimates derived for each individual pathway.

Risk assessment methods are designed to be highly conservative to address the uncertainties associated with each step in the process. Thus, actual risks are not likely to be greater than (and may be significantly less than) the risks estimated, and for this CHRA key factors that are likely to have overestimated potential health risks include:

- Using the maximum predicted groundwater concentration as the EPCs for onsite workers undertaking the remedial activities and assuming that the maximum groundwater concentration remains constant throughout the entire period of exposure.
- Assuming that the recreational adults and children have exposure to surface water in the Swamp Creek area for one hour a day for 104 days a year for a 30 year duration. This exposure scenario also assumes that the reported groundwater concentrations down-gradient of the CWS are also present in surface water with no allocation for dilution or attenuation of chemicals;
- Assuming that onsite workers would have direct contact with soil and groundwater in the CWS whereby their hands and face are exposed to impacted groundwater and soil, and they incidentally ingest soil and groundwater. This exposure scenario is likely to be overly conservative because health and safety procedures would be implemented to limit exposure to soil and groundwater during the CWS remediation.
- Assuming the non-carcinogenic chemicals assessed had a background exposure between 10% (fluoride and TPH) and 50% (arsenic) thereby reducing the adopted TDI/RfD.

As indicated above, the CHRA presented in this report has adopted conservative or reasonable upper-bound values for a variety of variables. The compounding effect of utilising multiple reasonable upper bound limits for quantitative parameters in the risk assessment is expected to give rise to an overestimation of actual exposure and associated health risk. Therefore, interpretation of the risk estimates should take this into consideration when deciding on risk management options.

There is moderate uncertainty regarding the asbestos risk analysis because a quantitative analysis of friable asbestos in the CWS is unknown. To compensate for this uncertainty, the CHRA has taken a conservative approach and assumed that the asbestos exposure risk values are based on the number of soil disturbance events which have been allocated a health value of 0.5. This method assumes that each soil disturbance event will emit the same amount of asbestos fibres available for inhalation, and will pose the same amount of health risk at various exposure scenarios. In addition, this report assumes that each soil disturbance event from any location within the CWS will generate asbestos dust. This assumption is conservative given that asbestos was not detected in some locations in the CWS (refer to **Section 4.5.2.5**) and where asbestos was detected it was only detected in trace amounts.

8. CONCLUSIONS

This CHRA was prepared by Ramboll Environ on behalf of Hydro to inform a comparative assessment of the Management Options for the CWS to assist Hydro and NSW regulators in determining the Management Option with the most appropriate outcomes. This CHRA assessed the potential for unacceptable human health risks posed to onsite and offsite human receptors that may result from potential contact with or exposure to chemicals (including asbestos) arising from the Management Options for the CWS.

This CHRA also assessed the potential health risk associated with a number of different 'additional scenarios' for each Management Option, that were considered to have a lower probability of occurrence such as exposure scenarios associated with potential failures in technology or as a result of human error. Assessment of these additional scenarios was undertaken to provide the Project stakeholders information regarding potential health risks that could occur however unlikely the probability of the event was considered to be. The CHRA estimated health risks for these additional scenarios assuming that they occurred as a single isolated event. The Management Options Analysis then scaled these results in accordance with their assigned probability of occurrence, which was used to estimate the total risk associated with each of the Management Options.

This CHRA was undertaken in accordance with Australian recommended guidance for performing human health risk assessments. This process involved 1) reviewing the project description, 2) identifying the source-pathway-receptor (SPR) linkages for each activity (i.e. developing a conceptual site model (CSM)), and 3) quantitatively and qualitatively assessing the potential health risk for all complete SPR linkages.

A summary of the CSM, which formed the basis of the CHRA, is provided below:

- *Health Impact Sources:* chemicals which exceeded appropriate Tier 1 health-based assessment criteria in groundwater, surface water and soil in the CWS and down-hydraulic gradient. Asbestos within the CWS was also considered to be a health impact source. Particulate and vapour concentrations were not predicted to occur above Tier 1 health-based acute and chronic assessment criteria.
- *Exposure pathways and receptors*: **Table C8.1** summarises the human receptors and exposure pathways that were assessed in the CHRA. Offsite recreational children who play near/in surface water bodies in the Swamp Creek area were considered to be the most sensitive offsite receptors. Onsite Workers for the Do Nothing scenario were considered to undertake activities such as monitoring and minor capping repairs. Onsite Workers for Management Options 2-7 were considered to undertake activities associated with remediation of the CWS material.

Table C8.1 Conceptual Site Model Summary

Exposure Pathway	Onsite CWS Workers	Onsite Monitoring Workers[b]	Offsite Recreational Receptors[c]	Offsite Intrusive Maintenance Worker[d]
Dermal contact and incidental ingestion of soil	✓ (Options 2-7)	X	X	X
Dermal contact and incidental ingestion of groundwater	✓ (Options 2-7)	✓ (Do Nothing and Options 2-4)	✓ (Do Nothing)	✓ (Do Nothing)
Inhalation of vapours within the CWS	✓ (Options 2-7)	X	X	X

excavation from groundwater				
Exposure to asbestos	✓ (Options 2-7)[a]	X	X	X

✓ Indicates a potential exposure pathway is present which will be assessed further in the CHRA
X Indicates a potential exposure pathway is not considered to be present, and will not be assessed further in the CHRA
a) Potential health risks are assessed qualitatively for the asbestos exposure scenario.
b) Monitoring workers for the CWS (Do Nothing) and proposed Containment Cell (Options 2-4)
c) Adult and child recreational users of the Swamp Creek area located down hydraulic gradient of the CWS (Do Nothing scenario)
d) Adult workers who undertake intrusive activities to maintain already installed subsurface utilities located in the down gradient area of the CWS (Do Nothing scenario)

On the basis of the available data and identified assumptions, the quantitative risk characterisation process identified that:

- Do Nothing scenario:
  - Threshold and non-threshold health risks for onsite workers who conduct monitoring of the CWS leachate were low and acceptable.
  - Health risks were similarly low for future offsite maintenance workers undertaking repairs on subsurface utilities where groundwater enters a trench.
  - Unacceptable health risks were identified for offsite recreational receptors who have the potential to incidentally ingest fluoride in surface water during recreational play in surface water bodies in the Swamp Creek area.
- Management Options 2-7:
  - Threshold and non-threshold health risks for onsite workers who conduct monitoring of the proposed onsite Containment Cell leachate were low and acceptable.
  - Potentially unacceptable threshold health risks were identified via the incidental ingestion of groundwater (driven by fluoride concentrations) and dermal contact with groundwater (driven by benzo(a)pyrene concentrations) during removal of the CWS material.
  - Threshold risks for the other exposure pathways (direct contact with soil and vapour inhalation with the CWS excavation) were considered to be low and acceptable.
  - Potentially unacceptable carcinogenic health risks were identified for Management Options 2-7 with estimates ranging between 1 in 50,251 (Management Options 2 and 4) and 1 in 4762 (Management Option 6). Dermal contact with benzo(a)pyrene in groundwater was identified to be the risk driving compound and exposure pathway for Management Options 2-7.

Management Option 6 was identified to have the greatest asbestos health risk, followed by (in descending order):

- Management Option 3
- Management Option 5
- Management Option 7
- Management Option 4
- Management Option 2
- Do nothing (this Management Option had ‘0’ asbestos health risk).

The asbestos risk estimates were greater for the Management Options involving more soil disturbance activities (such as Management Option 3) and for Management Options with a longer overall project duration (such as Management Option 6). Management Option 2 had the lowest asbestos health risk due to the shorter project duration time, and only three soil disturbance events.

Results presented in this CHRA will be compared in conjunction with other considerations, such as Ecological Health, Safety, Greenhouse Gas and Technology Risk when identifying the most appropriate Management Option for the CWS.

9. REFERENCES

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10. LIMITATIONS

Ramboll Environ Australia Pty Ltd prepared this report in accordance with the scope of work as outlined in our proposal to Hydro Aluminium Kurri Kurri Pty Ltd and in accordance with our understanding and interpretation of current regulatory standards.

The conclusions presented in this report represent Ramboll Environ's professional judgement based on information made available during the course of this assignment and are true and correct to the best of Ramboll Environ's knowledge as at the date of the assessment.

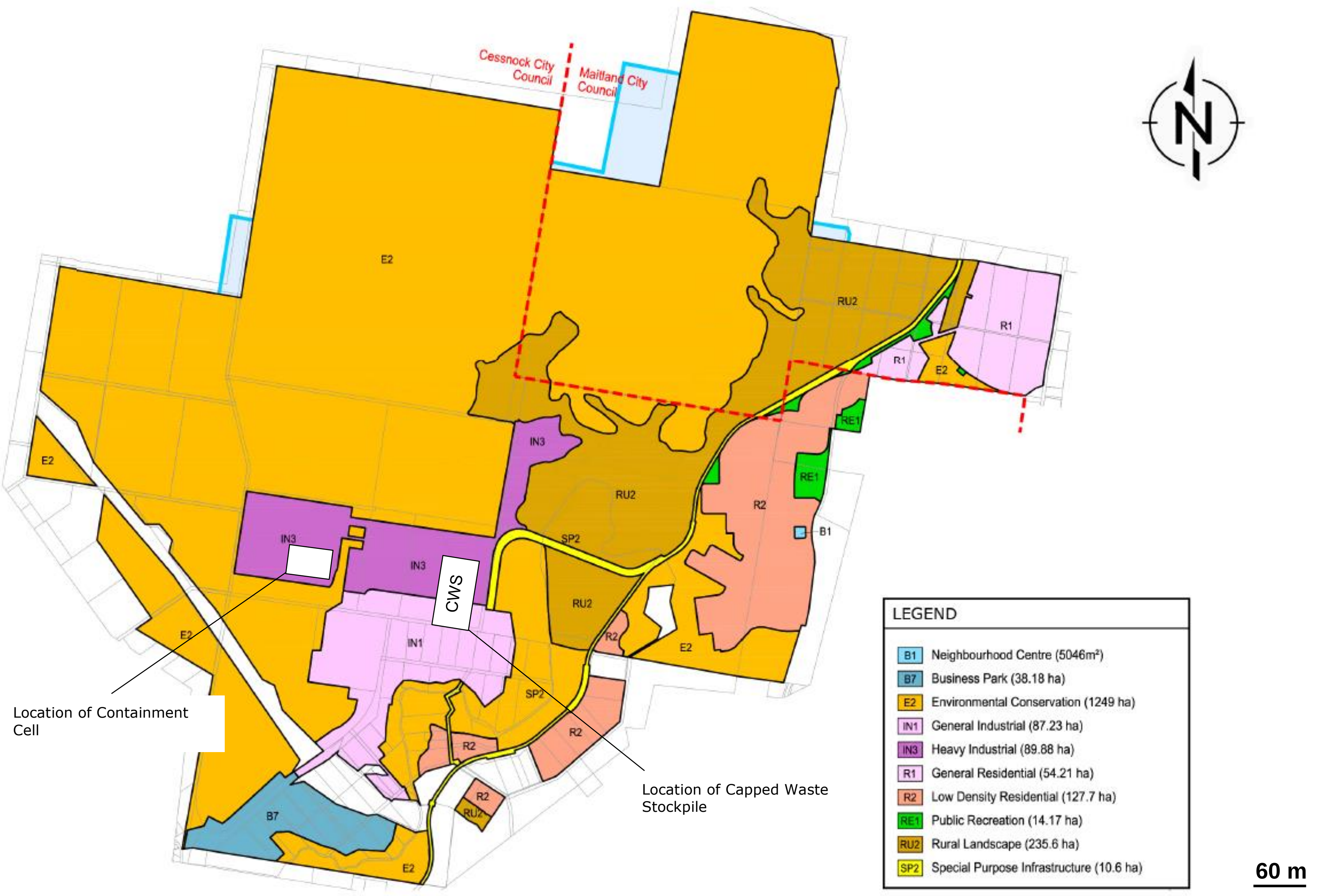
Ramboll Environ did not independently verify all of the written or oral information provided during the course of this investigation. While Ramboll Environ has no reason to doubt the accuracy of the information provided to it, the report is complete and accurate only to the extent that the information provided to Ramboll Environ was itself complete and accurate.

This report does not purport to give legal advice. This advice can only be given by qualified legal advisors.

10.1 User Reliance

This report has been prepared exclusively for Hydro Aluminium Kurri Kurri Pty Ltd and may not be relied upon by any other person or entity without Ramboll Environ's express written permission.

APPENDIX C1
FIGURES



HYDRO ALUMINIUM KURRI KURRI: CHRA FOR THE OPTIONS STUDY

REZONING MASTER PLAN

RAMBOLL ENVIRON JOB NO: AS130525 DATE: May 2017 FIGURE C1

HYDRO ALUMINIUM KURRI KURRI: CHRA FOR THE OPTIONS STUDY

SMELTER SITE LAYOUT

RAMBOLL ENVIRON JOB NO: AS130525 DATE: April 2017 FIGURE C2

◆	Exfiltrated groundwater sample location
◇	Surface water sample location
→	Surface water overland flow path
—	Swamp Creek

HYDRO ALUMINIUM KURRI KURRI CHRA FOR REMEDIAL OPTIONS

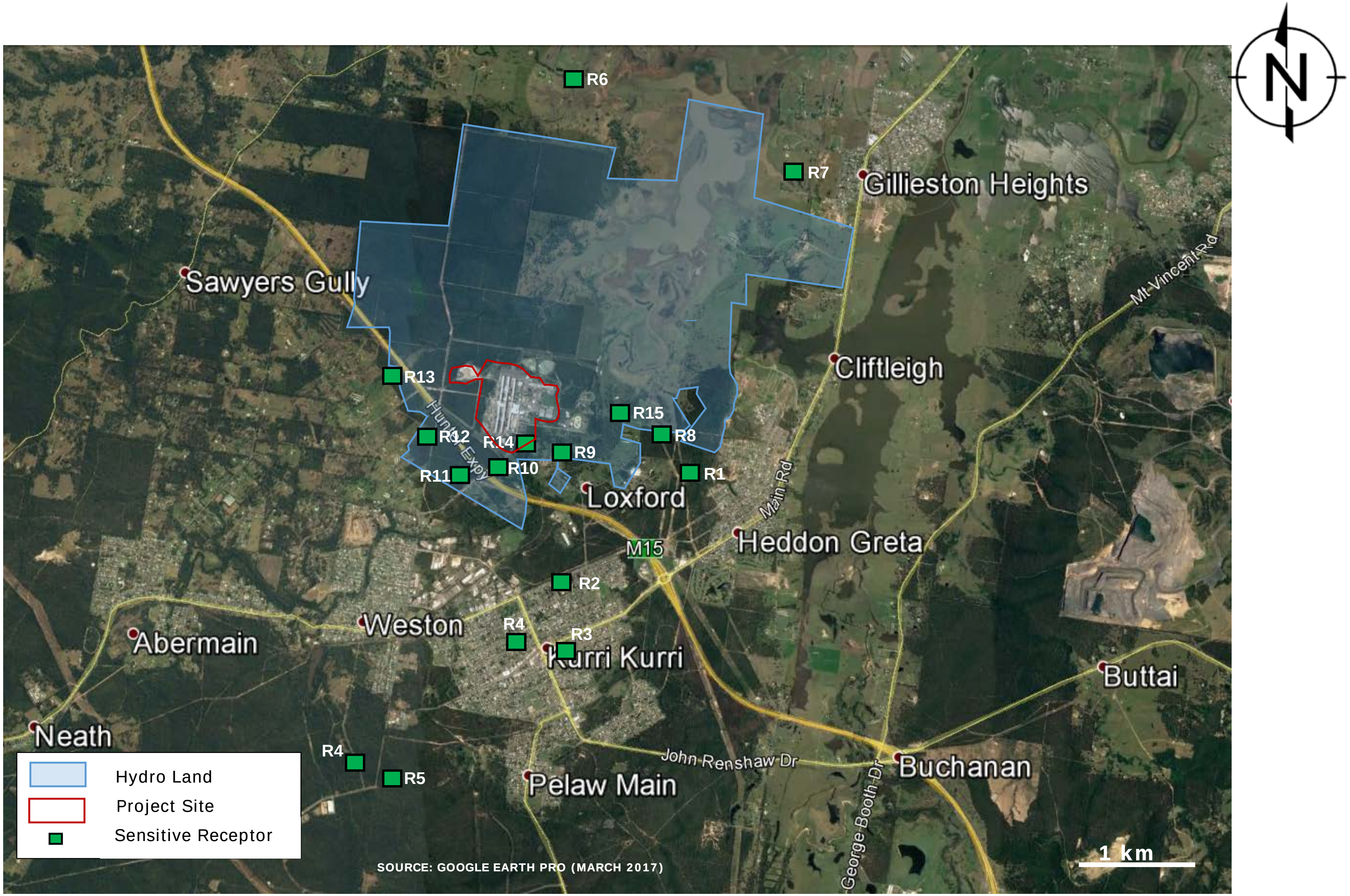
SURFACE WATER SAMPLING LOCATIONS

RAMBOLL ENVIRON

JOB NO: AS130525

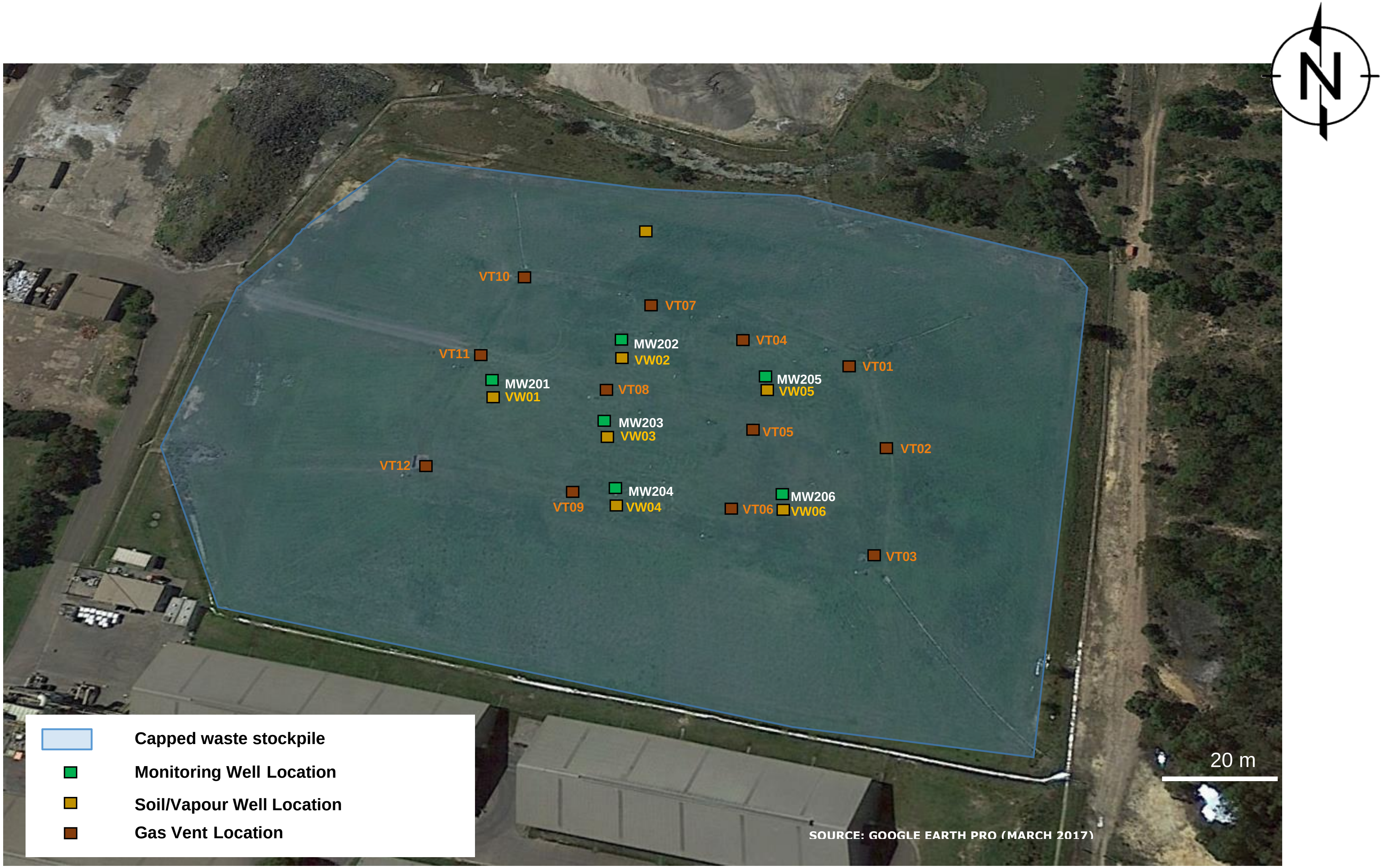
DATE: March 2017

FIGURE C3



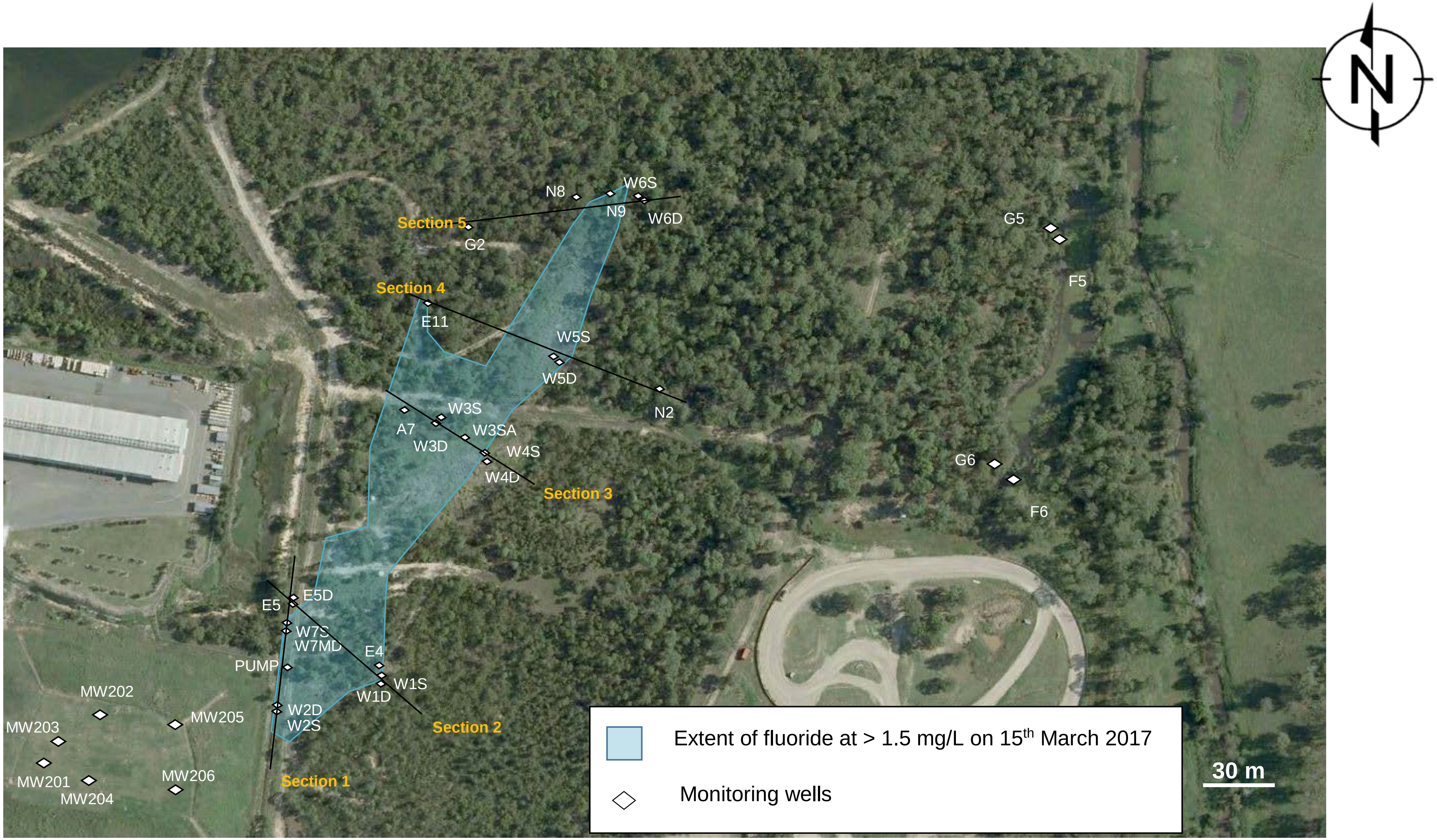
HYDRO ALUMINIUM KURRI KURRI: CHRA FOR THE OPTIONS STUDY	**LOCATION OF OFFSITE RECEPTORS**

RAMBOLL ENVIRON JOB NO: AS130525 DATE: March 2017 FIGURE C4



HYDRO ALUMINIUM KURRI KURRI: CHRA FOR THE OPTIONS STUDY	**LOCATION OF SOIL BORES AND SOIL VAPOUR SAMPLING POINTS**

RAMBOLL ENVIRON | JOB NO: AS130525 | DATE: March 2017 | FIGURE C5



HYDRO ALUMINIUM KURRI KURRI: CHRA FOR THE OPTIONS STUDY

LOCATION OF GROUNDWATER MONITORING WELLS

RAMBOLL ENVIRON

JOB NO: AS130525

DATE: March 2017

FIGURE C6

APPENDIX C2
AIR QUALITY STUDY

AIR QUALITY STUDY TO SUPPORT THE COMPARATIVE HEALTH RISK ASSESSMENT (CHRA), OPTIONS EVALUATION STUDY

1. Introduction

As stated in Section 4.5.2.2 of the CHRA, air borne particulates and vapours are likely to be generated from a number of sources during remediation of the Capped Waste Stockpile (CWS) (Remedial Options 2 to 7). Some of the compounds emitted would remain in vapour form, others would be released in particulate form, and other compounds could form particles after being emitted or by adhering to existing particles. Emissions from the Remedial Options would include products of combustion, fugitive dust or particulate matter (PM), ammonia, cyanide and a range of organic compounds including PAHs.

In order to calculate particulate and vapour concentrations likely to be generated during the remedial activities, air quality dispersion modelling has been undertaken by Ramboll Environ to predict ground level concentrations of various pollutants. The methodology and results are presented in this **Appendix C2** of the CHRA.

2. Methodology

In July 2016, Ramboll Environ completed an Air Quality Impact Assessment (AQIA) on behalf of Hydro to support an Environmental Impact Statement for submission to the Department of Planning and Environment prepared to assess the demolition and remediation of the Hydro Site. The 2016 AQIA and this current Air Quality Study are undertaken with consideration to the *NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005). The resources developed for the 2016 AQIA have been used in this current air quality study wherever possible. The 2016 AQIA should be referred to when reviewing this report.

Seven Remedial Options for the CWS are under consideration, and **Table C2-1** identifies the predicted particulate matter emission sources associated with each Remedial Option.

The following notes are made regarding the seven CWS Remedial Options:

- Option 1 involves leaving the CWS material *in-situ*. This option would have no emission sources and has therefore not been assessed.
- Option 2, 3 and 4 involve the storage of excavated CWS material in an onsite containment cell are very similar in nature. From an air quality impact assessment perspective, the differences are negligible. Consequently, a single modelling scenario representative of Options 2, 3 and 4 has been developed.
- Options 5 and 6 involve the storage of excavated CWS material in an offsite containment cell. With the removal of onsite storage of CWS material, the emissions potential from Options 5 and 6 is lower than Options 2, 3 and 4. Therefore, no modelling for Options 5 and 6 has been conducted on the basis that impacts would be lower than Options 2, 3 and 4.
- Option 7 involve the thermal treatment of excavated CWS material. It is understood that based on information provided by the thermal treatment option engineers, the technology would have negligible air quality emissions. The emissions potential from Remedial Option 7 is therefore lower than Options 2, 3 and 4. Consequently, no modelling for Option 7 has been conducted on the basis that impacts would be lower than Options 2, 3 and 4.

Therefore, based on the above discussion, a single emissions scenario, representative of Options 2, 3 and 4 is the focus of this air quality study.

Table C2-1 Particulate Sources for Capped Waste Stockpile Remedial Options

Activity Considered	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Excavate and remove CWS	N/A	✓	✓	✓	✓	✓	✓
Construction of onsite containment cell[1]	N/A	✓	✓	✓	X	X	X
Construction of offsite containment cell	N/A	X	X	X	✓	X	X
Placement of CWS in truck for offsite disposal	N/A	X	X	X	✓	✓	X
Placement of CWS in onsite/offsite containment cell	N/A	✓	✓	✓	✓	X	X
Placement of lime material in onsite/offsite containment cell with CWS material	N/A	X	✓	✓	✓	X	X
Capping of onsite/offsite containment cell	N/A	✓	✓	✓	✓	X	X
Sorting of recyclables from CWS and treatment of non-recyclables	N/A	X	✓[2]	X	✓[2]	✓[2]	✓[2]
Transportation and disposal of CWS to offsite waste disposal facility	N/A	X	X	X	✓	✓	X
Transportation and disposal of CWS to onsite treatment facility	N/A	X	X	X	X	X	✓
Remediation of haul road between CWS and onsite containment cell[3]	N/A	✓	✓	✓	X	X	X
Operation of Water Treatment Plant	✓	✓[4]	✓[4]	✓[4]	✓[4]	✓[4]	✓[4]

Note: N/A means 'Not Applicable' because the CWS material remains *in situ*.

1. Particulates can be generated during vegetation clearance, excavation of soil and operation of machinery such as trucks, tractors and grousers.
2. Particulates can be generated during the crushing of non-recyclable materials in preparation for disposal.
3. Remediation of haul road comprises removal of the top layer of soil, and placement into the onsite containment cell.
4. Water treatment plant will be operated only during CWS removal and while the onsite/offsite containment cell is open.

Emission calculation methods developed for the 2016 AQIA have been adopted for this air quality study modelling exercise. Particulate matter emissions from the following sources were quantified for the Options 2, 3 and 4 scenario:

- excavation and handling of material from the CWS;
- loading of excavated material to haul trucks;
- transportation by haul trucks of material to the onsite containment cell;
- unloading and handling of material at the containment cell; and
- wind erosion from exposed surfaces.

Other emission sources, such as construction of the onsite containment cell, would not occur at the same time as the activities listed above. Because the intention is to quantify the peak 24-hour emissions from CWS remedial activities, these other sources have not been included in the modelling study.

Emissions of total suspended particulates (TSP), particulate matter $(PM)_{10}$, $PM_{2.5}$, nitrogen dioxide (NO_2), sulfate (SO_2), carbon monoxide (CO), benzene, ethylbenzene, toluene and xylenes were quantified using the same techniques and emission factors as those applied in the 2016 AQIA. Updated soil analytical data and vapour/gas data collected from the CWS (as detailed in **Section 5.4.2.1** and **Section 4.5.2.6** of the CHRA, respectively) were used to identify the chemicals that required modelling in this study. The following pollutants and monitoring results were incorporated into this air quality study emission scenario, where the soil results represent the maximum detected concentration within the CWS and the vapour concentrations represent the average concentration:

- Hydrogen sulphide (H_2S) – 85.7 ppm;
- Ammonia – 326.3 ppm;
- Cyanide – 730 mg/kg;
- Arsenic – 850 mg/kg;
- Lead – 820 mg/kg;
- Fluoride (total) – 405,498 mg/kg;
- Total PAHs (BaP equivalent) – 1,210 mg/kg; and
- Naphthalene – 8.5 mg/kg.

3. Results

3.1 Annual Emission Concentrations

For emissions of H_2S and ammonia, the standpipe gas concentration was converted to an excavation-related emission rate (ADEQ, 2017; US EPA 1992). Emissions of the remaining pollutants listed above were quantified by scaling the quantified particulate matter from remedial activities by the in-soil concentration.

Annual emissions associated with the onsite CWS remedial option scenario are listed below. During the process of this modelling exercise, it was noted that a scaling error occurred in the 2016 AQIA (concentration was applied as mg/g instead of mg/kg), resulting in an over calculation of air toxic emissions. This error has been corrected for this modelling exercise.

- TSP - 15,180.9 kg
- PM_{10} - 8,209.0 kg
- $PM_{2.5}$ - 5,363.1 kg
- NO_x - 69,120.0 kg

- SO_2 - 36.9 kg
- CO - 28,569.6 kg
- Benzene - 39.4 kg
- Ethylbenzene - 20.3 kg
- Toluene - 80.0 kg
- Xylenes - 109.4 kg
- Arsenic – 0.448 kg
- Cyanide – 0.387 kg
- Ammonia - 234.4 kg
- Phenol – 0.049 kg
- H_2S - 123.3 kg
- Fluoride - 233.8 kg
- Lead – 0.432 kg
- Naphthalene – 0.0045 kg
- PAHs – 0.71 kg

The emissions inventory was input into the dispersion model configured for the 2016 AQIA.

3.2 Predicted Air Concentrations

The predicted air concentrations at the surrounding sensitive receptors (as defined in **Section 4.5.1** of the CHRA) and at the works boundary are presented in **Tables C2-2, Table C2-3, Table C2-4**, **Table C2-5**, **Table C2-6** and **Table C2-7**.

Section 4.5.2.2 of the CHRA (Appendix C) discusses these predicted air concentrations and compares the results against appropriate Tier 1 acute and chronic air quality guidelines in order to assess the potential for health risk to onsite and offsite receptors.

Table C2-2 Incremental Concentrations (µg/m³) – TSP, PM_{10}, $PM_{2.5}$, NO_2 and SO_2

Receptor ID	Annual TSP	Dust Deposition	24-hour PM_{10}	Annual PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$	1hr NO_2	Annual NO_2	1hr SO_2	24hr SO_2	Annual SO_2
R1	0.6	<0.1	1.2	0.3	0.9	0.3	21.5	0.8	<0.1	<0.1	<0.1
R2	0.5	<0.1	0.9	0.3	0.6	0.2	13.1	0.6	<0.1	<0.1	<0.1
R3	0.1	<0.1	0.2	0.1	0.2	<0.1	4.9	0.1	<0.1	<0.1	<0.1
R4	<0.1	<0.1	0.1	<0.1	0.1	<0.1	1.4	<0.1	<0.1	<0.1	<0.1
R5	<0.1	<0.1	0.1	<0.1	0.1	<0.1	4.9	<0.1	<0.1	<0.1	<0.1
R6	<0.1	<0.1	0.1	<0.1	0.0	<0.1	1.6	<0.1	<0.1	<0.1	<0.1
R7	<0.1	<0.1	0.1	<0.1	0.1	<0.1	1.7	<0.1	<0.1	<0.1	<0.1
R8	<0.1	<0.1	0.2	<0.1	0.1	<0.1	2.0	<0.1	<0.1	<0.1	<0.1
R9	0.2	<0.1	0.4	0.1	0.3	0.1	11.4	0.2	<0.1	<0.1	<0.1
R10	0.3	<0.1	0.7	0.2	0.5	0.1	10.2	0.4	<0.1	<0.1	<0.1
R11	0.1	<0.1	0.2	<0.1	0.2	<0.1	2.7	0.1	<0.1	<0.1	<0.1
R12	0.3	<0.1	0.6	0.1	0.4	0.1	7.3	0.3	<0.1	<0.1	<0.1
R13	<0.1	<0.1	0.0	<0.1	<0.1	<0.1	0.8	<0.1	<0.1	<0.1	<0.1
R14	0.2	<0.1	0.4	0.1	0.2	0.1	5.0	0.2	<0.1	<0.1	<0.1
R15	0.3	<0.1	0.6	0.1	0.4	0.1	8.4	0.3	<0.1	<0.1	<0.1
R16	0.1	<0.1	0.3	0.1	0.2	0.1	6.4	0.2	<0.1	<0.1	<0.1
R17	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.8	<0.1	<0.1	<0.1	<0.1
R18	<0.1	<0.1	0.1	<0.1	0.1	<0.1	3.0	<0.1	<0.1	<0.1	<0.1
R19	<0.1	<0.1	0.1	<0.1	0.1	<0.1	3.3	<0.1	<0.1	<0.1	<0.1
Boundary Max	2.69	1.96	4.22	1.46	3.51	1.18	65.78	3.94	0.035	0.006	0.002

All results in µg/m³ excluding dust deposition, which is in g/m²/month

Table C2-3 Incremental Concentrations (µg/m³) – CO, Benzene, Toluene, Xylenes and Ethylbenzene

Receptor ID	1hr CO	8hr CO	1hr Benzene	Annual Benzene	1hr Toluene	Annual Toluene	1hr Xylenes	Annual Xylenes	1hr Ethylbenzene	Annual Ethylbenzene
R1	8.9	1.9	1.23E-02	4.71E-04	2.49E-02	9.56E-04	3.40E-02	1.31E-03	6.32E-03	2.43E-04
R2	5.4	1.3	7.46E-03	3.23E-04	1.52E-02	6.57E-04	2.07E-02	8.97E-04	3.84E-03	1.67E-04
R3	2.0	0.5	2.81E-03	7.28E-05	5.71E-03	1.48E-04	7.81E-03	2.02E-04	1.45E-03	3.75E-05
R4	0.6	0.2	8.19E-04	1.84E-05	1.66E-03	3.73E-05	2.27E-03	5.10E-05	4.22E-04	9.47E-06
R5	2.0	0.3	2.79E-03	2.81E-05	5.67E-03	5.71E-05	7.74E-03	7.80E-05	1.44E-03	1.45E-05
R6	0.6	0.1	8.96E-04	1.78E-05	1.82E-03	3.62E-05	2.49E-03	4.94E-05	4.62E-04	9.18E-06
R7	0.7	0.2	9.79E-04	1.66E-05	1.99E-03	3.36E-05	2.72E-03	4.60E-05	5.04E-04	8.54E-06
R8	0.8	0.3	1.14E-03	2.66E-05	2.31E-03	5.41E-05	3.16E-03	7.39E-05	5.87E-04	1.37E-05
R9	4.7	0.8	6.50E-03	1.33E-04	1.32E-02	2.70E-04	1.80E-02	3.69E-04	3.35E-03	6.84E-05
R10	4.2	0.9	5.81E-03	2.37E-04	1.18E-02	4.81E-04	1.61E-02	6.57E-04	2.99E-03	1.22E-04
R11	1.1	0.3	1.52E-03	5.97E-05	3.09E-03	1.21E-04	4.22E-03	1.66E-04	7.83E-04	3.08E-05
R12	3.0	0.7	4.18E-03	1.80E-04	8.49E-03	3.65E-04	1.16E-02	4.99E-04	2.15E-03	9.25E-05
R13	0.3	0.1	4.56E-04	5.19E-06	9.26E-04	1.05E-05	1.26E-03	1.44E-05	2.35E-04	2.67E-06
R14	2.1	0.5	2.84E-03	1.12E-04	5.77E-03	2.27E-04	7.88E-03	3.10E-04	1.46E-03	5.76E-05
R15	3.5	0.8	4.81E-03	1.89E-04	9.76E-03	3.83E-04	1.33E-02	5.23E-04	2.48E-03	9.71E-05
R16	2.6	0.5	3.65E-03	9.99E-05	7.41E-03	2.03E-04	1.01E-02	2.77E-04	1.88E-03	5.14E-05
R17	0.3	0.1	4.39E-04	5.78E-06	8.91E-04	1.17E-05	1.22E-03	1.60E-05	2.26E-04	2.98E-06
R18	1.2	0.2	1.71E-03	1.09E-05	3.48E-03	2.21E-05	4.76E-03	3.02E-05	8.83E-04	5.61E-06
R19	1.4	0.2	1.89E-03	1.09E-05	3.84E-03	2.22E-05	5.25E-03	3.03E-05	9.75E-04	5.63E-06
Boundary Max	63	14.2	8.69E-02	8.50E-03	1.77E-01	1.73E-02	2.41E-01	2.36E-02	1.93E-02	1.16E-03

Table C2-4 Incremental Concentrations (µg/m³) – Cyanide, Phenol, Fluoride, PAHs and Naphthalene

Receptor ID	1hr Cyanide	Annual Cyanide	1hr Phenol	Annual Phenol	1hr Fluoride	Annual Fluoride	1hr PAHs	Annual PAHs	1hr Naphthalene	Annual Naphthalene
R1	1.07E-04	5.92E-06	1.07E-05	2.51E-07	5.94E-02	3.90E-03	1.77E-04	1.21E-05	9.58E-07	2.26E-08
R2	9.74E-05	3.32E-06	1.13E-05	2.33E-07	5.42E-02	2.54E-03	1.62E-04	8.10E-06	1.01E-06	2.10E-08
R3	3.92E-05	1.01E-06	4.04E-06	6.46E-08	2.19E-02	7.02E-04	6.53E-05	2.21E-06	3.64E-07	5.81E-09
R4	8.20E-06	1.88E-07	9.00E-07	1.32E-08	5.19E-03	1.42E-04	1.68E-05	4.54E-07	8.10E-08	1.18E-09
R5	5.11E-05	4.02E-07	3.89E-06	3.09E-08	3.06E-02	2.75E-04	9.31E-05	8.63E-07	3.50E-07	2.78E-09
R6	4.71E-06	1.74E-07	4.53E-07	1.28E-08	3.32E-03	1.33E-04	1.17E-05	4.27E-07	4.07E-08	1.15E-09
R7	5.99E-06	1.66E-07	6.43E-07	1.12E-08	4.98E-03	1.26E-04	1.62E-05	4.03E-07	5.78E-08	1.01E-09
R8	9.40E-06	2.61E-07	1.02E-06	1.76E-08	5.88E-03	2.00E-04	1.93E-05	6.38E-07	9.13E-08	1.58E-09
R9	5.53E-05	1.40E-06	5.51E-06	7.56E-08	3.08E-02	1.01E-03	9.26E-05	3.20E-06	4.96E-07	6.80E-09
R10	7.61E-05	2.47E-06	8.66E-06	1.71E-07	4.23E-02	1.86E-03	1.26E-04	5.92E-06	7.79E-07	1.54E-08
R11	1.29E-05	5.37E-07	1.33E-06	3.83E-08	7.19E-03	4.26E-04	2.18E-05	1.37E-06	1.20E-07	3.45E-09
R12	9.20E-05	1.90E-06	1.06E-05	1.44E-07	5.10E-02	1.46E-03	1.52E-04	4.65E-06	9.50E-07	1.30E-08
R13	2.93E-06	5.37E-08	2.44E-07	3.03E-09	2.45E-03	3.98E-05	7.96E-06	1.27E-07	2.19E-08	2.73E-10
R14	1.89E-05	9.88E-07	1.95E-06	7.26E-08	1.05E-02	7.95E-04	3.36E-05	2.56E-06	1.75E-07	6.53E-09
R15	2.90E-05	2.28E-06	2.91E-06	1.86E-07	1.86E-02	1.64E-03	6.21E-05	5.20E-06	2.62E-07	1.68E-08
R16	2.81E-05	1.35E-06	2.26E-06	1.05E-07	1.84E-02	9.31E-04	6.28E-05	2.92E-06	2.03E-07	9.42E-09
R17	2.77E-06	5.82E-08	1.82E-07	3.38E-09	2.14E-03	4.32E-05	7.02E-06	1.37E-07	1.64E-08	3.04E-10
R18	2.76E-05	1.44E-07	2.15E-06	1.00E-08	1.57E-02	1.01E-04	4.71E-05	3.17E-07	1.94E-07	9.01E-10
R19	2.73E-05	1.28E-07	3.51E-06	8.59E-09	1.74E-02	9.19E-05	5.60E-05	2.91E-07	3.16E-07	7.72E-10
Boundary Max	1.06E-03	7.72E-05	1.22E-04	6.63E-06	5.86E-01	4.39E-02	1.75E-03	1.32E-04	1.10E-05	5.97E-07

Table C2-5 Incremental Concentrations (µg/m³) – H_2S, Lead, Arsenic and Ammonia

Receptor ID	1hr H_2S	Annual H_2S	1hr Lead	Annual Lead	1hr Arsenic	Annual Arsenic	1hr Ammonia	Annual Ammonia
R1	7.12E-01	2.65E-02	1.19E-04	6.62E-06	1.23E-04	6.86E-06	1.35E+00	5.05E-02
R2	3.37E-01	1.05E-02	1.09E-04	3.71E-06	1.13E-04	3.85E-06	6.41E-01	1.99E-02
R3	8.08E-02	2.40E-03	4.38E-05	1.12E-06	4.54E-05	1.17E-06	1.54E-01	4.56E-03
R4	3.21E-02	4.49E-04	9.17E-06	2.10E-07	9.50E-06	2.18E-07	6.11E-02	8.54E-04
R5	1.33E-01	6.25E-04	5.70E-05	4.50E-07	5.91E-05	4.66E-07	2.53E-01	1.19E-03
R6	2.11E-02	3.81E-04	5.26E-06	1.94E-07	5.45E-06	2.02E-07	4.00E-02	7.24E-04
R7	4.26E-02	4.29E-04	6.70E-06	1.86E-07	6.94E-06	1.93E-07	8.10E-02	8.16E-04
R8	4.65E-02	7.15E-04	1.05E-05	2.92E-07	1.09E-05	3.03E-07	8.83E-02	1.36E-03
R9	2.19E-01	5.49E-03	6.18E-05	1.56E-06	6.41E-05	1.62E-06	4.15E-01	1.04E-02
R10	2.84E-01	8.14E-03	8.50E-05	2.76E-06	8.81E-05	2.86E-06	5.40E-01	1.55E-02
R11	5.97E-02	1.45E-03	1.44E-05	5.99E-07	1.49E-05	6.21E-07	1.13E-01	2.76E-03
R12	1.53E-01	4.67E-03	1.03E-04	2.12E-06	1.07E-04	2.20E-06	2.92E-01	8.87E-03
R13	1.79E-02	1.20E-04	3.27E-06	6.00E-08	3.39E-06	6.22E-08	3.40E-02	2.28E-04
R14	9.65E-02	2.30E-03	2.11E-05	1.10E-06	2.19E-05	1.14E-06	1.83E-01	4.38E-03
R15	1.01E-01	2.33E-03	3.24E-05	2.55E-06	3.36E-05	2.64E-06	1.91E-01	4.43E-03
R16	5.11E-02	1.23E-03	3.14E-05	1.51E-06	3.26E-05	1.57E-06	9.71E-02	2.34E-03
R17	1.78E-02	1.33E-04	3.10E-06	6.51E-08	3.21E-06	6.75E-08	3.39E-02	2.52E-04
R18	6.73E-02	2.31E-04	3.08E-05	1.61E-07	3.20E-05	1.67E-07	1.28E-01	4.39E-04
R19	5.56E-02	2.30E-04	3.05E-05	1.43E-07	3.16E-05	1.49E-07	1.06E-01	4.36E-04
Boundary Max	2.61E+00	1.22E-01	1.18E-03	8.63E-05	1.23E-03	8.94E-05	4.96E+00	2.32E-01

Table C2-6 Incremental 99.9th percentile 1-hour Concentrations (µg/m³) – air toxics

Receptor ID	1hr Benzene	1hr Toluene	1hr Xylenes	1hr Ethylbenzene	1hr Cyanide	1hr Phenol	1hr Fluoride	1hr PAHs	1hr H2S	1hr Ammonia	1hr Arsenic	1hr Lead	1hr Naphthalene
R1	8.73E-03	1.77E-02	2.42E-02	4.50E-03	7.13E-05	7.54E-06	4.01E-02	1.21E-04	1.12E+00	9.55E-01	8.25E-05	7.96E-05	6.78E-07
R2	6.65E-03	1.35E-02	1.84E-02	3.42E-03	6.88E-05	5.54E-06	3.84E-02	1.15E-04	4.77E-01	4.10E-01	7.97E-05	7.69E-05	4.98E-07
R3	1.81E-03	3.68E-03	5.03E-03	9.34E-04	2.62E-05	2.12E-06	1.55E-02	4.65E-05	8.70E-02	8.09E-02	3.03E-05	2.93E-05	1.91E-07
R4	4.51E-04	9.16E-04	1.25E-03	2.32E-04	4.65E-06	7.15E-07	2.95E-03	8.91E-06	1.46E-02	2.54E-02	5.38E-06	5.19E-06	6.43E-08
R5	1.40E-03	2.85E-03	3.89E-03	7.22E-04	2.13E-05	3.92E-06	1.41E-02	4.44E-05	2.62E-02	4.61E-02	2.47E-05	2.38E-05	3.53E-07
R6	4.54E-04	9.22E-04	1.26E-03	2.34E-04	2.89E-06	5.10E-07	2.04E-03	6.43E-06	1.29E-02	2.56E-02	3.34E-06	3.22E-06	4.59E-08
R7	4.60E-04	9.35E-04	1.28E-03	2.37E-04	4.29E-06	8.62E-07	3.13E-03	9.94E-06	1.39E-02	2.63E-02	4.97E-06	4.79E-06	7.75E-08
R8	6.79E-04	1.38E-03	1.89E-03	3.50E-04	5.61E-06	9.32E-07	3.82E-03	1.25E-05	2.44E-02	4.28E-02	6.49E-06	6.26E-06	8.38E-08
R9	2.46E-03	4.99E-03	6.82E-03	1.27E-03	3.18E-05	2.64E-06	1.80E-02	5.38E-05	2.35E-01	1.99E-01	3.68E-05	3.55E-05	2.37E-07
R10	5.06E-03	1.03E-02	1.40E-02	2.60E-03	5.29E-05	4.00E-06	2.96E-02	8.87E-05	3.68E-01	3.63E-01	6.13E-05	5.92E-05	3.60E-07
R11	1.43E-03	2.91E-03	3.98E-03	7.39E-04	8.35E-06	1.12E-06	5.31E-03	1.80E-05	6.04E-02	5.08E-02	9.67E-06	9.33E-06	1.01E-07
R12	3.87E-03	7.85E-03	1.07E-02	1.99E-03	5.82E-05	3.70E-06	3.23E-02	9.70E-05	2.03E-01	1.81E-01	6.75E-05	6.50E-05	3.33E-07
R13	3.24E-04	6.57E-04	8.98E-04	1.67E-04	2.04E-06	4.28E-07	1.49E-03	4.99E-06	5.83E-03	1.57E-02	2.37E-06	2.28E-06	3.85E-08
R14	2.59E-03	5.26E-03	7.19E-03	1.34E-03	9.66E-06	2.08E-06	9.42E-03	3.24E-05	9.89E-02	8.75E-02	1.12E-05	1.08E-05	1.87E-07
R15	4.49E-03	9.12E-03	1.25E-02	2.31E-03	2.08E-05	3.59E-06	1.62E-02	5.63E-05	9.36E-02	1.21E-01	2.41E-05	2.32E-05	3.23E-07
R16	3.24E-03	6.58E-03	8.99E-03	1.67E-03	1.72E-05	2.63E-06	1.18E-02	3.97E-05	4.41E-02	8.54E-02	2.00E-05	1.93E-05	2.37E-07
R17	3.14E-04	6.37E-04	8.71E-04	1.62E-04	1.86E-06	3.97E-07	1.46E-03	4.61E-06	6.34E-03	1.68E-02	2.15E-06	2.08E-06	3.57E-08
R18	7.22E-04	1.47E-03	2.00E-03	3.72E-04	8.14E-06	2.04E-06	6.20E-03	1.93E-05	1.14E-02	2.18E-02	9.42E-06	9.09E-06	1.83E-07
R19	6.43E-04	1.31E-03	1.78E-03	3.31E-04	5.86E-06	1.14E-06	4.38E-03	1.33E-05	1.17E-02	2.35E-02	6.78E-06	6.54E-06	1.02E-07
Boundary Max	8.70E-02	7.40E-02	1.00E-01	1.90E-02	6.91E-04	7.72E-05	3.85E-01	1.15E-03	4.49E+00	4.53E+00	8.01E-04	7.72E-04	6.94E-06

H2S is the 99th percentile 1-second concentration.

Table C2-7 Incremental Concentrations (µg/m³) – TSP, PM_{10}, $PM_{2.5}$, NO_2 SO_2 and CO

Receptor ID	Annual TSP	24-hour PM_{10}	Annual PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$	1hr NO_x	Annual NO_x	1hr SO_2	24hr SO_2	Annual SO_2	1hr CO	8hr CO
R1	48.3	46.6	19.4	19.9	7.3	94.8	17.5	81.2	18.3	3.3	9,619.8	2,761.9
R2	48.2	46.3	19.4	19.6	7.2	86.4	17.3	81.2	18.3	3.3	9,616.3	2,761.3
R3	47.9	45.6	19.2	19.2	7.0	78.3	16.8	81.2	18.3	3.3	9,612.9	2,760.5
R4	47.8	45.5	19.1	19.1	7.0	74.8	16.7	81.2	18.3	3.3	9,611.5	2,760.2
R5	47.8	45.5	19.1	19.1	7.0	78.2	16.7	81.2	18.3	3.3	9,612.9	2,760.3
R6	47.8	45.5	19.1	19.0	7.0	74.9	16.7	81.2	18.3	3.3	9,611.5	2,760.1
R7	47.8	45.5	19.1	19.1	7.0	75.0	16.7	81.2	18.3	3.3	9,611.6	2,760.2
R8	47.8	45.6	19.1	19.1	7.0	75.3	16.7	81.2	18.3	3.3	9,611.7	2,760.3
R9	47.9	45.8	19.2	19.3	7.1	84.7	16.9	81.2	18.3	3.3	9,615.6	2,760.8
R10	48.1	46.1	19.3	19.5	7.1	83.5	17.1	81.2	18.3	3.3	9,615.1	2,760.9
R11	47.8	45.6	19.1	19.2	7.0	76.0	16.8	81.2	18.3	3.3	9,612.0	2,760.3
R12	48.0	46.0	19.2	19.4	7.1	80.7	17.0	81.2	18.3	3.3	9,613.9	2,760.7
R13	47.8	45.4	19.1	19.0	7.0	74.1	16.7	81.2	18.3	3.3	9,611.2	2,760.1
R14	47.9	45.8	19.2	19.2	7.1	78.3	16.9	81.2	18.3	3.3	9,612.9	2,760.5
R15	48.0	46.0	19.2	19.4	7.1	81.7	17.0	81.2	18.3	3.3	9,614.4	2,760.8
R16	47.9	45.7	19.2	19.2	7.1	79.7	16.9	81.2	18.3	3.3	9,613.5	2,760.5
R17	47.8	45.5	19.1	19.0	7.0	74.1	16.7	81.2	18.3	3.3	9,611.2	2,760.1
R18	47.8	45.5	19.1	19.1	7.0	76.3	16.7	81.2	18.3	3.3	9,612.1	2,760.2
R19	47.8	45.5	19.1	19.1	7.0	76.6	16.7	81.2	18.3	3.3	9,612.2	2,760.2

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RAMBOLL ENVIRON

ENVIRONMENT
& HEALTH

Belinda Sinclair
Ramboll Environ Australia Pty Ltd
PO Box 435
The Junction NSW 2291

HYDRO KURRI KURRI CAPPED WASTE STORAGE REMEDIAL OPTIONS – AIR QUALITY MODELLING

Dear Belinda,

Date 25/05/2017

Ramboll Environ Australia
Level 3
100 Pacific Highway
PO Box 560
North Sydney
NSW 2060
Australia

T +61 2 9954 8100
F +61 2 9954 8150
www.ramboll-environ.com

Ref AS130525

A number of remedial options for the capped waste stockpile (CWS) at the former Hydro Aluminium Kurri Kurri site are being considered by Hydro. Analysis of the implications for human health risk of these options is required. To facilitate this analysis, air quality dispersion modelling has been undertaken to predict ground level concentrations of various pollutants. The resources developed for the air quality impact assessment completed by Ramboll Environ Australia Pty Ltd, dated 8 July 2016 (the AQIA), have been used in this options modelling study wherever possible. The AQIA should be referred to when reviewing this report.

Up to seven remedial options are under consideration, with the particulate matter emissions associated with each listed in **Therefore,** based on the above discussion, a single emissions scenario, representative of Options 2, 3 and 4 is the focus of this air quality modelling exercise.

Table 1.

The following notes are made regarding the eight CWS remedial options:

- Option 1 involves leaving the CWS material in-situ. This option would have no emission sources and has therefore not been assessed;
- Option 2, 3 and 4 involve the storage of excavated CWS material in an onsite containment cell are very similar in nature. From an air quality impact assessment perspective, the differences are negligible. Consequently, a single modelling scenario representative of Options 2, 3 and 4 has been developed;
- Options 5 and 6 involve the storage of excavated CWS material in an off-site containment cell. With the removal of onsite storage of CWS material, the emissions potential from Options 5 and 6 is lower than Options 2, 3 and 4. Therefore, no modelling for Options 5 and 6 has been conducted on the basis that impacts would be lower than Options 2, 3 and 4;

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ABN 49 095 437 442

- Options 7 involve the thermal treatment of excavated CWS material. It is understood based on information provided by the thermal treatment option engineers the technology would have negligible air quality emissions. The emissions potential from Options 7 is therefore lower than Options 2, 3 and 4. Consequently, no modelling for Options 7 has been conducted on the basis that impacts would be lower than Options 2, 3 and 4.

Therefore, based on the above discussion, a single emissions scenario, representative of Options 2, 3 and 4 is the focus of this air quality modelling exercise.

Table 1 Particulate Sources for Capped Waste Stockpile Remedial Options

Activity Considered	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
Excavate and remove CWS	N/A	✓	✓	✓	✓	✓	✓
Construction of onsite containment cell[1]	N/A	✓	✓	✓	X	X	X
Construction of offsite containment cell	N/A	X	X	X	✓	X	X
Placement of CWS in truck for offsite disposal	N/A	X	X	X	✓	✓	X
Placement of CWS in onsite/offsite containment cell	N/A	✓	✓	✓	✓	X	X
Placement of lime material in onsite/offsite containment cell with CWS material	N/A	X	✓	✓	✓	X	X
Capping of onsite/offsite containment cell	N/A	✓	✓	✓	✓	X	X
Sorting of recyclables from CWS and treatment of non-recyclables	N/A	X	✓[2]	X	✓[2]	✓[2]	✓[2]
Transportation and disposal of CWS to offsite waste disposal facility	N/A	X	X	X	✓	✓	X

Transportation and disposal of CWS to onsite treatment facility	N/A	X	X	X	X	X	✓
Remediation of haul road between CWS and onsite containment cell[3]	N/A	✓	✓	✓	X	X	X
Operation of Water Treatment Plant	✓	✓[4]	✓[4]	✓[4]	✓[4]	✓[4]	✓[4]

Note: N/A means 'Not Applicable' because the CWS material remains *in situ*.

1. Particulates can be generated during vegetation clearance, excavation of soil and operation of machinery such as trucks, tractors and grousers.
2. Particulates can be generated during the crushing of non-recyclable materials in preparation for disposal.
3. Remediation of haul road comprises removal of the top layer of soil, and placement into the onsite containment cell.
4. Water treatment plant will be operated only during CWS removal and while the onsite/offsite containment cell is open.

Emission calculation methods developed for the AQIA have been adopted for this modelling exercise. Particulate matter emissions from the following sources were quantified for the Options 2, 3 and 4 scenario:

- Excavation and handling of material from the CWS;
- Loading of excavated material to haul trucks;
- Transportation by haul trucks of material to the onsite containment cell;
- Unloading and handling of material at the containment cell; and
- Wind erosion from exposed surfaces.

Other emissions sources listed in **Therefore,** based on the above discussion, a single emissions scenario, representative of Options 2, 3 and 4 is the focus of this air quality modelling exercise.

Table 1, such as the construction of the containment cell, would not occur at the same time as the activities listed above. Because the intention is to quantify the peak 24-hour emissions from CWS remedial activities, these other sources have not been included in the modelling study.

Emissions of TSP, PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, benzene, ethylbenzene, toluene and xylenes were quantified using the same techniques and emission factors as those applied in the AQIA. Updated soil monitoring and CWS standpipe gas monitoring results were provided, with the updated recorded pollutant concentrations adopted. The following pollutants and monitoring results were incorporated into the CWS remedial option emission scenario:

- H_2S – 85.7 ppm;
- Ammonia – 826.3 ppm;
- Cyanide – 730 mg/kg;
- Arsenic – 850 mg/kg;
- Phenol – 94.5 mg/kg;
- Lead – 820 mg/kg;

- Fluoride – 405,498 mg/kg;
- Total PAHs (BaP equivalent) – 1,210 mg/kg; and
- Napthalene – 8.5 mg/kg.

For emissions of H_2S and ammonia, the standpipe gas concentration was converted to an excavation-related emission rate (AZDEQ, 2016; US-EPA 1992). Emissions of the remaining pollutants listed above were quantified by scaling the quantified particulate matter from remedial activities by the in-soil concentration.

Annual emissions associated with the onsite CWS remedial option scenario are listed below. During the process of this modelling exercise, it was noted that a scaling error occurred in the AQIA (concentration was applied as mg/g instead of mg/kg), resulting in an over calculation of air toxic emissions. This error has been corrected for this modelling exercise.

- TSP - 15,180.9kg
- PM_{10} - 8,209.0kg
- $PM_{2.5}$ - 5,363.1kg
- NO_x - 69,120.0kg
- SO_2 - 36.9 kg
- CO - 28,569.6 kg
- Benzene - 39.4 kg
- Ethylbenzene - 20.3 kg
- Toluene - 80.0 kg
- Xylenes - 109.4 kg
- Arsenic - 4.48E-01 kg
- Cyanide - 3.87E-01 kg
- Ammonia - 234.4 kg
- Phenol - 4.97E-02 kg
- H_2S - 123.3 kg
- Fluoride - 233.8 kg
- Lead - 4.32E-01 kg
- Naphthalene - 4.48E-03 kg
- PAHs - 7.11E-01 kg

The emissions inventory was input into the dispersion model configured for the AQIA. The predicted air pollution concentrations at the surrounding sensitive receptors and at the works boundary are presented in **Appendix 1**. The results of the dispersion modelling show that concentrations of all pollutants would be in compliance with all applicable ambient air quality criteria for the CWS remedial option assessed.

On the basis that the CWS remedial option assessed is considered to have the highest potential for air quality emission generation and associated impacts of the seven possible options, all proposed remedial options will not adversely impact the surrounding environment on the basis of the modelling results presented in this report.

Yours sincerely

Scott Fishwick
Manager
Air Quality

D +61299548126
M +61423001583
sfishwick@environcorp.com

APPENDIX 1 – Model Predictions

Table A1 – Incremental Concentrations – TSP, PM_{10}, $PM_{2.5}$, NO_2 and SO_2

Receptor ID	Annual TSP	Dust Deposition	24-hour PM_{10}	Annual PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$	1hr NO_2	Annual NO_2	1hr SO_2	24hr SO_2	Annual SO_2
R1	0.6	<0.1	1.2	0.3	0.9	0.3	21.5	0.8	<0.1	<0.1	<0.1
R2	0.5	<0.1	0.9	0.3	0.6	0.2	13.1	0.6	<0.1	<0.1	<0.1
R3	0.1	<0.1	0.2	0.1	0.2	<0.1	4.9	0.1	<0.1	<0.1	<0.1
R4	<0.1	<0.1	0.1	<0.1	0.1	<0.1	1.4	<0.1	<0.1	<0.1	<0.1
R5	<0.1	<0.1	0.1	<0.1	0.1	<0.1	4.9	<0.1	<0.1	<0.1	<0.1
R6	<0.1	<0.1	0.1	<0.1	0.0	<0.1	1.6	<0.1	<0.1	<0.1	<0.1
R7	<0.1	<0.1	0.1	<0.1	0.1	<0.1	1.7	<0.1	<0.1	<0.1	<0.1
R8	<0.1	<0.1	0.2	<0.1	0.1	<0.1	2.0	<0.1	<0.1	<0.1	<0.1
R9	0.2	<0.1	0.4	0.1	0.3	0.1	11.4	0.2	<0.1	<0.1	<0.1
R10	0.3	<0.1	0.7	0.2	0.5	0.1	10.2	0.4	<0.1	<0.1	<0.1
R11	0.1	<0.1	0.2	<0.1	0.2	<0.1	2.7	0.1	<0.1	<0.1	<0.1
R12	0.3	<0.1	0.6	0.1	0.4	0.1	7.3	0.3	<0.1	<0.1	<0.1
R13	<0.1	<0.1	0.0	<0.1	<0.1	<0.1	0.8	<0.1	<0.1	<0.1	<0.1
R14	0.2	<0.1	0.4	0.1	0.2	0.1	5.0	0.2	<0.1	<0.1	<0.1
R15	0.3	<0.1	0.6	0.1	0.4	0.1	8.4	0.3	<0.1	<0.1	<0.1
R16	0.1	<0.1	0.3	0.1	0.2	0.1	6.4	0.2	<0.1	<0.1	<0.1
R17	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.8	<0.1	<0.1	<0.1	<0.1
R18	<0.1	<0.1	0.1	<0.1	0.1	<0.1	3.0	<0.1	<0.1	<0.1	<0.1
R19	<0.1	<0.1	0.1	<0.1	0.1	<0.1	3.3	<0.1	<0.1	<0.1	<0.1
Boundary Max	2.69	1.96	4.22	1.46	3.51	1.18	65.78	3.94	0.035	0.006	0.002

All results in µg/m³ excluding dust deposition, which is in g/m²/month

Table A2 – Incremental Concentrations – CO, Benzene, Toluene, Xylenes and Ethylbenzene

Receptor ID	1hr CO	8hr CO	1hr Benzene	Annual Benzene	1hr Toluene	Annual Toluene	1hr Xylenes	Annual Xylenes	1hr Ethylbenzene	Annual Ethylbenzene
R1	8.9	1.9	1.23E-02	4.71E-04	2.49E-02	9.56E-04	3.40E-02	1.31E-03	6.32E-03	2.43E-04
R2	5.4	1.3	7.46E-03	3.23E-04	1.52E-02	6.57E-04	2.07E-02	8.97E-04	3.84E-03	1.67E-04
R3	2.0	0.5	2.81E-03	7.28E-05	5.71E-03	1.48E-04	7.81E-03	2.02E-04	1.45E-03	3.75E-05
R4	0.6	0.2	8.19E-04	1.84E-05	1.66E-03	3.73E-05	2.27E-03	5.10E-05	4.22E-04	9.47E-06
R5	2.0	0.3	2.79E-03	2.81E-05	5.67E-03	5.71E-05	7.74E-03	7.80E-05	1.44E-03	1.45E-05
R6	0.6	0.1	8.96E-04	1.78E-05	1.82E-03	3.62E-05	2.49E-03	4.94E-05	4.62E-04	9.18E-06
R7	0.7	0.2	9.79E-04	1.66E-05	1.99E-03	3.36E-05	2.72E-03	4.60E-05	5.04E-04	8.54E-06
R8	0.8	0.3	1.14E-03	2.66E-05	2.31E-03	5.41E-05	3.16E-03	7.39E-05	5.87E-04	1.37E-05
R9	4.7	0.8	6.50E-03	1.33E-04	1.32E-02	2.70E-04	1.80E-02	3.69E-04	3.35E-03	6.84E-05
R10	4.2	0.9	5.81E-03	2.37E-04	1.18E-02	4.81E-04	1.61E-02	6.57E-04	2.99E-03	1.22E-04
R11	1.1	0.3	1.52E-03	5.97E-05	3.09E-03	1.21E-04	4.22E-03	1.66E-04	7.83E-04	3.08E-05
R12	3.0	0.7	4.18E-03	1.80E-04	8.49E-03	3.65E-04	1.16E-02	4.99E-04	2.15E-03	9.25E-05
R13	0.3	0.1	4.56E-04	5.19E-06	9.26E-04	1.05E-05	1.26E-03	1.44E-05	2.35E-04	2.67E-06
R14	2.1	0.5	2.84E-03	1.12E-04	5.77E-03	2.27E-04	7.88E-03	3.10E-04	1.46E-03	5.76E-05
R15	3.5	0.8	4.81E-03	1.89E-04	9.76E-03	3.83E-04	1.33E-02	5.23E-04	2.48E-03	9.71E-05
R16	2.6	0.5	3.65E-03	9.99E-05	7.41E-03	2.03E-04	1.01E-02	2.77E-04	1.88E-03	5.14E-05
R17	0.3	0.1	4.39E-04	5.78E-06	8.91E-04	1.17E-05	1.22E-03	1.60E-05	2.26E-04	2.98E-06
R18	1.2	0.2	1.71E-03	1.09E-05	3.48E-03	2.21E-05	4.76E-03	3.02E-05	8.83E-04	5.61E-06
R19	1.4	0.2	1.89E-03	1.09E-05	3.84E-03	2.22E-05	5.25E-03	3.03E-05	9.75E-04	5.63E-06
Boundary Max	63	14.2	8.69E-02	8.50E-03	1.77E-01	1.73E-02	2.41E-01	2.36E-02	1.93E-02	1.16E-03

All results in µg/m³

Table A3 – Incremental Concentrations – Cyanide, Phenol, Fluoride, PAHs and Naphthalene

Receptor ID	1hr Cyanide	Annual Cyanide	1hr Phenol	Annual Phenol	1hr Fluoride	Annual Fluoride	1hr PAHs	Annual PAHs	1hr Naphthalene	Annual Naphthalene
R1	1.07E-04	5.92E-06	1.07E-05	2.51E-07	5.94E-02	3.90E-03	1.77E-04	1.21E-05	9.58E-07	2.26E-08
R2	9.74E-05	3.32E-06	1.13E-05	2.33E-07	5.42E-02	2.54E-03	1.62E-04	8.10E-06	1.01E-06	2.10E-08
R3	3.92E-05	1.01E-06	4.04E-06	6.46E-08	2.19E-02	7.02E-04	6.53E-05	2.21E-06	3.64E-07	5.81E-09
R4	8.20E-06	1.88E-07	9.00E-07	1.32E-08	5.19E-03	1.42E-04	1.68E-05	4.54E-07	8.10E-08	1.18E-09
R5	5.11E-05	4.02E-07	3.89E-06	3.09E-08	3.06E-02	2.75E-04	9.31E-05	8.63E-07	3.50E-07	2.78E-09
R6	4.71E-06	1.74E-07	4.53E-07	1.28E-08	3.32E-03	1.33E-04	1.17E-05	4.27E-07	4.07E-08	1.15E-09
R7	5.99E-06	1.66E-07	6.43E-07	1.12E-08	4.98E-03	1.26E-04	1.62E-05	4.03E-07	5.78E-08	1.01E-09
R8	9.40E-06	2.61E-07	1.02E-06	1.76E-08	5.88E-03	2.00E-04	1.93E-05	6.38E-07	9.13E-08	1.58E-09
R9	5.53E-05	1.40E-06	5.51E-06	7.56E-08	3.08E-02	1.01E-03	9.26E-05	3.20E-06	4.96E-07	6.80E-09
R10	7.61E-05	2.47E-06	8.66E-06	1.71E-07	4.23E-02	1.86E-03	1.26E-04	5.92E-06	7.79E-07	1.54E-08
R11	1.29E-05	5.37E-07	1.33E-06	3.83E-08	7.19E-03	4.26E-04	2.18E-05	1.37E-06	1.20E-07	3.45E-09
R12	9.20E-05	1.90E-06	1.06E-05	1.44E-07	5.10E-02	1.46E-03	1.52E-04	4.65E-06	9.50E-07	1.30E-08
R13	2.93E-06	5.37E-08	2.44E-07	3.03E-09	2.45E-03	3.98E-05	7.96E-06	1.27E-07	2.19E-08	2.73E-10
R14	1.89E-05	9.88E-07	1.95E-06	7.26E-08	1.05E-02	7.95E-04	3.36E-05	2.56E-06	1.75E-07	6.53E-09
R15	2.90E-05	2.28E-06	2.91E-06	1.86E-07	1.86E-02	1.64E-03	6.21E-05	5.20E-06	2.62E-07	1.68E-08
R16	2.81E-05	1.35E-06	2.26E-06	1.05E-07	1.84E-02	9.31E-04	6.28E-05	2.92E-06	2.03E-07	9.42E-09
R17	2.77E-06	5.82E-08	1.82E-07	3.38E-09	2.14E-03	4.32E-05	7.02E-06	1.37E-07	1.64E-08	3.04E-10
R18	2.76E-05	1.44E-07	2.15E-06	1.00E-08	1.57E-02	1.01E-04	4.71E-05	3.17E-07	1.94E-07	9.01E-10
R19	2.73E-05	1.28E-07	3.51E-06	8.59E-09	1.74E-02	9.19E-05	5.60E-05	2.91E-07	3.16E-07	7.72E-10
Boundary Max	1.06E-03	7.72E-05	1.22E-04	6.63E-06	5.86E-01	4.39E-02	1.75E-03	1.32E-04	1.10E-05	5.97E-07

All results in μg/m³

Table A4 – Incremental Concentrations – H_2S, Lead, Arsenic and Ammonia

Receptor ID	1hr H_2S	Annual H_2S	1hr Lead	Annual Lead	1hr Arsenic	Annual Arsenic	1hr Ammonia	Annual Ammonia
R1	7.12E-01	2.65E-02	1.19E-04	6.62E-06	1.23E-04	6.86E-06	1.35E+00	5.05E-02
R2	3.37E-01	1.05E-02	1.09E-04	3.71E-06	1.13E-04	3.85E-06	6.41E-01	1.99E-02
R3	8.08E-02	2.40E-03	4.38E-05	1.12E-06	4.54E-05	1.17E-06	1.54E-01	4.56E-03
R4	3.21E-02	4.49E-04	9.17E-06	2.10E-07	9.50E-06	2.18E-07	6.11E-02	8.54E-04
R5	1.33E-01	6.25E-04	5.70E-05	4.50E-07	5.91E-05	4.66E-07	2.53E-01	1.19E-03
R6	2.11E-02	3.81E-04	5.26E-06	1.94E-07	5.45E-06	2.02E-07	4.00E-02	7.24E-04
R7	4.26E-02	4.29E-04	6.70E-06	1.86E-07	6.94E-06	1.93E-07	8.10E-02	8.16E-04
R8	4.65E-02	7.15E-04	1.05E-05	2.92E-07	1.09E-05	3.03E-07	8.83E-02	1.36E-03
R9	2.19E-01	5.49E-03	6.18E-05	1.56E-06	6.41E-05	1.62E-06	4.15E-01	1.04E-02
R10	2.84E-01	8.14E-03	8.50E-05	2.76E-06	8.81E-05	2.86E-06	5.40E-01	1.55E-02
R11	5.97E-02	1.45E-03	1.44E-05	5.99E-07	1.49E-05	6.21E-07	1.13E-01	2.76E-03
R12	1.53E-01	4.67E-03	1.03E-04	2.12E-06	1.07E-04	2.20E-06	2.92E-01	8.87E-03
R13	1.79E-02	1.20E-04	3.27E-06	6.00E-08	3.39E-06	6.22E-08	3.40E-02	2.28E-04
R14	9.65E-02	2.30E-03	2.11E-05	1.10E-06	2.19E-05	1.14E-06	1.83E-01	4.38E-03
R15	1.01E-01	2.33E-03	3.24E-05	2.55E-06	3.36E-05	2.64E-06	1.91E-01	4.43E-03
R16	5.11E-02	1.23E-03	3.14E-05	1.51E-06	3.26E-05	1.57E-06	9.71E-02	2.34E-03
R17	1.78E-02	1.33E-04	3.10E-06	6.51E-08	3.21E-06	6.75E-08	3.39E-02	2.52E-04
R18	6.73E-02	2.31E-04	3.08E-05	1.61E-07	3.20E-05	1.67E-07	1.28E-01	4.39E-04
R19	5.56E-02	2.30E-04	3.05E-05	1.43E-07	3.16E-05	1.49E-07	1.06E-01	4.36E-04
Boundary Max	2.61E+00	1.22E-01	1.18E-03	8.63E-05	1.23E-03	8.94E-05	4.96E+00	2.32E-01

All results in µg/m³

Table A5 – Incremental 99.9th percentile 1-hour Concentrations – air toxics

Receptor ID	1hr Benzene	1hr Toluene	1hr Xylenes	1hr Ethylbenzene	1hr Cyanide	1hr Phenol	1hr Fluoride	1hr PAHs	1hr H2S	1hr Ammonia	1hr Arsenic	1hr Lead	1hr Naphthalene
R1	8.73E-03	1.77E-02	2.42E-02	4.50E-03	7.13E-05	7.54E-06	4.01E-02	1.21E-04	1.12E+00	9.55E-01	8.25E-05	7.96E-05	6.78E-07
R2	6.65E-03	1.35E-02	1.84E-02	3.42E-03	6.88E-05	5.54E-06	3.84E-02	1.15E-04	4.77E-01	4.10E-01	7.97E-05	7.69E-05	4.98E-07
R3	1.81E-03	3.68E-03	5.03E-03	9.34E-04	2.62E-05	2.12E-06	1.55E-02	4.65E-05	8.70E-02	8.09E-02	3.03E-05	2.93E-05	1.91E-07
R4	4.51E-04	9.16E-04	1.25E-03	2.32E-04	4.65E-06	7.15E-07	2.95E-03	8.91E-06	1.46E-02	2.54E-02	5.38E-06	5.19E-06	6.43E-08
R5	1.40E-03	2.85E-03	3.89E-03	7.22E-04	2.13E-05	3.92E-06	1.41E-02	4.44E-05	2.62E-02	4.61E-02	2.47E-05	2.38E-05	3.53E-07
R6	4.54E-04	9.22E-04	1.26E-03	2.34E-04	2.89E-06	5.10E-07	2.04E-03	6.43E-06	1.29E-02	2.56E-02	3.34E-06	3.22E-06	4.59E-08
R7	4.60E-04	9.35E-04	1.28E-03	2.37E-04	4.29E-06	8.62E-07	3.13E-03	9.94E-06	1.39E-02	2.63E-02	4.97E-06	4.79E-06	7.75E-08
R8	6.79E-04	1.38E-03	1.89E-03	3.50E-04	5.61E-06	9.32E-07	3.82E-03	1.25E-05	2.44E-02	4.28E-02	6.49E-06	6.26E-06	8.38E-08
R9	2.46E-03	4.99E-03	6.82E-03	1.27E-03	3.18E-05	2.64E-06	1.80E-02	5.38E-05	2.35E-01	1.99E-01	3.68E-05	3.55E-05	2.37E-07
R10	5.06E-03	1.03E-02	1.40E-02	2.60E-03	5.29E-05	4.00E-06	2.96E-02	8.87E-05	3.68E-01	3.63E-01	6.13E-05	5.92E-05	3.60E-07
R11	1.43E-03	2.91E-03	3.98E-03	7.39E-04	8.35E-06	1.12E-06	5.31E-03	1.80E-05	6.04E-02	5.08E-02	9.67E-06	9.33E-06	1.01E-07
R12	3.87E-03	7.85E-03	1.07E-02	1.99E-03	5.82E-05	3.70E-06	3.23E-02	9.70E-05	2.03E-01	1.81E-01	6.75E-05	6.50E-05	3.33E-07
R13	3.24E-04	6.57E-04	8.98E-04	1.67E-04	2.04E-06	4.28E-07	1.49E-03	4.99E-06	5.83E-03	1.57E-02	2.37E-06	2.28E-06	3.85E-08
R14	2.59E-03	5.26E-03	7.19E-03	1.34E-03	9.66E-06	2.08E-06	9.42E-03	3.24E-05	9.89E-02	8.75E-02	1.12E-05	1.08E-05	1.87E-07
R15	4.49E-03	9.12E-03	1.25E-02	2.31E-03	2.08E-05	3.59E-06	1.62E-02	5.63E-05	9.36E-02	1.21E-01	2.41E-05	2.32E-05	3.23E-07
R16	3.24E-03	6.58E-03	8.99E-03	1.67E-03	1.72E-05	2.63E-06	1.18E-02	3.97E-05	4.41E-02	8.54E-02	2.00E-05	1.93E-05	2.37E-07
R17	3.14E-04	6.37E-04	8.71E-04	1.62E-04	1.86E-06	3.97E-07	1.46E-03	4.61E-06	6.34E-03	1.68E-02	2.15E-06	2.08E-06	3.57E-08
R18	7.22E-04	1.47E-03	2.00E-03	3.72E-04	8.14E-06	2.04E-06	6.20E-03	1.93E-05	1.14E-02	2.18E-02	9.42E-06	9.09E-06	1.83E-07
R19	6.43E-04	1.31E-03	1.78E-03	3.31E-04	5.86E-06	1.14E-06	4.38E-03	1.33E-05	1.17E-02	2.35E-02	6.78E-06	6.54E-06	1.02E-07
Boundary Max	8.70E-02	7.40E-02	1.00E-01	1.90E-02	6.91E-04	7.72E-05	3.85E-01	1.15E-03	4.49E+00	4.53E+00	8.01E-04	7.72E-04	6.94E-06
Criteria	**2.90E+01**	**3.60E+02**	**1.90E+02**	**8.00E+03**	**9.00E+01**	**2.00E+01**		**4.00E-01**	**2.76E+00**	**3.30E+02**	**9.00E-02**		

All results in μg/m³. H2S is the 99th percentile 1-second concentration.

Table A6 – Incremental Concentrations – TSP, PM_{10}, $PM_{2.5}$, NO_2 SO_2 and CO

Receptor ID	Annual TSP	24-hour PM_{10}	Annual PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$	1hr NO_x	Annual NO_x	1hr SO_2	24hr SO_2	Annual SO_2	1hr CO	8hr CO
R1	48.3	46.6	19.4	19.9	7.3	94.8	17.5	81.2	18.3	3.3	9,619.8	2,761.9
R2	48.2	46.3	19.4	19.6	7.2	86.4	17.3	81.2	18.3	3.3	9,616.3	2,761.3
R3	47.9	45.6	19.2	19.2	7.0	78.3	16.8	81.2	18.3	3.3	9,612.9	2,760.5
R4	47.8	45.5	19.1	19.1	7.0	74.8	16.7	81.2	18.3	3.3	9,611.5	2,760.2
R5	47.8	45.5	19.1	19.1	7.0	78.2	16.7	81.2	18.3	3.3	9,612.9	2,760.3
R6	47.8	45.5	19.1	19.0	7.0	74.9	16.7	81.2	18.3	3.3	9,611.5	2,760.1
R7	47.8	45.5	19.1	19.1	7.0	75.0	16.7	81.2	18.3	3.3	9,611.6	2,760.2
R8	47.8	45.6	19.1	19.1	7.0	75.3	16.7	81.2	18.3	3.3	9,611.7	2,760.3
R9	47.9	45.8	19.2	19.3	7.1	84.7	16.9	81.2	18.3	3.3	9,615.6	2,760.8
R10	48.1	46.1	19.3	19.5	7.1	83.5	17.1	81.2	18.3	3.3	9,615.1	2,760.9
R11	47.8	45.6	19.1	19.2	7.0	76.0	16.8	81.2	18.3	3.3	9,612.0	2,760.3
R12	48.0	46.0	19.2	19.4	7.1	80.7	17.0	81.2	18.3	3.3	9,613.9	2,760.7
R13	47.8	45.4	19.1	19.0	7.0	74.1	16.7	81.2	18.3	3.3	9,611.2	2,760.1
R14	47.9	45.8	19.2	19.2	7.1	78.3	16.9	81.2	18.3	3.3	9,612.9	2,760.5
R15	48.0	46.0	19.2	19.4	7.1	81.7	17.0	81.2	18.3	3.3	9,614.4	2,760.8
R16	47.9	45.7	19.2	19.2	7.1	79.7	16.9	81.2	18.3	3.3	9,613.5	2,760.5
R17	47.8	45.5	19.1	19.0	7.0	74.1	16.7	81.2	18.3	3.3	9,611.2	2,760.1
R18	47.8	45.5	19.1	19.1	7.0	76.3	16.7	81.2	18.3	3.3	9,612.1	2,760.2
R19	47.8	45.5	19.1	19.1	7.0	76.6	16.7	81.2	18.3	3.3	9,612.2	2,760.2
Criteria	**90**	**50**	**30**	**25**	**8**	**246**	**62**	**570**	**228**	**60**	**100,000**	**30,000**

All results in $\mu g/m^3$

APPENDIX C3
TABLES

Sample Identification			Tier 1 Screening Criteria[A]	MW201_3.0	MW201_6.0	MW201_9.0	MW201_11.5	MW201_14	MW202_2.0	MW202_6.5	MW202_9.8	MW202-12	MW202-13.5	MW202_13.5 Dulpicate	MW203_2.5	MW203_2.5 Duplicate	MW203_7.0	MW203_9.0	MW203_12.5	MW203_14.5	MW204_2.5	MW204_2.5 Duplicate	MW204_2.5 Triplicate
Date		PQL		2-Dec-2015	2-Dec-15	2-Dec-15	27-Oct-15	28-Oct-15	2-Dec-15	2-Dec-15	2-Dec-15	5-Nov-15	5-Nov-15		2-Dec-15		2-Dec-15	2-Dec-15	29-Oct-15	29-Oct-15	2-Dec-15	2-Dec-15	2-Dec-15
Strata				Waste	Waste	Waste	Sandy Clay	Sandy Clay	Waste	Waste	Waste	Clay	Clay		Waste		Waste	Waste	Sandy Clay	Sandy Clay	Waste		
Depth		mbgs		3	6	9	11.5	14	2	6.5	9.8	12	13.5		2.5		7	9	12.5	14.5	2.5	2.5	2.5
Moisture Content (dried @ 103°C)	%	1	-	14.3	10.3	17.1	20.1	16.5	9	20	31	20.3	12	13.3	29.2	21.6	13.8	13.6	16.9	18.7	16.8	21.8	19
pH Value	pH Unit	0.1	-	9.1	9.6	9.9	9.7	10.1	11.4	10.2	10.1	10.5	9.9	9.8	9.7	9.4	9.8	11.4	10.5	10	6.3	6.4	6.3
Asbestos	presence	Y/N	Y/N	No	Yes	Yes + Trace	-	-	No	Yes	Yes	-	-	-	No	No	Yes	Yes	-	-	No	No	-
Asbestos	Type		-	-	Am	Am	-	-	-	Am	Am	-	-	-	-	-	Ch + Am	Am	-	-	-	-	
Chloride																							
Chloride	mg/kg	10	-	-	-	-	550	<100	-	-	-	210	290	530	-	-	-	-	660	780	-	-	-
Metals																							
Sodium	mg/kg	10	-	3300	3810	7240	2990	5630	14500	14800	2990	3750	3760	4650	5960	3260	4660	16400	3450	1860	8040	6770	40000
Potassium	mg/kg	10	-	-	-	-	1310	1600	-	-	-	40	60	40	-	-	-	-	770	760	-	-	-
Aluminium	mg/kg	50	100,000**	-	-	-	10400	16100	-	-	-	7050	12300	16800	-	-	-	-	15100	4460	-	-	-
Mercury	mg/kg	0.1	40	-	-	-	<0.1	<0.1	-	-	-	<0.1	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-
Cyanide																							
Total Cyanide	mg/kg	1	250	14	86	78	734	53	33	50	49	26	44	51	158	142	35	70	532	4	20	23	<5
Fluoride																							
Fluoride (total)	mg/kg	40	-	-	-	-	490	1170	-	-	-	2880	2140	3740	-	-	-	-	1700	90	-	-	-
Fluoride (soluble)	mg/kg	1	440**	2440	2220	3030	-	-	21100	3220	1500	-	-	-	3560	2610	3120	21000	-	-	184	192	110
Polychlorinated Biphenyls																							
Total Polychlorinated biphenyls	mg/kg	0.1	1	-	-	-	<0.1	<0.1	-	-	-	<0.1	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-
Polynuclear Aromatic Hydrocarbons																							
Naphthalene	mg/kg	0.5	3*	<3.0	-	-	<0.5	<0.5	-	1	-	<0.5	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-
Acenaphthylene	mg/kg	0.5	3600[C]	<3.0	-	-	<0.5	<0.5	-	<0.5	-	<0.5	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-
Acenaphthene	mg/kg	0.5	3600[B]	15.3	-	-	<0.5	<0.5	-	2.2	-	0.6	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-
Fluorene	mg/kg	0.5	2400[B]	7.1	-	-	<0.5	<0.5	-	1	-	<0.5	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-
Phenanthrene	mg/kg	0.5	18000[C]	57.9	-	-	<0.5	<0.5	-	9.9	-	4.3	<0.5	<0.5	-	-	-	<0.5	2.6	<0.5	8.3	-	-
Anthracene	mg/kg	0.5	18000[B]	12.3	-	-	<0.5	<0.5	-	2.2	-	0.9	<0.5	<0.5	-	-	-	<0.5	0.5	<0.5	1	-	-
Fluoranthene	mg/kg	0.5	2400[B]	148	-	-	<0.5	0.6	-	27.3	-	10.2	<0.5	<0.5	-	-	-	0.5	6.6	<0.5	47	-	-
Pyrene	mg/kg	0.5	1800[B]	126	-	-	<0.5	0.6	-	24.1	-	10.4	<0.5	<0.5	-	-	-	<0.5	6.4	<0.5	22.9	-	-
Benz(a)anthracene	mg/kg	0.5	-[D]	132	-	-	<0.5	<0.5	-	21.7	-	4.9	<0.5	<0.5	-	-	-	<0.5	2.8	<0.5	19.5	-	-
Chrysene	mg/kg	0.5	-[D]	116	-	-	<0.5	0.6	-	19.9	-	4.8	<0.5	<0.5	-	-	-	<0.5	2.8	<0.5	52.5	-	-
Benzo(b+j)fluoranthene	mg/kg	0.5	-[D]	238	-	-	<0.5	0.5	-	42	-	7.4	<0.5	<0.5	-	-	-	<1	3.3	<0.5	55	-	-
Benzo(k)fluoranthene	mg/kg	0.5	-[D]		-	-	<0.5	<0.5	-		-	2.7	<0.5	<0.5	-	-	-		0.9	<0.5		-	-
Benzo(a)pyrene	mg/kg	0.5	-[D]	124	-	-	<0.5	<0.5	-	22.9	-	6.4	<0.5	<0.5	-	-	-	<0.5	2.8	<0.5	5.1	-	-
Indeno(1.2.3.cd)pyrene	mg/kg	0.5	-[D]	56.3	-	-	<0.5	<0.5	-	9	-	3.4	<0.5	<0.5	-	-	-	<0.5	1.7	<0.5	5.6	-	-
Dibenz(a.h)anthracene	mg/kg	0.5	-[D]	17	-	-	<0.5	<0.5	-	3.4	-	0.7	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	2.6	-	-
Benzo(g.h.i)perylene	mg/kg	0.5	-[D]	59.5	-	-	<0.5	<0.5	-	9.4	-	4.8	<0.5	<0.5	-	-	-	<0.5	1.9	<0.5	5.4	-	-
Sum of polycyclic aromatic hydrocarbons	mg/kg	0.5	300	1110	-	-	<0.5	2.3	-	196	-	61.5	<0.5	<0.5	-	-	-	0.5	32.3	<0.5	225	-	-
Benzo(a)pyrene TEQ	mg/kg	0.5	3	185	-	-	0.6	0.6	-	33.9	-	9	0.6	0.6	-	-	-	0.6	4	0.6	16.3	-	-
Total Recoverable Hydrocarbons - NEPM 2013 Fractions																							
C6 - C10 Fraction	mg/kg	10	-	-	-	-	<10	<10	-	-	-	<10	<10	<10	-	-	-	-	<10	<10	-	-	-
C6 - C10 Fraction minus BTEX (F1)	mg/kg	10	45*	-	-	-	<10	<10	-	-	-	<10	<10	<10	-	-	-	-	<10	<10	-	-	-
>C10 - C16 Fraction	mg/kg	50	-	-	-	-	<50	<50	-	-	-	<50	<50	<50	-	-	-	-	<50	<50	-	-	-
>C10 - C16 Fraction minus Naphthalene (F2)	mg/kg	50	110*	-	-	-	<50	<50	-	-	-	<50	<50	<50	-	-	-	-	<50	<50	-	-	-
>C16 - C34 Fraction	mg/kg	100	4500^	-	-	-	<100	<100	-	-	-	470	<100	<100	-	-	-	-	<100	<100	-	-	-
>C34 - C40 Fraction	mg/kg	100	6300^	-	-	-	<100	<100	-	-	-	<100	<100	<100	-	-	-	-	<100	<100	-	-	-
BTEX																							
Benzene	mg/kg	0.2	0.5*	-	-	-	<0.2	<0.2	-	-	-	<0.2	<0.2	<0.2	-	-	-	-	<0.2	<0.2	-	-	-
Toluene	mg/kg	0.5	160*	-	-	-	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-
Ethylbenzene	mg/kg	0.5	55*	-	-	-	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-
Total Xylenes	mg/kg	0.5	40*	-	-	-	<0.5	<0.5	-	-	-	<0.5	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C] Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equilvalents, therefore when the BaP TEQ HIL is exceeded, all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

** Site-specific soil criteria for residential landuse derived from 'Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013)'

^ CRC CARE (2011) Soil Health screening Levels for Direct Contact, Low density residential

Cells with '-' indicates testing was not completed or appropriate screening criteria was not available

Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Sample Identification			Tier 1 Screening Criteria[A]	MW204_4	MW204_6.0	MW204_9.0	MW204_12.2	MW204_14.0	MW205_5.5	MW205_9.0	MW205_11.3	MW205_12.2	MW205_14.5	MW206_3.0	MW206_7.0	MW206_11.0	MW206_12	MW206_13	MW206_13.5	MW206_14	MW206_15.0
Date		PQL		6-Nov-15	2-Dec-15	2-Dec-15	6-Nov-15	6-Nov-15	2-Dec-15	2-Dec-15	2-Dec-15	30-Oct-15	30-Oct-15	2-Dec-15	2-Dec-15	2-Dec-15	3-Nov-15	3-Nov-15	3-Nov-15	3-Nov-15	3-Nov-15
Strata				Waste	Waste	Waste	Sandy clay	Sandy clay	Waste	Waste	Waste	Sand	Sandy clay	Waste	Waste	Waste	Sand	Sand	Sand	Sand	Sand
Depth		mbgs		4	6	9	12.2	14	5.5	9	11.3	12.2	14.5	3	7	11	12	13	13.5	14	15
Moisture Content (dried @ 103°C)	%	1	-	-	15.6	13.8	20	11	11.1	8.6	11.4	13.4	11.6	21.5	16.6	20.9	23.1	-	-	-	20
pH Value	pH Unit	0.1	-	-	10.7	11.3	10.2	9.6	8.3	10.7	9.4	10.3	9.2	10.4	9.6	9.8	9.9	-	-	-	10.5
Asbestos	presence	Y/N	Y/N	No	No	No	-	-	No	No	No	-	-	No	No	No	-	-	-	-	-
Asbestos	Type		-		-	-			-	-	-			-	-	-					
Chloride																					
Chloride	mg/kg	10	-	-	-	-	1180	710	-	-	-	130	40	-	-	-	150	-	-	-	130
Metals																					
Sodium	mg/kg	10	-	-	16400	18000	6940	970	1510	7250	3870	3880	170	12200	2960	5450	6730	-	-	-	5170
Potassium	mg/kg	10	-	-	-	-	1210	780	-	-	-	20	100	-	-	-	60	-	-	-	40
Aluminium	mg/kg	50	100,000**	-	-	-	14800	5080	-	-	-	3330	4530	-	-	-	103000	-	-	-	8890
Mercury	mg/kg	0.1	40	-	-	-	<0.1	<0.1	-	-	-	<0.1	<0.1	-	-	-	0.1	-	-	-	<0.1
Cyanide																					
Total Cyanide	mg/kg	1	250	-	72	45	114	<1	77	56	71	58	<1	139	110	57	100	-	-	-	60
Fluoride																					
Fluoride (total)	mg/kg	40	-	-	-	-	2290	110	-	-	-	830	200	-	-	-	69000	-	-	-	1510
Fluoride (soluble)	mg/kg	1	440**	-	10500	18400	-	-	1240	12700	1740	-	-	5470	2390	2410	2700	2360	1490	574	-
Polychlorinated Biphenyls																					
Total Polychlorinated biphenyls	mg/kg	0.1	1	-	-	-	0.1	<0.1	-	-	-	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1
Polynuclear Aromatic Hydrocarbons																					
Naphthalene	mg/kg	0.5	3*	-	-	-	<0.5	<0.5	-	-	3.8	<0.5	<0.5	-	-	8.1	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthylene	mg/kg	0.5	3600[C]	-	-	-	<0.5	<0.5	-	-	<3.0	<0.5	<0.5	-	-	<3.0	<0.5	<0.5	<0.5	<0.5	<0.5
Acenaphthene	mg/kg	0.5	3600[B]	-	-	-	0.8	<0.5	-	-	27	<0.5	<0.5	-	-	41.7	3.4	<0.5	<0.5	<0.5	<0.5
Fluorene	mg/kg	0.5	2400[B]	-	-	-	<0.5	<0.5	-	-	9.9	<0.5	<0.5	-	-	25.5	1.8	<0.5	<0.5	<0.5	<0.5
Phenanthrene	mg/kg	0.5	18000[C]	-	-	-	4.2	<0.5	-	-	186	<0.5	<0.5	-	-	212	13.4	<0.5	<0.5	<0.5	<0.5
Anthracene	mg/kg	0.5	18000[B]	-	-	-	0.8	<0.5	-	-	44.8	<0.5	<0.5	-	-	105	3.2	<0.5	<0.5	<0.5	<0.5
Fluoranthene	mg/kg	0.5	2400[B]	-	-	-	8.4	<0.5	-	-	739	1.6	<0.5	-	-	508	42.2	<0.5	<0.5	<0.5	<0.5
Pyrene	mg/kg	0.5	1800[B]	-	-	-	8.5	<0.5	-	-	706	1.6	<0.5	-	-	449	45.3	<0.5	<0.5	<0.5	<0.5
Benz(a)anthracene	mg/kg	0.5	-[D]	-	-	-	3.9	<0.5	-	-	731	1.3	<0.5	-	-	550	48.2	<0.5	<0.5	<0.5	<0.5
Chrysene	mg/kg	0.5	-[D]	-	-	-	4	<0.5	-	-	626	1.4	<0.5	-	-	448	49.3	<0.5	<0.5	<0.5	<0.5
Benzo(b+j)fluoranthene	mg/kg	0.5	-[D]	-	-	-	5.6	<0.5	-	-	1330	2	<0.5	-	-	990	86	<0.5	<0.5	<0.5	<0.5
Benzo(k)fluoranthene	mg/kg	0.5	-[D]	-	-	-	1.9	<0.5				0.8	<0.5				22.8	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene	mg/kg	0.5	-[D]	-	-	-	4.9	<0.5	-	-	832	1.8	<0.5	-	-	536	60	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	mg/kg	0.5	-[D]	-	-	-	2.7	<0.5	-	-	442	0.9	<0.5	-	-	270	39.5	<0.5	<0.5	<0.5	<0.5
Dibenz(a.h)anthracene	mg/kg	0.5	-[D]	-	-	-	0.5	<0.5	-	-	116	<0.5	<0.5	-	-	78.1	12.6	<0.5	<0.5	<0.5	<0.5
Benzo(g.h.i)perylene	mg/kg	0.5	-[D]	-	-	-	3.9	<0.5	-	-	528	1.1	<0.5	-	-	284	47.2	<0.5	<0.5	<0.5	<0.5
Sum of polycyclic aromatic hydrocarbons	mg/kg	0.5	300	-	-	-	50.1	<0.5	-	-	6,320	12.5	<0.5	-	-	4,500	475	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ	mg/kg	0.5	3	-	-	-	6.9	0.6	-	-	1210	2.6	0.6	-	-	802	93.2	0.6	0.6	0.6	0.6
Total Recoverable Hydrocarbons - NEPM 2013 Fractions																					
C6 - C10 Fraction	mg/kg	10	-	-	-	-	<10	<10	-	-	-	<10	<10	-	-	-	<10	-	-	-	<10
C6 - C10 Fraction minus BTEX (F1)	mg/kg	10	45*	-	-	-	<10	<10	-	-	-	<10	<10	-	-	-	<10	-	-	-	<10
>C10 - C16 Fraction	mg/kg	50	-	-	-	-	<50	<50	-	-	-	<50	<50	-	-	-	<50	-	-	-	<50
>C10 - C16 Fraction minus Naphthalene (F2)	mg/kg	50	110*	-	-	-	<50	<50	-	-	-	<50	<50	-	-	-	<50	-	-	-	<50
>C16 - C34 Fraction	mg/kg	100	4500^	-	-	-	<100	<100	-	-	-	<100	<100	-	-	-	2,340	-	-	-	<100
>C34 - C40 Fraction	mg/kg	100	6300^	-	-	-	<100	<100	-	-	-	<100	<100	-	-	-	1120	-	-	-	<100
BTEX																					
Benzene	mg/kg	0.2	0.5*	-	-	-	<0.2	<0.2	-	-	-	<0.2	<0.2	-	-	-	<0.2	-	-	-	<0.2
Toluene	mg/kg	0.5	160*	-	-	-	<0.5	<0.5	-	-	-	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Ethylbenzene	mg/kg	0.5	55*	-	-	-	<0.5	<0.5	-	-	-	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Total Xylenes	mg/kg	0.5	40*	-	-	-	<0.5	<0.5	-	-	-	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C]Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equivalents, therefore when the BaP TEQ HIL is exceeded, all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

** Site-specific soil criteria for residential landuse derived from 'Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013)'

^ CRC CARE (2011) Soil Health screening Levels for Direct Contact, Low density residential

Cells with '-' indicates testing was not completed or appropriate screening criteria was not available

Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Table C2: Additional Soil Data from the Capped Waste Stockpile
Comparative Health Risk Assessment
Hydro Aluminium, Lot1 Hart Rd, Loxford

Contaminant	Units	LOR	Tier 1 Screening Criteria[A]	MW201 - BULK 1st sub-sample	MW201 - BULK 1st sub-sample	MW202 - BULK 1st sub-sample	MW203 - BULK 1st sub-sample	MW204 - BULK 1st sub-sample	MW205 - BULK 1st sub-sample	MW206 - BULK 1st sub-sample	MW201 - 1st sub-sample>125mm	MW202 - 1st sub-sample>125mm	MW203 - 1st sub-sample>125mm	MW204 - 1st sub-sample>125mm	MW205 - 1st sub-sample>125mm	MW205 - 1st sub-sample>125mm	MW206 - 1st sub-sample>125mm
Benzene	mg/kg	0.2	0.5*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2
Toluene	mg/kg	0.5	160*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5
Ethylbenzene	mg/kg	1	55*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1
Total Xylenes	mg/kg	1	40*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1
TPH C6 - C10 less BTEX (F1)	mg/kg	25	45*	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25		28
TRH >C10 - C16 less Naphthalene (F2)	mg/kg	50	110*	<50	<50	**150**	<50	89	<50	93	<50	<50	<50	<50	<50		69
TRH >C16-C34	mg/kg	100	4500^	1300	1400	**5400**	1600	4500	3900	**7700**	<100	220	<100	<100	1300		<100
TRH >C34-C40	mg/kg	100	6300^	350	380	1400	760	1600	1100	2000	<100	<100	<100	<100	410		<100
Naphthalene	mg/kg	0.1	3*	<1	<1	7.7	1.3	3	1.7	1.8	1.2	0.2	0.3	3.2	0.4		1.2
Acenaphthylene	mg/kg	0.1	3600[C]	<1	<1	1	<1	1.7	<1	<1	<0.1	0.1	<0.1	<0.1	<0.1		<0.1
Acenaphthene	mg/kg	0.1	3600[B]	2.7	3	27	4.2	9.2	5	15	0.7	3	0.7	2.6	1.7		0.8
Fluorene	mg/kg	0.1	2400[B]	1.3	1.7	10	1.4	4.3	4	7.3	<0.1	1.1	0.1	0.1	0.7		0.3
Phenanthrene	mg/kg	0.1	18000[C]	17	18	120	16	79	51	98	2.3	18	5.4	3.2	13		3.2
Anthracene	mg/kg	0.1	18000[B]	5.9	4.8	28	5.8	15	14	28	0.7	5	0.8	0.3	3.4		0.9
Fluoranthene	mg/kg	0.1	2400[B]	52	36	240	43	140	140	230	3.3	20	9.9	1.7	33		6.6
Pyrene	mg/kg	0.1	1800[B]	52	33	230	41	130	130	210	2.9	17	9.1	1.4	33		6
Benzo(a)anthracene	mg/kg	0.1	-[D]	46	45	190	27	91	160	250	0.6	10	2.8	0.2	37		3.4
Chrysene	mg/kg	0.1	-[D]	51	51	150	21	73	120	210	0.7	9.2	2.6	0.2	36		2.8
Benzo(b,j+k)fluoranthene	mg/kg	0.2	-[D]	100	100	320	45	150	300	460	0.4	15	3.1	<0.2	67		3
Benzo(a)pyrene	mg/kg	0.05	3	**41**	**40**	**210**	**25**	**85**	**160**	**290**	0.2	**7.3**	1.4	<0.05	**43**		1.3
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	-[D]	22	20	95	11	38	73	140	<0.1	2.2	0.3	<0.1	25		0.2
Dibenzo(a,h)anthracene	mg/kg	0.1	-[D]	6	7.6	24	3	10	24	61	<0.1	1	0.1	<0.1	11		0.1
Benzo(g,h,i)perylene	mg/kg	0.1	-[D]	26	23	100	14	42	78	140	<0.1	2.2	0.4	<0.1	27		0.2
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	3	**65**	**65**	**300**	**37**	**120**	**230**	**440**	<0.5	**11**	2.2	<0.5	**68**		2.1
Total +ve PAH's	mg/kg	0.5	300	**430**	**380**	**1800**	260	**860**	**1300**	**2200**	13	110	37	13	**330**		30
Arsenic	mg/kg	4	100	6	6	**120**	92	8	39	13	<4	<4	4	<4	5		<4
Cadmium	mg/kg	0.4	20	0.5	0.5	0.6	0.5	0.7	1	0.7	<0.4	<0.4	<0.4	<0.4	<0.4		<0.4
Copper	mg/kg	-	6000	24	30	260	400	41	230	54	9	5	6	9	21		9
Lead	mg/kg	-	300	25	27	**490**	**330**	20	210	42	3	5	6	3	9		8
Mercury	mg/kg	0.1	40	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1
Molybdenum	mg/kg	1	-	2	4	9	9	6	10	6	1	1	1	<1	2		1
Nickel	mg/kg	-	400	43	45	83	49	80	170	85	17	15	12	12	40		27
Selenium	mg/kg	2	200	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2
Silver	mg/kg	1	-	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1
Tin	mg/kg	1	-	2	3	10	16	3	14	4	<1	<1	<1	<1	1		<1
Zinc	mg/kg		7400	170	180	2500	3700	98	4600	360	6	23	23	14	43		70
Free Cyanide in soil	mg/kg	0.5	250	0.9	0.7	1	5	3	4	8.4	6.3	3	1	0.8	4	3	0.6
Total Cyanide	mg/kg		-	110	100	120	220	110	200	140	47	57	68	50	190	190	38
Hexavalent Chromium, Cr6+	mg/kg	1	100	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1
Total Fluoride	mg/kg		440**	**35411**	**33898**	**25702**	**36790**	**34822**	**32566**	**24834**	**24232**	**21613**	**28692**	**29168**	**22764**	**24332**	**17833**

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C]Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equilvalents, therefore a when the BaP TEQ HIL is exceeded all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

** Site-specific soil criteria for residential landuse derived from 'Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013)'

^ CRC CARE (2011) Soil Health screening Levels for Direct Contact, Low density residential
Cells with '-' indicates testing was not completed or appropriate screening criteria was not available

PQL=Practical Quantitation Limit

Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Contaminant	Units	LOR	Tier 1 Screening Criteria[A]	MW201 - 1st sub-sample<1 25mm	MW202 - 1st sub-sample<1 25mm	MW203 - 1st sub-sample<1 25mm	MW204 - 1st sub-sample<1 25mm	MW205 - 1st sub-sample<1 25mm	MW206 - 1st sub-sample<1 25mm	MW201 - BULK 2nd sub-sample	MW202 - BULK 2nd sub-sample	MW203 - BULK 2nd sub-sample	MW203 - BULK 2nd sub-sample	MW204 - BULK 2nd sub-sample	MW205 - BULK 2nd sub-sample	MW206 - BULK 2nd sub-sample	MW201 - 2nd sub-sample>1 25mm
Benzene	mg/kg	0.2	0.5*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.5	160*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	1	55*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes	mg/kg	1	40*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH C6 - C10 less BTEX (F1)	mg/kg	25	45*	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
TRH >C10 - C16 less Naphthalene (F2)	mg/kg	50	110*	<50	150	<50	74	64	96	<50	150	<50	<50	85	<50	98	<50
TRH >C16-C34	mg/kg	100	4500[^]	920	9500	2200	5300	7900	13000	1200	5400	1500	1500	4300	3600	7700	<100
TRH >C34-C40	mg/kg	100	6300[^]	270	1800	1100	1400	1900	3400	390	1300	720	810	1500	1000	2000	<100
Naphthalene	mg/kg	0.1	3*	1.4	4	0.8	2.9	4.2	1.7	0.6	8	1.2	1.7	2.5	1.3	1.9	0.5
Acenaphthylene	mg/kg	0.1	3600[C]	0.2	1.3	0.2	3.3	1.7	<1	0.2	<1	0.2	0.2	1.6	<1	<1	<0.1
Acenaphthene	mg/kg	0.1	3600[B]	1.9	31	3.7	12	11	20	2	28	3.7	4	8.6	4.7	16	0.2
Fluorene	mg/kg	0.1	2400[B]	1	15	1.4	6.4	8.3	9.8	1.1	11	1.3	1.5	4.4	3.4	8.5	<0.1
Phenanthrene	mg/kg	0.1	18000[C]	14	170	24	120	120	160	14	120	17	19	77	44	100	0.2
Anthracene	mg/kg	0.1	18000[B]	3.1	33	6.7	25	29	53	3.8	29	4.3	4.7	12	13	32	<0.1
Fluoranthene	mg/kg	0.1	2400[B]	34	310	60	240	270	450	45	240	40	40	130	110	240	0.2
Pyrene	mg/kg	0.1	1800[B]	32	300	56	220	250	420	42	230	37	37	110	100	220	0.1
Benzo(a)anthracene	mg/kg	0.1	-[D]	31	280	32	160	260	420	34	200	23	23	72	110	260	<0.1
Chrysene	mg/kg	0.1	-[D]	30	230	30	140	220	450	38	150	20	21	78	110	220	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	0.2	-[D]	55	460	57	270	470	810	75	340	41	42	130	230	500	<0.2
Benzo(a)pyrene	mg/kg	0.05	3	29	310	36	150	290	430	35	220	24	24	67	110	310	0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	-[D]	16	160	18	71	140	260	21	98	11	12	34	58	130	<0.1
Dibenzo(a,h)anthracene	mg/kg	0.1	-[D]	5.9	43	6.3	21	44	100	7.9	27	2.9	3.4	13	18	62	<0.1
Benzo(g,h,i)perylene	mg/kg	0.1	-[D]	17	170	21	76	140	260	23	110	13	13	37	60	140	<0.1
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	3	46	450	53	230	420	690	57	310	34	36	100	170	460	<0.5
Total +ve PAH's	mg/kg	0.5	300	270	2500	350	1500	2200	3800	340	1800	240	250	780	970	2200	1.2
Arsenic	mg/kg	4	100	7	44	330	9	22	14	6	100	180	160	8	67	13	<4
Cadmium	mg/kg	0.4	20	<0.4	0.6	0.5	0.7	0.9	0.7	0.5	0.5	0.5	0.6	0.6	1	0.7	<0.4
Copper	mg/kg	-	6000	17	310	420	34	150	37	31	250	390	410	28	250	69	7
Lead	mg/kg	-	300	21	820	220	27	130	19	27	500	330	350	18	310	37	1
Mercury	mg/kg	0.1	40	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	mg/kg	1	-	2	8	7	3	8	7	3	6	7	8	3	8	7	<1
Nickel	mg/kg	-	400	36	66	44	64	79	110	42	81	44	46	64	71	96	12
Selenium	mg/kg	2	200	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Silver	mg/kg	1	-	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	<1	<1
Tin	mg/kg	1	-	2	14	18	3	11	3	4	11	16	16	2	13	6	<1
Zinc	mg/kg		7400	110	4000	2300	110	2100	100	180	2600	3800	3800	89	4100	320	1
Free Cyanide in soil	mg/kg	0.5	250	3	4	4	1	3	2	0.5	0.8	0.7	0.6	5	3	3	4
Total Cyanide	mg/kg		-	78	79	160	75	140	120	110	61	190	200	130	190	120	42
Hexavalent Chromium, Cr6+	mg/kg	1	100	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1
Total Fluoride	mg/kg		440**	24719	22153	29656	12663	20301	15300	25423	18756	24494		14696	24182	17227	25052

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C]Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equilvalents, therefore a when the BaP TEQ HIL is exceeded all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

** Site-specific soil criteria for residential landuse derived from 'Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013)'

^ CRC CARE (2011) Soil Health screening Levels for Direct Contact, Low density residential
Cells with '-' indicates testing was not completed or appropriate screening criteria was not available

PQL=Practical Quantitation Limit

Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Contaminant	Units	LOR	Tier 1 Screening Criteria[A]	MW202 - 2nd sub-sample>125mm	MW203 - 2nd sub-sample>125mm	MW204 - 2nd sub-sample>125mm	MW205 - 2nd sub-sample>125mm	MW206 - 2nd sub-sample>125mm	MW201 - 2nd sub-sample<125mm	MW201 - 2nd sub-sample<125mm	MW202 - 2nd sub-sample<125mm	MW202 - 2nd sub-sample<125mm	MW203 - 2nd sub-sample<125mm	MW204 - 2nd sub-sample<125mm	MW205 - 2nd sub-sample<125mm	MW206 - 2nd sub-sample<125mm
Benzene	mg/kg	0.2	0.5*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.5	160*	<0.5	<0.5	0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	1	55*	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1
Total Xylenes	mg/kg	1	40*	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1
TPH C6 - C10 less BTEX (F1)	mg/kg	25	45*	<25	<25	<25	<25	<25	<25		<25	<25	<25	<25	<25	<25
TRH >C10 - C16 less Naphthalene (F2)	mg/kg	50	110*	<50	<50	<50	<50	<50	<50		150	150	<50	89	74	110
TRH >C16-C34	mg/kg	100	4500^	200	<100	<100	1300	<100	910		9500	9600	2200	5800	8300	14000
TRH >C34-C40	mg/kg	100	6300^	<100	<100	<100	390	<100	230		2000	1900	1100	1500	2000	3300
Naphthalene	mg/kg	0.1	3*	0.1	0.2	3.4	0.4	0.5	0.3		3.7	3.9	1.1	2.8	3.7	2.2
Acenaphthylene	mg/kg	0.1	3600[C]	0.2	<0.1	<0.1	0.1	<0.1	0.2		1.3	1.7	0.2	3.4	1.6	1.1
Acenaphthene	mg/kg	0.1	3600[B]	2.7	0.4	2.8	1.8	0.1	1.9		32	31	3.9	13	11	20
Fluorene	mg/kg	0.1	2400[B]	1	<0.1	0.1	0.7	<0.1	0.8		16	14	1.6	7.2	7.9	10
Phenanthrene	mg/kg	0.1	18000[C]	17	4.2	3.7	13	<0.1	13		170	170	23	140	110	150
Anthracene	mg/kg	0.1	18000[B]	4.9	0.8	0.5	3.4	<0.1	3.7		37	37	5.9	28	27	48
Fluoranthene	mg/kg	0.1	2400[B]	20	7.7	2.1	470	0.1	42		340	380	41	270	260	360
Pyrene	mg/kg	0.1	1800[B]	17	7	1.6	47	<0.1	40		330	370	40	240	240	340
Benzo(a)anthracene	mg/kg	0.1	-[D]	10	2.2	0.2	43	<0.1	32		280	310	30	170	250	420
Chrysene	mg/kg	0.1	-[D]	8.6	1.6	0.3	44	<0.1	32		230	230	27	160	230	350
Benzo(b,j+k)fluoranthene	mg/kg	0.2	-[D]	14	2	<0.2	80	<0.2	61		480	510	56	300	490	730
Benzo(a)pyrene	mg/kg	0.05	3	6.9	0.95	<0.05	44	<0.05	30		310	340	33	170	300	470
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	-[D]	1.9	0.2	<0.1	28	<0.1	16		150	170	17	81	140	250
Dibenzo(a,h)anthracene	mg/kg	0.1	-[D]	0.8	<0.1	<0.1	12	<0.1	6.2		43	45	5.9	24	60	110
Benzo(g,h,i)perylene	mg/kg	0.1	-[D]	1.9	0.3	<0.1	30	<0.1	18		170	180	19	87	150	250
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	3	11	1.4	<0.5	72	<0.5	48		450	490	49	250	450	730
Total +ve PAH's	mg/kg	0.5	300	110	27	15	820	0.67	300		2600	2800	300	1700	2300	3500
Arsenic	mg/kg	4	100	<4	4	<4	5	<4	6		410	83	92	8	23	13
Cadmium	mg/kg	0.4	20	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4		0.5	0.5	0.5	0.7	0.9	0.7
Copper	mg/kg	-	6000	3	6	11	24	3	20		450	250	350	52	130	43
Lead	mg/kg	-	300	4	5	3	10	2	22		800	740	270	24	100	22
Mercury	mg/kg	0.1	40	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	0.3	<0.1
Molybdenum	mg/kg	1	-	1	<1	<1	2	<1	2		9	5	9	5	10	6
Nickel	mg/kg	-	400	14	11	14	47	13	35		84	67	44	81	85	110
Selenium	mg/kg	2	200	<2	<2	<2	<2	<2	<2		<2	<2	<2	<2	<2	<2
Silver	mg/kg	1	-	<1	<1	<1	<1	<1	<1		2	1	<1	<1	<1	<1
Tin	mg/kg	1	-	<1	<1	<1	1	<1	3		20	11	15	3	9	4
Zinc	mg/kg		7400	10	22	12	57	4	160		3200	3100	3300	98	1200	120
Free Cyanide in soil	mg/kg	0.5	250	2	4	5.7	6.8	1	<0.5	<0.5	0.9		3	4	0.8	5.5
Total Cyanide	mg/kg		-	58	68	38	140	32	93	91	87		160	100	180	140
Hexavalent Chromium, Cr6+	mg/kg	1	100	<1	<1	<1	<1	<1	<1		<1		<1	<1	<1	<1
Total Fluoride	mg/kg		440**	22155	8727	405498	21671	41339	34022		11200		29396	16418	20832	42424

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C]Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equilvalents, therefore a when the BaP TEQ HIL is exceeded all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

** Site-specific soil criteria for residential landuse derived from 'Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013)'

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Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Table C2: Additional Soil Data from the Capped Waste Stockpile

Comparative Health Risk Assessment

Hydro Aluminium, Lot1 Hart Rd, Loxford

Contaminant	Units	LOR	Tier 1 Screening Criteria[A]	MW201 - BULK 3rd sub-sample	MW202 - BULK 3rd sub-sample	MW203 - BULK 3rd sub-sample	MW204 - BULK 3rd sub-sample	MW205 - BULK 3rd sub-sample	MW205 - BULK 3rd sub-sample	MW206 - BULK 3rd sub-sample	MW201 - BULK 4TH sub-sample	MW201 - BULK 4TH sub-sample	MW202 - BULK 4TH sub-sample	MW203 - BULK 4TH sub-sample	MW204 - BULK 4TH sub-sample	MW205 - BULK 4TH sub-sample	MW206 - BULK 4TH sub-sample
Benzene	mg/kg	0.2	0.5*	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.5	160*	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	1	55*	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes	mg/kg	1	40*	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1
TPH C6 - C10 less BTEX (F1)	mg/kg	25	45*	<25	<25	<25	<25	<25		<25	<25	<25	<25	<25	<25	<25	<25
TRH >C10 - C16 less Naphthalene (F2)	mg/kg	50	110*	<50	180	<50	100	58		110	<50	<50	160	<50	110	58	91
TRH >C16-C34	mg/kg	100	4500^	1300	4200	1600	4500	4000		8000	1600	1400	5200	1700	4700	3800	7800
TRH >C34-C40	mg/kg	100	6300^	400	1000	780	1500	1200		2100	480	360	1300	840	1500	1100	2000
Naphthalene	mg/kg	0.1	3*	0.4	7.6	1.7	2.3	1.4		1.9	<1	<1	8.5	1.8	3.1	1.2	2
Acenaphthylene	mg/kg	0.1	3600[C]	0.2	2.1	0.1	1.1	1.4		1.1	<1	<1	<1	<1	1.6	1.1	<1
Acenaphthene	mg/kg	0.1	3600[B]	1.9	29	4.2	9.1	5.9		16	2.3	2	28	5.2	10	4.8	16
Fluorene	mg/kg	0.1	2400[B]	0.9	11	1.7	4.6	4.7		8.6	1.4	<1	9.4	2.3	5.3	4	8.1
Phenanthrene	mg/kg	0.1	18000[C]	12	120	21	81	58		110	18	14	110	26	69	51	100
Anthracene	mg/kg	0.1	18000[B]	3	30	5.5	13	17		34	4.2	4.1	27	6.1	16	18	33
Fluoranthene	mg/kg	0.1	2400[B]	47	220	47	130	170		260	89	68	210	55	71	140	230
Pyrene	mg/kg	0.1	1800[B]	45	210	45	120	160		240	85	66	200	51	69	130	210
Benzo(a)anthracene	mg/kg	0.1	-[D]	40	190	22	73	210		300	62	51	160	31	69	170	250
Chrysene	mg/kg	0.1	-[D]	41	120	22	75	150		240	69	61	150	25	60	130	220
Benzo(b,j+k)fluoranthene	mg/kg	0.2	-[D]	83	290	42	130	380		560	120	110	290	52	110	310	500
Benzo(a)pyrene	mg/kg	0.05	3	38	190	23	67	210		340	45	42	180	31	70	170	300
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	-[D]	22	82	11	29	90		160	22	23	83	14	34	81	140
Dibenzo(a,h)anthracene	mg/kg	0.1	-[D]	8.2	19	3.3	11	35		54	8.3	8.6	24	3.7	13	31	62
Benzo(g,h,i)perylene	mg/kg	0.1	-[D]	24	91	13	32	98		160	25	26	91	16	37	87	140
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	3	61	270	35	100	310		500	75	70	260	44	110	260	450
Total +ve PAH's	mg/kg	0.5	300	370	1600	260	780	1600		2500	550	480	1600	320	640	1300	2200
Arsenic	mg/kg	4	100	6	43	190	7	40		14	6	6	180	98	7	39	12
Cadmium	mg/kg	0.4	20	0.4	0.6	0.6	0.7	1		0.8	0.4	0.4	0.5	0.5	0.6	1	0.7
Copper	mg/kg	-	6000	24	210	430	39	200		67	22	22	340	370	31	210	57
Lead	mg/kg	-	300	24	540	330	23	200		46	23	20	630	320	20	190	34
Mercury	mg/kg	0.1	40	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
Molybdenum	mg/kg	1	-	2	5	8	3	8		7	3	3	8	9	3	9	6
Nickel	mg/kg	-	400	46	84	38	61	61		85	43	39	87	34	57	63	76
Selenium	mg/kg	2	200	<2	<2	<2	<2	<2		<2	<2	<2	<2	<2	<2	<2	<2
Silver	mg/kg	1	-	<1	1	<1	<1	<1		<1	<1	<1	2	<1	<1	<1	<1
Tin	mg/kg	1	-	2	10	17	3	13		6	2	2	14	15	2	12	4
Zinc	mg/kg		7400	170	2400	3700	150	4100		400	160	110	3100	3500	100	3900	310
Free Cyanide in soil	mg/kg	0.5	250	0.8	2	6.9	3	4	3	8.5	3		0.8	3	2	2	5
Total Cyanide	mg/kg		-	110	82	210	110	250	260	160	110		95	210	120	210	150
Hexavalent Chromium, Cr6+	mg/kg	1	100	<1	<1	<1	<1	<1		<1	<1		<1	<1	<1	<1	<1
Total Fluoride	mg/kg		440**	45624	38615	31990	35282	14200		36700	34200		41300	19400	50000	51700	36800

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C]Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equilvalents, therefore a when the BaP TEQ HIL is exceeded all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

** Site-specific soil criteria for residential landuse derived from 'Preliminary Screening Level Health Risk Assessment for Fluoride and Aluminium (ENVIRON 2013)'

^ CRC CARE (2011) Soil Health screening Levels for Direct Contact, Low density residential
Cells with '-' indicates testing was not completed or appropriate screening criteria was not available

PQL=Practical Quantitation Limit

Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Contaminant	Units	LOR	Tier 1 Screening Criteria[A]	MW201 - BULK 5TH sub-sample	MW202 - BULK 5TH sub-sample	MW203 - BULK 5TH sub-sample	MW203 - BULK 5TH sub-sample	MW204 - BULK 5TH sub-sample	MW205 - BULK 5TH sub-sample	MW206 - BULK 5TH sub-sample	MW201 - BULK 6TH sub-sample	MW201 - BULK 6TH sub-sample	MW202 - BULK 6TH sub-sample	MW203 - BULK 6TH sub-sample	MW204 - BULK 6TH sub-sample	MW205 - BULK 6TH sub-sample	MW206 - BULK 6TH sub-sample
Benzene	mg/kg	0.2	0.5*	<0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	0.5	160*	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	1	55*	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes	mg/kg	1	40*	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TPH C6 - C10 less BTEX (F1)	mg/kg	25	45*	<25	<25	<25		<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
TRH >C10 - C16 less Naphthalene (F2)	mg/kg	50	110*	<50	140	<50		110	60	110	<50	<50	160	<50	110	<50	85
TRH >C16-C34	mg/kg	100	4500^	1400	5300	1700		4600	3900	7900	1300	1200	5300	1600	4500	3700	7800
TRH >C34-C40	mg/kg	100	6300^	380	1300	760		1500	1100	2000	450	380	1300	750	1500	1000	2000
Naphthalene	mg/kg	0.1	3*	0.3	7	1.9		2.4	1.5	2.4	1.3	<1	6.9	1.7	2.3	<1	2
Acenaphthylene	mg/kg	0.1	3600[C]	0.2	1.5	0.2		1.1	1.4	<1	<1	<1	<1	<1	2.1	<1	1.1
Acenaphthene	mg/kg	0.1	3600[B]	2.3	26	5		9.1	5.6	17	1.8	2.1	27	4.6	9.4	6.1	18
Fluorene	mg/kg	0.1	2400[B]	1.1	10	2.4		4.5	4.4	9.5	1.1	1.3	10	1.9	4.6	4.4	9.7
Phenanthrene	mg/kg	0.1	18000[C]	14	120	24		81	53	120	13	12	120	22	80	52	120
Anthracene	mg/kg	0.1	18000[B]	3.3	29	5.8		14	16	34		3.7	29	6.6	16	17	35
Fluoranthene	mg/kg	0.1	2400[B]	57	240	49		140	140	250	51	50	230	54	140	130	290
Pyrene	mg/kg	0.1	1800[B]	56	230	45		120	130	230	49	48	210	50	120	130	260
Benzo(a)anthracene	mg/kg	0.1	-[D]	54	210	24		82	170	270	45	50	180	34	96	140	350
Chrysene	mg/kg	0.1	-[D]	61	150	24		78	130	240	49	40	150	24	71	130	250
Benzo(b,j+k)fluoranthene	mg/kg	0.2	-[D]	120	330	46		140	320	530	100	93	300	50	140	280	620
Benzo(a)pyrene	mg/kg	0.05	3	45	220	26		76	170	320	35	40	190	28	84	150	390
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	-[D]	25	100	12		35	77	140	19	19	88	13	39	69	190
Dibenzo(a,h)anthracene	mg/kg	0.1	-[D]	9.9	28	4.4		13	27	66	7.3	6.3	25	3.6	11	29	80
Benzo(g,h,i)perylene	mg/kg	0.1	-[D]	28	110	14		37	84	150	21	23	97	15	43	72	190
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	0.5	3	76	310	39		120	250	480	59	63	280	42	120	220	590
Total +ve PAH's	mg/kg	0.5	300	480	1800	280		830	1300	2400	400	390	1700	310	870	1200	2800
Arsenic	mg/kg	4	100	7	280	850		8	38	22	7	6	55	240	8	62	14
Cadmium	mg/kg	0.4	20	0.5	0.6	0.4		0.6	1	0.7	0.5	0.5	0.5	0.5	0.7	1	0.8
Copper	mg/kg	-	6000	28	410	720		35	220	58	25	30	270	450	27	220	64
Lead	mg/kg	-	300	27	640	370		20	190	39	27	29	610	350	18	210	35
Mercury	mg/kg	0.1	40	<0.1	<0.1	<0.1		<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	mg/kg	1	-	3	8	12		4	10	5	3	3	6	8	3	9	7
Nickel	mg/kg	-	400	44	66	65		61	69	77	42	43	69	37	62	63	95
Selenium	mg/kg	2	200	<2	<2	<2		<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Silver	mg/kg	1	-	<1	2	1		<1	<1	<1	<1	<1	1	<1	<1	<1	<1
Tin	mg/kg	1	-	3	17	28		2	13	4	2	5	13	17	2	14	5
Zinc	mg/kg		7400	210	3500	3900		99	4300	350	190	250	3600	3700	86	4400	330
Free Cyanide in soil	mg/kg	0.5	250	1	0.8	3	3	2	2	6	2		3	6.9	4	7.4	8.8
Total Cyanide	mg/kg		-	110	76	270	270	110	220	150	120		130	200	120	220	150
Hexavalent Chromium, Cr6+	mg/kg	1	100	<1	<1	<1		<1	<1	<1	<1		<1	<1	<1	<1	<1
Total Fluoride	mg/kg		440**	39384	21756	29268		37526	24302	36971	17176		21200	23945	39575	30872	20494

A NEPC (2013) Health Investigation Level 'A' (Low density residential)

[B] USEPA Regional Screen level for Resident Soil non-carcinogenic value

[C]Acenaphthene tier 1 criteria adopted for acenaphthylene; anthracene tier 1 Criteria adopted for phenanthrene

[D] NEPC (2013) HILs for carcinogenic PAHs is assessed as BaP toxic equilvalents, therefore a when the BaP TEQ HIL is exceeded all eight carcinogenic PAHs are considered to exceed the HIL, and will be assessed further.

* NEPC (2103) Soil Health screening Levels for Vapour Intrusion, Sand, at 0-1 m Low-High density residential

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Cells with '-' indicates testing was not completed or appropriate screening criteria was not available

PQL=Practical Quantitation Limit

Results shown in shading are in excess of the human health criteria

<LOR or <value= Leass than the laboratory Limit of reporting

Sample ID:			Guidelines		MW202	MW203	MW204	MW206	MW206 Duplicate
Depth	m		Drinking Water[A]	Health-based guideline adjusted for incidential ingestion[B]	12.19	13.21	12.49	12.45	12.45
Date:		PQL			11-Nov-15	11-Nov-15	11-Nov-15	11-Nov-15	
Alkalinity									
Hydroxide Alkalinity as CaCO3	mg/L	1	-	-	<1	-	-	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	26700	-	-	24700	26200
Bicarbonate Alkalinity as CaCO3	mg/L	1	-	-	727	-	-	242	727
Total Alkalinity as CaCO3	mg/L	1	-	-	27400	-	-	25000	26900
Sulfate									
Sulfate as SO4 - Turbidimetric	mg/L	1	250		1250	-	-	9000	9460
Chloride									
Chloride	mg/L	1	250		568	-	-	522	553
Sodium									
Sodium	mg/L	1	180		8300	-	-	16700	17400
Potassium									
Potassium	mg/L	1	-	-	13	-	-	68	73
Metals (disolved)									
Aluminium	µg/L	10	9000[F]		200	-	790	2410	2860
Mercury	µg/L	0.1	1	10	<0.1	-	-	<0.1	<0.1
Cyanide									
Total Cyanide	µg/L	400	-	-	7810	-	227000	223000	207000
Free Cyanide	µg/L	400	80	800		<400	<400	<400	
Fluoride									
Soluble Fluoride	µg/L	100	1500[F]		1880000	200	1380000	1640000	1720000
PCBs									
Total Polychlorinated biphenyls	µg/L	1	-	-	<1	-	-	<1	<1
Polycyclic Aromatic Hydrocarbons									
Naphthalene	µg/L	1	1.7[D]	17	1.4	-	-	30.2	38.8
Acenaphthylene	µg/L	1	-	-	<1.0	-	-	<1.0	<1.0
Acenaphthene	µg/L	1	530[D]	5300	<1.0	-	-	3.5	3.5
Fluorene	µg/L	1	290[D]	2900	<1.0	-	-	2.1	1.8
Phenanthrene	µg/L	1	-	-	<1.0	-	-	6	4.3
Anthracene	µg/L	1	1800[D]	18000	<1.0	-	-	2.7	2.2
Fluoranthene	µg/L	1	800[D]	8000	<1.0	-	-	8.8	5.3
Pyrene	µg/L	1	120[D]	1200	1	-	-	8.7	5.2
Benz(a)anthracene	µg/L	1	0.10[E]	1.0	<1.0	-	-	9.2	4.4

Sample ID:			Guidelines		MW202	MW203	MW204	MW206	MW206 Duplicate
Depth	m		Drinking Water[A]	Health-based guideline adjusted for incidential ingestion[B]	12.19	13.21	12.49	12.45	12.45
Date:		PQL			11-Nov-15	11-Nov-15	11-Nov-15	11-Nov-15	
Chrysene	µg/L	1	1.0[E]	10	<1.0	-	-	8.4	3.9
Benzo(b+j)fluoranthene	µg/L	1	0.10[E]	1.0	<1.0	-	-	12.3	5.4
Benzo(k)fluoranthene	µg/L	1	0.10[E]	1.0	<1.0	-	-	3.9	2
Benzo(a)pyrene	µg/L	0.5	0.01[A]	0.1	<0.5	-	-	9.6	4.1
Indeno(1.2.3.cd)pyrene	µg/L	1	0.10[E]	1.0	<1.0	-	-	7	2.8
Dibenz(a.h)anthracene	µg/L	1	0.01[E]	0.1	<1.0	-	-	1.7	<1
Benzo(g.h.i)perylene	µg/L	1	1.0[E]	10	<1.0	-	-	8.2	3.2
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5	-	-	2.4	-	-	122	86.9
Benzo(a)pyrene TEQ	µg/L	0.5	-	-	<0.5	-	-	14.7	5.6
Total Petroleum Hydrocarbons									
C6 - C9 Fraction	µg/L	20	1	10	110	-	-	330	310
C10 - C14 Fraction	µg/L	50	90[C]	900	<50	-	-	200	200
C15 - C28 Fraction	µg/L	100	90[C]	900	<100	-	-	540	530
C29 - C36 Fraction	µg/L	50	90[C]	900	120	-	-	100	90
BTEXN									
Benzene	µg/L	1	1	10	23	-	-	3	3
Toluene	µg/L	2	800	8000	6	-	-	4	5
Ethylbenzene	µg/L	2	300	3000	<2	-	-	<2	<2
meta- & para-Xylene	µg/L	2	-	-	<2	-	-	3	4
ortho-Xylene	µg/L	2	-	-	<2	-	-	<2	<2
Total Xylenes	µg/L	2	600	6000	<2	-	-	3	4
Naphthalene	µg/L	5	1.7[D]	17	<5	-	-	48	58

A NHMRC (2016) Australian Drinking Water Guidelines

B NHMRC (2008) Guidelines for Managing Risks in Recreational Water. Application of a x10 factor to the health-based drinking water guideline. Drinking water guidelines based on aesthetic considerations were not adjusted.

C WHO (2008) Petroleum Products in Drinking Water

D USEPA (May 2016) Regional Screening Level, Residential Tapwater value.

E NHMRC (2011) states that "Data are inadequate to set guidelines for other PAHs, however comparative carcinogenic potency can be used to determine an approximate risk when complex mixtures of PAHs are present in drinking water". Toxicity equivalance factors from NEPM (2013) are adopted.

F Site-specific assessment criteria derived for 'recreational' exposure (Environ, 2013).

Table C4: Groundwater Data Down-Gradient of the Capped Waste Stockpile (Shallow data)

Hydro Aluminium, Lot1 Hart Rd, Loxford

	Well ID	W1S	W2S	E5	PUMP	W7S	W7M	E4	A7	W3S	W4S	E11	W5S	N8	N9	W6S	G5	G6
Jul-13	**Soluble Fluoride (mg/L)**	53	115	495	79	34	878	699	436	237	Dry	102	35	0.27	85	195	NS	NS
Nov-13		69	58	410	51	31	650	650	420	310	480	160	61	0.17	200	Dry	NS	NS
Feb-14		42	Dry	450	280	Dry	730	650	410	210	Dry	190	Dry	0.26	Dry	Dry	NS	NS
Jul-14		Dry	Dry	Dry	550	Dry	Dry	590	380	270	Dry	160	100	0.27	170	Dry	NS	NS
Nov-14		Dry	Dry	Dry	930	Dry	910	380	410	210	Dry	150	Dry	0.29	210	Dry	NS	NS
Feb-15		66	Dry	Dry	740	Dry	840	340	550	250	Dry	230	93	0.35	210	200	NS	NS
Jun-15		120	Dry	410	200	Dry	810	260	500	230	490	7.4	88	0.9	24	180	NS	NS
Sep-15		38	Dry	350	680	Dry	670	280	400	200	400	110	70	0.3	25	Dry	NS	NS
Dec-15		Dry	Dry	Dry	360	Dry	540	300	320	160	Dry	96	Dry	0.4	9	180	NS	NS
Apr-16		39	Dry	330	570	Dry	640	330	330	190	Dry	120	Dry	<10	Dry	Dry	<10	<10
Jul-16		Dry	Dry	Dry	280	Dry	870	570	320	170	Dry	120	62	0.4	140	Dry	0.4	<0.1
Oct-16		Dry	Dry	Dry	85	Dry	1100	550	360	150	Dry	130	Dry	0.6	Dry	Dry	<0.1	0.2
Dec-16		Dry	Dry	Dry	88	Dry	1000	450	380	110	Dry	200	Dry	0.4	Dry	Dry	0.3	<0.1
Mar-17		Dry	Dry	Dry	210	Dry	220	670	500	180	Dry	230	Dry	1	200	Dry	0.6	<0.1
	Guideline[A]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

A Site-specific assessment criteria derived for 'recreational' exposure (Environ, 2013).

Results shown in shading are in excess of the preliminary screening criteria

	Well ID	W1S	W2S	E5	PUMP	W7S	W7M	E4	A7	W3S	W4S	E11	W5S	N8	N9	W6S	G5	G6
Jul-13	**Free Cyanide (mg/L)**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nov-13		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Feb-14		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Jul-14		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nov-14		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Feb-15		0.004	Dry	Dry	0.021	Dry	0.020	<0.004	11	<0.004	Dry	0.005	<0.004	<0.004	<0.004	0.019	NS	NS
Jun-15		<4	Dry	<0.8	<0.08	Dry	<2	<0.4	<2	<0.4	<4	<0.004	<4	<0.4	<0.4	<0.4	NS	NS
Sep-15		Dry	Dry	Dry	0.029	Dry	<0.4	<0.04	<0.020	<0.02	<40	<0.004	<0.02	<0.02	<0.02	Dry	NS	NS
Dec-15		Dry	Dry	Dry	0.100	Dry	0.210	0.032	0.190	0.023	Dry	0.033	Dry	0.005	<0.004	0.058	NS	NS
Apr-16		Dry	Dry	Dry	0.010	Dry	0.013	0.004	<0.004	0.007	Dry	<0.004	Dry	<0.004	Dry	Dry	<0.004	<0.004
Jul-16		Dry	Dry	Dry	0.018	Dry	0.072	0.049	0.026	0.005	Dry	0.009	Dry	0.004	<0.004	Dry	0.006	<0.004
Oct-16		Dry	Dry	Dry	<0.004	Dry	Dry	0.045	0.032	0.014	Dry	0.016	Dry	<0.004	Dry	Dry	<0.004	<0.004
Dec-16		Dry	Dry	Dry	0.006	Dry	0.007	<0.004	<0.004	<0.004	Dry	0.004	Dry	<0.004	Dry	Dry	<0.004	<0.004
Mar-17		Dry	Dry	Dry	0.006	Dry	0.090	0.029	0.039	0.007	Dry	0.015	Dry	0.006	<0.004	Dry	<0.004	<0.004
	Guideline[A]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	Guideline[B]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

A NHMRC Australian Drinking Water Guidelines, 2016

B NHMRC (2008) Guidelines for Managing Risks in Recreational Water. Application of a x10 factor to the health-based drinking water guideline.

Results shown in shading are in excess of the preliminary screening criteria

Table C4: Groundwater Data Down-Gradient of the Capped Waste Stockpile (Shallow data)

Hydro Aluminium, Lot1 Hart Rd, Loxford

	Well ID	W1S	W2S	E5	PUMP	W7S	W7M	E4	A7	W3S	W4S	E11	W5S	N8	N9	W6S	G5	G6
Jul-13	**Total Aluminium (mg/L)**	121	91.5	0.33	58.1	415	11.4	0.379	0.208	11.7	Dry	23	13	0.102	14.7	60.1	NS	NS
Nov-13		130	33	0.52	60	42	2.3	0.89	4.7	2.6	3.6	23	13	12	62	Dry	NS	NS
Feb-14		27	Dry	2.5	17	Dry	45	0.4	0.7	7.1	Dry	4	Dry	0.11	Dry	Dry	NS	NS
Jul-14		Dry	Dry	Dry	Dry	210	Dry	3.2	0.26	9.2	Dry	7.8	15	0.3	9	Dry	NS	NS
Nov-14		Dry	Dry	Dry	310	Dry	21	35	0.71	5.3	Dry	3.6	Dry	91	130	Dry	NS	NS
Feb-15		120	Dry	Dry	370	Dry	0.99	46	1.7	34	Dry	5	22	1.8	8	3.5	NS	NS
Jun-15		1200	Dry	3	120	Dry	32	49	2.7	4.4	2.3	2.5	7	29	14	7.7	NS	NS
Sep-15		Dry	Dry	Dry	610	Dry	8.7	53	0.61	24	13	11	31	5.3	22	Dry	NS	NS
Dec-15		Dry	Dry	Dry	97	Dry	7.8	18	0.72	92	Dry	2.7	Dry	3.4	0.89	22	NS	NS
Apr-16		15	Dry	Dry	280	Dry	4.4	14	14	15	Dry	7.6	Dry	34	Dry	Dry	1.8	28
Jul-16		Dry	Dry	Dry	93	Dry	0.08	9.9	2.9	6.9	Dry	23	10	0.47	5.5	Dry	24	0.78
Oct-16		Dry	Dry	Dry	90	Dry	6.2	2.6	2.1	21	Dry	22	Dry	1.6	Dry	Dry	0.14	0.13
Dec-16		Dry	Dry	Dry	120	Dry	11	36	3	90	Dry	15	Dry	1	Dry	Dry	0.17	29
Mar-17		Dry	Dry	Dry	740	Dry	3.4	12	25	48	Dry	89	Dry	34	Dry	Dry	6.2	25
	Guideline[A]	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

A Site-specific assessment criteria derived for 'recreational' exposure (Environ, 2013). Criteria is based on 'soluble' aluminium and therefore a conservative value when compared to 'total' aluminium.

Results shown in shading are in excess of the preliminary screening criteria

	Well ID	W1S	W2S	E5	PUMP	W7S	W7M	E4	A7	W3S	W4S	E11	W5S	N8	N9	W6S	G5	G6
Jul-13	**pH**	7.22	7.33	9.54	7.45	7.29	9.81	9.91	9.63	8.53	Dry	9.36	7.37	6.36	9.16	8.87	NS	NS
Nov-13		7.17	6.82	9.37	7.24	7.1	9.87	9.79	9.47	8.82	9.13	9.36	7.37	6.38	8.9	Dry	NS	NS
Feb-14		6.84	Dry	9.78	9.65	Dry	10.1	9.94	9.67	7.61	Dry	9.33	Dry	6.48	Dry	Dry	NS	NS
Jul-14		6.9	Dry	Dry	10.14	Dry	10.12	9.84	9.66	8.89	Dry	9.41	7.39	6.53	9.17	8.79	NS	NS
Nov-14		Dry	Dry	Dry	10.01	Dry	9.78	9.4	9.24	7.68	Dry	9.32	Dry	6.39	8.91	Dry	NS	NS
Feb-15		6.66	Dry	Dry	9.95	Dry	9.44	8.84	8.56	6.38	Dry	8.86	6.55	6.11	8.46	7.27	NS	NS
Jun-15		6.83	Dry	9.14	9.87	Dry	9.82	9.46	9.45	7.53	9.13	7.97	7.26	6.49	7.22	8.72	NS	NS
Sep-15		6.86	Dry	9.42	10.22	Dry	9.91	9.62	9.8	7.53	9.07	9.23	7.2	6.69	7.34	8.98	NS	NS
Dec-15		Dry	Dry	Dry	10.27	Dry	9.7	10.57	10.71	Dry	Dry	8.65	Dry	6.74	7.7	8.67	NS	NS
Apr-16		7.21	Dry	9.48	10.13	Dry	9.99	9.73	9.75	7.46	Dry	9.2	Dry	6.59	6.61	Dry	6.36	3.6
Jul-16		Dry	Dry	Dry	10.22	Dry	9.95	9.83	9.37	7.02	5.11	9.29	7.29	6.63	8.11	Dry	6.77	3.82
Oct-16		Dry	Dry	Dry	9.98	Dry	10.17	9.94	9.57	7.01	Dry	9.41	Dry	6.92	8.54	Dry	6.72	4.04
Dec-16		Dry	Dry	Dry	9.72	Dry	9.68	9.53	9.15	6.4	Dry	9.1	Dry	6.4	Dry	Dry	5.88	3.79
Mar-17		Dry	Dry	Dry	9.56	Dry	9.61	9.53	9.12	7.4	Dry	8.7	Dry	6.54	8.61	Dry	5.73	3.66
	Guideline[A]	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5

A NHMRC Australian Drinking Water Guidelines, 2016

Results shown in shading are in excess of the preliminary screening criteria

Table C5: Groundwater Data Down-Gradient of the Capped Waste Stockpile (Deep data)
Hydro Aluminium, Lot1 Hart Rd, Loxford

	Well ID	W1D	W2D	E5D	W3D	W4D	W5D	N2	G2	W6D	F5	F6
Jul-13	**Soluble Fluoride (mg/L)**	39.0	682.0	1.2	1.2	1.5	20.0	0.4	0.3	1.2	NS	NS
Nov-13		5.4	790.0	40.0	Dry	1.7	0.5	6.2	0.3	0.3	NS	NS
Feb-14		3.5	880.0	44.0	Dry	1.3	0.6	1.9	0.3	0.2	NS	NS
Jul-14		5.1	930.0	23.0	0.2	0.4	0.7	1.4	0.3	0.4	NS	NS
Nov-14		3.3	1080.0	12.0	0.4	1.6	0.5	0.7	0.3	0.2	NS	NS
Feb-15		Dry	1279.0	18.0	0.2	1.1	0.4	0.5	0.3	0.3	NS	NS
Jun-15		4.4	1300.0	16.0	0.3	Dry	Dry	8.1	0.3	0.1	NS	NS
Sep-15		3.5	1300.0	14.0	0.3	0.2	0.4	1.4	0.3	0.1	NS	NS
Dec-15		2.6	1300.0	16.0	Dry	Dry	0.5	1.4	0.3	Dry	NS	NS
Apr-16		<10	1300.0	19.0	Dry	Dry	<10	15.0	<10	<10	<10	<10
Jul-16		3.1	1400.0	18.0	Dry	Dry	0.5	8.6	0.3	0.2	<0.1	0.6
Oct-16		3.3	1500.0	15.0	Dry	<0.1	0.5	1.3	0.3	0.1	<0.1	0.5
Dec-16		3.4	1400.0	16.0	Dry	Dry	0.5	0.8	0.3	0.1	<0.1	0.5
Mar-17		3.9	1700.0	22.0	Dry	Dry	0.4	0.5	0.4	1.4	<0.1	0.5
	Guideline[A]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

A Site-specific assessment criteria derived for 'recreational' exposure (Environ, 2013).

Results shown in shading are in excess of the Tier 1 assessment criteria

	Well ID	W1D	W2D	E5D	W3D	W4D	W5D	N2	G2	W6D	F5	F6
Jul-13	**Free Cyanide (mg/L)**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nov-13		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Feb-14		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Jul-14		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nov-14		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Feb-15		Dry	0.03	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	NS	NS
Jun-15		<0.2	<4	<0.4	<0.004	Dry	Dry	<0.004	<0.004	Dry	NS	NS
Sep-15		<0.02	0.06	<0.02	<0.004	Dry	<0.004	<0.004	<0.02	<0.004	NS	NS
Dec-15		Dry	0.88	<0.004	Dry	Dry	<0.004	<0.004	<0.004	<0.004	NS	NS
Apr-16		<0.004	0.21	<0.004	Dry	Dry	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Jul-16		<0.004	0.11	<0.004	Dry	Dry	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Oct-16		<0.004	0.11	<0.004	Dry	Dry	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dec-16		<0.004	0.12	<0.004	Dry	Dry	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Mar-17		<0.004	0.15	<0.004	Dry	Dry	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
	Guideline[A]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	Guideline[B]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

A NHMRC Australian Drinking Water Guidelines, 2016

B NHMRC (2008) Guidelines for Managing Risks in Recreational Water. Application of a x10 factor to the health-based drinking water guideline.

Results shown in shading are in excess of the Tier 1 assessment criteria

Table C5: Groundwater Data Down-Gradient of the Capped Waste Stockpile (Deep data)
Hydro Aluminium, Lot1 Hart Rd, Loxford

	Well ID	W1D	W2D	E5D	W3D	W4D	W5D	N2	G2	W6D	F5	F6
Jul-13	**Total Aluminium (mg/L)**	21.2	2.9	1.7	0.7	0.8	0.3	5.8	0.1	1.1	NS	NS
Nov-13		0.9	0.6	1.5	Dry	0.5	0.0	3.0	0.1	0.1	NS	NS
Feb-14		2.4	0.7	110.0	Dry	0.2	0.0	4.6	0.0	0.0	NS	NS
Jul-14		2.4	1.4	2.2	0.6	0.3	0.0	4.5	1.2	1.2	NS	NS
Nov-14		0.3	44.0	3.3	0.7	0.5	0.1	6.7	2.1	0.5	NS	NS
Feb-15		0.3	0.0	3.4	0.8	0.4	0.2	28.0	2.9	0.1	NS	NS
Jun-15		4.0	0.2	2.1	0.8	Dry	Dry	3.4	2.0	0.2	NS	NS
Sep-15		1.0	0.0	2.1	0.0	Dry	1.0	2.4	4.1	0.7	NS	NS
Dec-15		0.4	3.5	4.3	Dry	Dry	0.5	9.1	1.8	Dry	NS	NS
Apr-16		1.5	0.1	3.6	Dry	Dry	0.4	24.0	9.6	0.1	2.2	0.6
Jul-16		0.7	0.1	2.7	Dry	Dry	0.2	3.2	1.2	0.1	2.1	0.7
Oct-16		0.9	0.9	1.9	Dry	Dry	0.1	3.7	1.6	0.2	0.9	0.2
Dec-16		18.0	31.0	4.2	Dry	Dry	0.1	5.9	1.2	Dry	2.3	0.1
Mar-17		89.0	1.0	64.0	Dry	Dry	0.0	23.0	1.2	1.1	2.3	0.3
	Guideline[A]	9	9	9	9	9	9	9	9	9	9	9

A Site-specific assessment criteria derived for 'recreational' exposure (Environ, 2013). Criteria is based on 'soluble' aluminium and therefore a conservative value when compared to 'to

Results shown in shading are in excess of the Tier 1 assessment criteria

	Well ID	W1D	W2D	E5D	W3D	W4D	W5D	N2	G2	W6D	F5	F6
Jul-13	**pH**	7.0	10.1	7.2	5.9	6.0	6.0	3.3	6.0	6.5	NS	NS
Nov-13		6.6	9.9	7.3	-	5.7	6.3	6.5	6.1	6.1	NS	NS
Feb-14		6.7	10.1	7.5	-	5.7	6.1	4.0	6.1	5.8	NS	NS
Jul-14		6.7	10.1	7.4	4.4	5.4	6.1	3.9	6.1	5.8	NS	NS
Nov-14		6.6	9.9	8.3	3.6	5.4	6.1	3.5	6.0	5.5	NS	NS
Feb-15		-	10.0	6.8	3.3	4.7	5.3	3.3	5.7	8.2	NS	NS
Jun-15		6.8	10.1	7.2	4.9	-	-	6.6	6.0	5.8	NS	NS
Sep-15		6.8	10.3	7.2	3.6	5.2	6.3	5.8	6.0	5.8	NS	NS
Dec-15		8.5	10.3	7.2	-	9.9	8.4	8.1	7.9	5.5	NS	NS
Apr-16		6.7	10.4	7.1	-	6.1	6.4	6.8	6.1	5.8	7.4	7.0
Jul-16		6.8	10.3	7.3	-	-	5.7	6.4	6.1	5.6	5.6	6.7
Oct-16		7.0	10.4	7.4	-	3.9	6.7	5.4	6.3	6.2	5.3	7.1
Dec-16		6.8	10.0	7.0	-	-	6.4	4.7	6.2	6.0	4.5	6.5
Mar-17		6.7	10.1	7.1	Dry	Dry	6.2	4.6	5.7	5.9	4.1	6.3
	Guideline[A]	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5

A NHMRC Australian Drinking Water Guidelines, 2016

Results shown in shading are in excess of the Tier 1 assessment criteria

		Sampling Location	Tier 1 Assessment Criteria	SW1	SW1	SW2	SW2	SW3	SW3	SW4	SW4	SW4	SW5	SW5
		Sampling Date		9/8/12	28/9/12	9/8/12	28/9/12	9/8/12	28/9/12	9/8/12	28/9/12	3/9/14	9/8/12	28/9/12
		Sample Appearance		Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Constituents	**Units**	**PQL**												
pH	-	-	6.5-8.5	7.3	7.9	7.3	7.5	7.9	7.3	8.1	7.2	7.09	8	7.3
Electrical Conductivity	µS/cm	-	300[C,D]	1100	1200	5300	1300	500	620	1100	1300	-	1200	1400
Soluble Fluoride	mg/L	0.1	15[E]	0.49	0.42	0.66	0.49	18	21	1.5	1.6	0.474	0.89	0.68
Total Cyanide	mg/L	0.004	8[A,B]	<0.004	0.76	<0.004	0.34	0.026	0.22	<0.004	0.23	-	<0.004	210
Free Cyanide	mg/L	0.004	8[A,B]	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-	<0.004	<0.004
Total Aluminium pH>6.5	mg/L	0.01	90[E]	0.11	0.31	0.16	0.15	2	1.7	0.27	0.37	-	0.24	0.2
Calcium	mg/L	0.5	-	26	34	26	32	9.5	13	24	30	-	23	32
Potassium	mg/L	0.5	-	14	17	15	15	3.7	4.3	12	13	-	11	13
Sodium	mg/L	0.5	180	200	210	210	230	99	120	200	240	-	190	260
Magnesium	mg/L	0.5	-	17	17	17	21	5.1	6.5	19	23	-	18	27
Hydroxide Alkalinity	mg/L	5	-	<5	<5	<5	<5	<5	<5	<5	<5	-	<5	<5
Bicarbonate Alkalinity	mg/L	5	-	120	130	140	120	81	64	130	120	-	110	120
Cabonate Alkalinity	mg/L	5	-	<5	<5	<5	<5	<5	<5	<5	<5	-	<5	<5
Total Alkalinity	mg/L	5	-	120	130	140	120	81	64	130	120	-	110	120
Sulphate	mg/L	1	250	82	91	85	95	42	63	84	110	-	90	120
Chloride	mg/L	1	250	210	250	220	260	63	94	210	270	-	230	310
Ionic Balance	mg/L	%	-	8.3	5.3	7.3	7.4	11	11	7	6.7	-	4.4	6

A NHMRC Australian Drinking Water Guidelines, 2011
B NHMRC (2008) Guidelines for Managing Risks in Recreational Water. Application of a x10 factor to the health-based drinking water guideline.
C Lowland Rivers in Slightly Disturbed Ecosystems, South-East Australia (ANZECC 2000)
D Higher conductivity may occur in areas with saline influence (ANZECC 2000)
E Site-specific assessment criteria for recreational receptors (Environ, 2013).
Results shown in shading are in excess of the Tier 1 assessment criteria

Table C6: Surface Water Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

Sampling Location			Tier 1 Assessment Criteria	SW5	SW6	SW6	SW7	SW7	SW8	DZ1	DZ2
Sampling Date				8/6/16	9/8/12	28/9/12	9/8/12	28/9/12	17/8/12	15/8/12	15/8/12
Sample Appearance				Clear	Clear	Clear	Clear	Clear	Brown	Brown	Brown
Constituents	**Units**	**PQL**									
pH	-	-	6.5-8.5	7.63	8	7.2	6.7	5.9	9.1	9.7	8.8
Electrical Conductivity	µS/cm	-	300[C,D]	-	1300	1200	1500	2600	5400	15000	1900
Soluble Fluoride	mg/L	0.1	15[E]	0.462	1.2	0.59	3.7	3.5	91	350	45
Total Cyanide	mg/L	0.004	8[A,B]	-	<0.004	0.16	0.026	0.16	8.3	33	3.9
Free Cyanide	mg/L	0.004	8[A,B]	-	<0.004	<0.004	0.007	<0.004	0.034	6.1	<0.004
Total Aluminium pH>6.5	mg/L	0.01	90[E]	-	0.59	1.7	150	1.1	9.5	0.75	48
Calcium	mg/L	0.5	-	-	27	28	15	29	12	5.6	1
Potassium	mg/L	0.5	-	-	9.2	9.6	6.3	7.8	11	12	9.6
Sodium	mg/L	0.5	180	-	200	210	230	460	1700	5200	600
Magnesium	mg/L	0.5	-	-	23	26	30	68	8.9	5.6	4.7
Hydroxide Alkalinity	mg/L	5	-	-	<5	<5	<5	<5	<5	<5	<5
Bicarbonate Alkalinity	mg/L	5	-	-	120	99	19	18	1600	2900	840
Cabonate Alkalinity	mg/L	5	-	-	<5	<5	<5	<5	550	4000	<5
Total Alkalinity	mg/L	5	-	-	120	99	19	18	2200	6900	840
Sulphate	mg/L	1	250	-	100	110	43	150	480	2600	140
Chloride	mg/L	1	250	-	230	250	400	740	110	280	72
Ionic Balance	mg/L	%	-	-	5.4	7	2.9	5.7	15	6.5	9.9

A NHMRC Australian Drinking Water Guidelines, 2011

B NHMRC (2008) Guidelines for Managing Risks in Recreational Water. Appli

C Lowland Rivers in Slightly Disturbed Ecosystems, South-East Australia (AN

D Higher conductivity may occur in areas with saline influence (ANZECC 200

E Site-specific assessment criteria for recreational receptors (Environ, 2013).

Results shown in shading are in excess of the Tier 1 assessment criteria

Sample Identification	Unit	PQL	Tier 1 Assessment Criteria[A,B]	S1	S2	S3	S4	S5	S6
Date				25/3/13	25/3/13	25/3/13	25/3/13	25/3/13	25/3/13
Depth to Water (mAHD)				Surface	Surface	Surface	Surface	Surface	Surface
Sample Appearance				sl turbid	sl turbid	sl turbid	sl turbid	sl turbid/black	sl turbid
Sample collected by				SC	SC	SC	SC	SC	SC
Analytes									
pH	-	-	6.5-8.5	6.18	6.01	6.41	6.92	5.81	6.11
Redox Potential	mV	-	-	105	25	-13	-98	-104	74
Dissolved Oxygen	mg/L	-	-	1.6	0.7	0.65	0.74	0.6	2.45
Temperature	°C	-	-	26	24.6	27.7	24	27.2	30.4
Electrical Conductivity	µS/cm	-	300[C,D]	500	533	846	1074	340	349
Soluble Fluoride	mg/L	0.1	15[E]	2.6	2.8	4.9	6.3	1.5	0.9
Dissolved Aluminium	mg/L	0.01	90[E]	0.25	0.26	0.29	0.25	0.32	0.07
total Nitrogen	mg/L	-		8.5	7.2	9	12	5.6	6.9
total Phosphorus	mg/L	-		1.02	0.78	1.29	1.37	0.96	1.16

A NHMRC Australian Drinking Water Guidelines, 2016

B NHMRC (2008) Guidelines for Managing Risks in Recreational Water. Application of a x10 factor to the health-based drinking water guideline.

C Lowland Rivers in Slightly Disturbed Ecosystems, South-East Australia (ANZECC 2000)

D higher conductivity may occur in areas with saline influence (ANZECC 2000)

E Site-specific assessment criteria for recreational receptors (Environ, 2013).

Results shown in shading are in excess of the preliminary screening criteria

Table C8: Identification of Asbestos in CWS Soil Sample December 2015

Hydro Aluminium, Lot1 Hart Rd, Loxford

Sample Location	Depth (m)	Asbestos Detected	Asbestos Type	Sample dry weight (g)	Description
MW201	3.0	No	-	60.3	Mid red - brown clay soil with slag debris.
MW201	6.0	Yes	Amosite	58.2	Dark grey soil with several loose bundles of friable asbestos fibres approx 2 x 1 x 0.5 mm.
MW201	9.0	Yes + Trace	Amosite	47.7	Mid grey sandy soil with slag debris and several loose bundles of friable asbestos fibres approx 2 x 1 x 0.5 mm.
MW202	2.0	No	Amosite	74	Dark grey soil with soil debris.
MW202	6.5	Yes	Amosite	60.5	Mid grey - brown clay soil with several bundles of friable asbestos fibres approx 2 x 1 x 1 mm.
MW202	9.8	Yes	Amosite	37.4	Mid grey - brown clay soil with several bundles of friable asbestos fibres approx 2 x 1 x 1 mm.
MW203	2.5	No	-	16.2	Mid brown clay soil with grey rocks.
MW203	7.0	Yes	Chyrsotile + Amosite	70.8	Dark grey soil with several loose bundles of friable asbestos fibres approx 3 x 1 x 0.5 mm.
MW203	9.0	Yes	Amosite	72.4	Dark grey soil with several loose bundles of friable asbestos fibres approx 3 x 1 x 0.5 mm.
MW204	2.5	No	-	42.9	Dark grey soil with slag debris.
MW204	6.0	No	-	36.4	Dark grey soil with slag debris.
MW204	9.0	No	-	51.8	Dark grey soil with slag debris.
MW205	5.5	No	-	60.9	Dark grey soil with slag debris.
MW205	9.0	No	-	60.2	Dark grey soil with slag debris.
MW205	11.3	No	-	55.8	Dark grey soil with slag debris.
MW206	3.0	No	-	57.6	Dark grey soil with slag debris.
MW206	7.0	No	-	49	Mid grey clay soil with slag debris.
MW206	11.0	No	-	48	Dark grey soil with slag debris.

Table C9: Capped Waste Stockpile Gas Vent Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

Ammonia (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	12-Feb-96	04-Jul-96	18-Oct-96	07-Jan-97	09-Apr-97	22-Jul-97	11-Nov-97	17-Feb-98	02-Dec-98	03-Jul-99	06-Apr-00	22-Mar-01	12-Feb-02	23-Jun-03
VT1	-	-	-	140	110	110	-	-	-	-	40	350	20	400
VT2	-	-	9	-	10	-	160	-	2	-	25	280	9	270
VT3	-	0.3	-	-	1	-	0.5	-	13	1.5	1	3	0.5	3
VT4	-	-	-	<0.2	8	0.2	-	-	-	<0.2	1	10	1	5.5
VT5	-	60	-	-	90	-	210	-	40	410	35	1000	60	760
VT6	-	800	-	-	450	1000	-	-	50	1500	85	1500	130	1500
VT7	-	-	-	3000	3500	-	-	220	110	-	140	2500	70	360
VT8	-	-	<0.2	-	1	-	0.5	-	-	<0.2	1	3	0.5	1.5
VT9	-	-	-	5	1	-	-	1	-	1	0.5	9	0.5	4.5
VT10	-	-	<0.2	-	0.5	-	-	<0.2	-	-	0.5	<0.1	<0.1	<0.1
VT11	-	-	<0.2	-	0.5	<0.2	-	-	2	-	1.5	1.5	1.5	0.8
VT12	-	<1	-	-	<0.1	-	-	<0.2	-	<0.2	0.2	1	<0.1	<0.1

Phosphine/Arsine (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	12-Feb-96	04-Jul-96	18-Oct-96	07-Jan-97	09-Apr-97	22-Jul-97	11-Nov-97	17-Feb-98	02-Dec-98	03-Jul-98	06-Apr-00	22-Mar-01	12-Feb-02	23-Jun-03
VT1	-	-	-	<0.1	<0.1	<0.1	-	-	-	-	<0.1	<0.1	<0.1	<0.1
VT2	-	-	<0.1	-	<0.1	-	<0.1	-	<0.1	-	<0.1	<0.1	<0.1	<0.1
VT3	-	<0.1	-	-	<0.1	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
VT4	-	-	-	<0.1	<0.1	<0.1	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1
VT5	-	<0.1	-	-	<0.1	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
VT6	-	<0.1	-	-	<0.1	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
VT7	-	-	-	<0.1	<0.1	-	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1
VT8	-	-	<0.1	-	<0.1	-	<0.1	-	-	<0.1	<0.1	<0.1	<0.1	<0.1
VT9	-	-	-	<0.1	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1
VT10	-	-	<0.1	-	<0.1	-	-	<0.1	-	-	<0.1	<0.1	<0.1	<0.1
VT11	-	-	<0.1	-	<0.1	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	<0.1
VT12	-	<0.1	-	-	<0.1	-	-	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1

Table C9: Capped Waste Stockpile Gas Vent Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

HCN (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	12-Feb-96	04-Jul-96	18-Oct-96	07-Jan-97	09-Apr-97	22-Jul-97	11-Nov-97	17-Feb-98	02-Dec-98	03-Jul-98	06-Apr-00	22-Mar-01	12-Feb-02	23-Jun-03
VT1	-	-	-	<1	<1	<1	-	-	-	-	<1	<1	<1	<1
VT2	-	-	<2	-	<1	-	<1	-	<1	-	<1	<1	<1	<1
VT3	-	<2	-	-	<1	-	<1	-	<1	<1	<1	<1	<1	<1
VT4	-	-	-	<1	<1	<1	-	-	-	<1	<1	<1	<1	<1
VT5	-	<2	-	-	<1	-	<1	-	<1	<1	<1	<1	<1	<1
VT6	-	<2	-	-	<1	<1	-	-	<1	<1	<1	<1	<1	<1
VT7	-	-	-	<1	<1	-	-	<1	<1	-	<1	<1	<1	<1
VT8	-	-	<2	-	<1	-	<1	-	-	<1	<1	<1	<1	<1
VT9	-	-	-	<1	<1	-	-	<1	-	<1	<1	<1	<1	<1
VT10	-	-	<2	-	<1	-	-	<1	-	-	<1	<1	<1	<1
VT11	-	-	<2	-	<1	<1	-	-	<1	-	<1	<1	<1	<1
VT12	-	<2	-	-	<1	-	-	<1	-	<1	<1	<1	<1	<1

H_2S (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	12-Feb-96	04-Jul-96	18-Oct-96	07-Jan-97	09-Apr-97	22-Jul-97	11-Nov-97	17-Feb-98	02-Dec-98	03-Jul-98	06-Apr-00	22-Mar-01	12-Feb-02	23-Jun-03
VT1	-	-	-	<1	<1	<1	-	-	-	-	<1	<1	<1	<1
VT2	-	-	<1	-	<1	-	<1	-	<1	-	<1	<1	<1	<1
VT3	-	<1	-	-	<1	-	<1	-	<1	<1	<1	<1	<1	<1
VT4	-	-	-	<1	<1	<1	-	-	-	<1	<1	<1	<1	<1
VT5	-	<1	-	-	<1	-	<1	-	<1	<1	<1	<1	<1	<1
VT6	-	<1	-	-	<1	<1	-	-	<1	<1	<1	<1	<1	<1
VT7	-	-	-	<1	<1	-	-	<1	<1	-	<1	<1	<1	<1
VT8	-	-	<1	-	<1	-	<1	-	-	<1	<1	<1	<1	<1
VT9	-	-	-	<1	<1	-	-	<1	-	<1	<1	<1	<1	<1
VT10	-	-	<1	-	<1	-	-	<1	-	-	<1	<1	<1	<1
VT11	-	-	<1	-	<1	<1	-	-	<1	-	<1	<1	<1	<1
VT12	-	<1	-	-	<1	-	-	<1	-	<1	<1	<1	<1	<1

Table C9: Capped Waste Stockpile Gas Vent Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

Methane %	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	12-Feb-96	04-Jul-96	18-Oct-96	07-Jan-97	09-Apr-97	22-Jul-97	11-Nov-97	17-Feb-98	02-Dec-98	03-Jul-98	06-Apr-00	22-Mar-01	12-Feb-02	23-Jun-03
VT1	5.8	-	-	4.4	3.2	0.94	-	-	-	1.1	0.09	0.81	<0.01	0.47
VT2	0.7	-	1.95	-	0.28	-	2.8	-	<0.01	0.29	<0.01	0.76	<0.01	0.51
VT3	5.6	0.36	-	-	0.45	-	1.75	-	<0.01	0.07	<0.01	0.26	<0.01	0.21
VT4	5	-	-	4.4	2.4	<0.01	-	-	-	0.47	<0.01	0.59	<0.01	0.03
VT5	6.4	3.8	-	-	1.75	-	3.7	-	<0.01	0.99	0.02	1.2	<0.01	0.59
VT6	5.4	2.9	-	-	1.55	0.27	-	-	<0.01	0.99	0.03	0.92	<0.01	0.8
VT7	6.1	-	-	2.85	5	-	-	0.03	<0.01	2.3	<0.01	1.55	<0.01	0.09
VT8	2.55	-	0.14	-	0.05	-	1.8	-	-	0.43	<0.01	0.15	<0.01	0.02
VT9	3.6	-	-	3.9	<0.01	-	-	<0.01	-	0.12	<0.01	0.19	<0.01	0.19
VT10	2.3	-	0.11	-	0.24	-	-	<0.01	-	0.12	<0.01	0.04	<0.01	<0.01
VT11	0.56	-	<0.01	-	<0.01	1.95	-	-	<0.01	0.02	<0.01	<0.01	<0.01	0.02
VT12	0.56	0.05	-	-	<0.01	-	-	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01

Hydrogen %	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	12-Feb-96	04-Jul-96	18-Oct-96	07-Jan-97	09-Apr-97	22-Jul-97	11-Nov-97	17-Feb-98	02-Dec-98	03-Jul-98	06-Apr-00	22-Mar-01	12-Feb-02	23-Jun-03
VT1	1.7	-	-	0.08	0.53	0.3	-	-	-	0.48	0.17	0.44	<0.001	0.52
VT2	0.54	-	0.04	-	0.011	-	0.44	-	<0.001	0.17	0.12	0.28	<0.001	0.55
VT3	0.008	0.041	-	-	0.054	-	0.012	-	<0.001	0.029	<0.01	0.003	<0.001	0.024
VT4	0.43	-	-	0.08	<0.001	<0.001	-	-	-	<0.001	<0.01	0.005	<0.001	0.003
VT5	4.2	2	-	-	0.29	-	2.3	-	<0.001	1.2	0.11	1.1	<0.001	0.67
VT6	1.8	1.2	-	-	0.26	<0.001	-	-	<0.001	0.96	0.12	0.84	<0.001	1.2
VT7	3.1	-	-	0.1	0.51	-	-	0.024	<0.001	1.8	0.002	1.7	0.42	0.43
VT8	0.019	-	<0.001	-	<0.001	-	0.002	-	-	<0.001	<0.01	0.024	<0.001	0.02
VT9	1.8	-	-	0.01	<0.001	-	-	<0.001	-	<0.001	<0.01	0.002	<0.001	0.003
VT10	<0.001	-	<0.001	-	0.091	-	-	<0.001	-	0.12	<0.01	<0.001	<0.001	<0.001
VT11	<0.001	-	<0.001	-	<0.001	0.19	-	-	<0.001	0.001	<0.01	<0.001	<0.001	<0.001
VT12	<0.001	<0.001	-	-	<1	-	-	<0.001	-	0.001	<0.01	<0.001	<0.001	0.004

"-" means not sampled or analysed

Ammonia (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	23-Jun-04	31-Mar-05	30-Mar-06	22-Jun-07	14-Aug-08	11-Nov-09	24-Nov-10	07-Dec-11	12-Jul-12	16-Dec-16	13-Jan-17	27-Jan-17	24-Feb-17	31-Mar-17	28-Apr-17
VT1	1000	1000	200	20	50	60	160	20	30	-	-	-	150	72	<50
VT2	700	500	100	10	110	10	40	4	40	-	-	-	50	20	<50
VT3	0.7	12	8	<0.1	<0.1	<0.1	2	<1	<1	-	-	-	25	5	<50
VT4	20	60	60	<0.1	22	8	180	500	50	-	-	-	100	80	75
VT5	1600	2000	1000	30	140	400	1000	500	1000	-	-	-	600	10	<50
VT6	2000	2000	1500	30	20	6	500	12	>260<500	-	-	-	300	80	<50
VT7	5500	4000	2700	40	160	220	1000	40	1500	-	-	-	>900	>900	280
VT8	1	20	30	1	2	<0.1	5	1	<1	-	-	-	50	<50	<50
VT9	19	60	40	1	3	<0.1	80	1	14	-	-	-	0	40	<50
VT10	<0.1	<0.1	2	<0.1	1	<0.1	6	<1	<1	-	-	-	<50	120	<50
VT11	1	6	14	<0.1	<0.1	<0.1	14	1	4	-	-	-	<50	20	<50
VT12	<0.1	4	4	<0.1	<0.1	<0.1	4	<1	4	-	-	-	0	25	<50

Phosphine/Arsine (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	23-Jun-04	31-Mar-05	30-Mar-06	22-Jun-07	14-Aug-08	11-Nov-09	24-Nov-10	07-Dec-11	12-Jul-12	16-Dec-16	13-Jan-17	27-Jan-17	24-Feb-17	31-Mar-17	28-Apr-17
VT1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-
VT12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-

Table C9: Capped Waste Stockpile Gas Vent Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

HCN (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	23-Jun-04	31-Mar-05	30-Mar-06	22-Jun-07	14-Aug-08	11-Nov-09	24-Nov-10	07-Dec-11	12-Jul-12	16-Dec-16	13-Jan-17	27-Jan-17	24-Feb-17	31-Mar-17	28-Apr-17
VT1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT2	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT3	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT4	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT5	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT6	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT7	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT8	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT9	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT10	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT11	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-
VT12	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-

H2S (ppm)	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	23-Jun-04	31-Mar-05	30-Mar-06	22-Jun-07	14-Aug-08	11-Nov-09	24-Nov-10	07-Dec-11	12-Jul-12	16-Dec-16	13-Jan-17	27-Jan-17	24-Feb-17	31-Mar-17	28-Apr-17
VT1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	3	0	3	7	4
VT2	<1	<1	<1	<1	<1	<1	<1	<1	<1	5	0	0	1	8	3
VT3	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	0	1	1	0	0
VT4	<1	<1	<1	<1	<1	<1	<1	<1	<1	10	7	4	6	12	11
VT5	<1	<1	<1	<1	<1	<1	<1	<1	<1	200	0	152	44	26	74
VT6	<1	<1	<1	<1	<1	<1	<1	<1	<1	87	11	37	15	32	40
VT7	<1	<1	<1	<1	<1	<1	<1	<1	<1	106	38	47	25	57	32
VT8	<1	<1	<1	<1	<1	<1	<1	<1	<1	13	0	0	1		2
VT9	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	0	0	0	0	0
VT10	<1	<1	<1	<1	<1	<1	<1	<1	<1	12	0	2	0	5	0
VT11	<1	<1	<1	<1	<1	<1	<1	<1	<1	4	0	0	0	1	0
VT12	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	0	0	0	0	0

Table C9: Capped Waste Stockpile Gas Vent Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

Methane %	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	23-Jun-04	31-Mar-05	30-Mar-06	22-Jun-07	14-Aug-08	11-Nov-09	24-Nov-10	07-Dec-11	12-Jul-12	16-Dec-16	13-Jan-17	27-Jan-17	24-Feb-17	31-Mar-17	28-Apr-17
VT1	0.29	0.23	0.03	<0.01	0.17	0.02	<0.01	<0.01	0.03	0.1	0	0	0	0	0.1
VT2	0.69	0.29	0.08	<0.01	0.25	0.03	0.04	<0.01	0.04	0	0	0	0	0	0.1
VT3	0.12	0.07	0.05	<0.01	0.13	0.02	0.04	<0.01	0.02	-	0	0	0	0	0
VT4	0.78	0.2	0.04	<0.01	0.38	0.18	0.26	<0.01	0.08	0	0	0	0	0	0.1
VT5	0.93	0.68	0.56	<0.01	0.46	0.35	0.12	<0.01	0.2	0.3	0	0.2	0.1	0	0.1
VT6	0.86	0.72	0.57	<0.01	0.37	0.14	0.06	<0.01	0.21	0.3	0.1	0.1	0	0	0.2
VT7	1.15	0.82	0.05	<0.01	0.39	0.16	0.22	<0.01	<0.01	0.2	0	0.1	0	0	0.1
VT8	0.06	0.04	<0.01	<0.01	<0.01	<0.001	0.03	<0.01	<0.01	0	0	0	0		0
VT9	0.61	0.25	0.19	<0.01	0.34	0.16	0.09	<0.01	0.1	-	0	1	0	0	0
VT10	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.11	0	0	3	0	0	0
VT11	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	2	0	0	0	0	0
VT12	<0.01	0.04	<0.01	<0.01	0.09	<0.01	0.18	<0.01	<0.01	0	0	0	0	0	0

Hydrogen %	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Standpipe Number	23-Jun-04	31-Mar-05	30-Mar-06	22-Jun-07	14-Aug-08	11-Nov-09	24-Nov-10	07-Dec-11	12-Jul-12	16-Dec-16	13-Jan-17	27-Jan-17	24-Feb-17	31-Mar-17	28-Apr-17
VT1	0.49	0.2	0.013	<0.001	0.14	0.007	<0.001	<0.001	0.0425	-	-	-	-	-	-
VT2	2	0.23	0.018	<0.001	0.33	<0.001	<0.001	<0.001	0.018	-	-	-	-	-	-
VT3	0.004	<0.001	<0.001	<0.001	0.06	<0.001	<0.001	<0.001	<1	-	-	-	-	-	-
VT4	<0.001	0.002	<0.001	<0.001	0.28	0.016	0.037	0.0005	0.072	-	-	-	-	-	-
VT5	3.8	2.3	1.6	<0.001	1.7	0.12	0.36	<0.001	0.8635	-	-	-	-	-	-
VT6	1.9	0.91	0.72	<0.001	0.14	0.6	0.1	<0.001	0.491	-	-	-	-	-	-
VT7	2.8	1.3	0.49	<0.001	0.6	0.3	<0.001	<0.001	<0.001	-	-	-	-	-	-
VT8	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-	-	-
VT9	0.082	0.011	0.033	<0.001	0.19	0.013	0.007	<0.001	0.015	-	-	-	-	-	-
VT10	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-	-	-
VT11	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-	-	-
VT12	0.099	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-	-	-

"-" means not sampled or analysed

Table C10: Capped Waste Stockpile Monitoring Well Gas Data
Hydro Aluminium, Lot1 Hart Rd, Loxford

Well ID	Date	Water Level mTOC	Start Time	Temp	Flow (L/hr)	H_2S (ppm)	CO (ppm)	CH_4 (%v/v)	CO_2 (%v/v)	Min O_2 (%v/v)	H_2S (ppm)	CO (ppm)	CH_4 (%v/v)	CO_2 (%v/v)	Min O_2 (%v/v)	Balance	Ammonia (ppm)
MW201	16/12/2016	DRY	13:41	30.2	0	353	368	0.5	0	0.1	353	368	0.5	0	0.1	99.4	NS
	13/01/2017	DRY	10:16	28.2	0	222	409	0.4	0.1	3.4	222	409	0.4	0	3.5	96.1	NS
	27/01/2017	DRY	11:10	24.2	0.1	259	420	0.4	0.1	1.3	259	420	0.4	0	1.3	98.3	NS
	24/02/2017	DRY	10:21	28.2	0	445	1402	0.5	0	0.8	445	1402	0.5	0	0.8	98.7	>900
	31/03/2017	DRY	13:00	23.8	0	251	315	0.5	0.1	0.6	251	315	0.5	0	0.6	98.9	>900
	28/04/2017	DRY	12:40	22.7	0.2	207	253	0.6	0.1	0.5	207	253	0.6	0	0.5	98.9	>900
MW202	16/12/2016	12.77	13:35	32.2	0.1	16	4	0	0	17.6	16	4	0	0	18.5	81.5	NS
	13/01/2017	12.75	10:23	30.3	-0.1	18	16	0.1	0.1	12	18	16	0	0.1	19.4	80.5	NS
	27/01/2017	12.76	11:17	25.3	-0.5	42	16	0.4	0.1	6.7	42	16	0	0.1	18.6	81.3	NS
	24/02/2017	12.88	10:59	27.1	0.4	72	90	0.1	0.4	12.6	72	90	0.1	0.4	12.7	86.8	100
	31/03/2017	12.78	13:10	23.3	0	51	26	0.1	0.4	14.4	51	26	0.1	0.4	14.8	84.7	100
	28/04/2017	12.83	12:35	20.4	1.9	53	45	0.2	0.6	9	53	45	0.2	0.6	9	90.2	150
MW203	16/12/2016	12.35	13:29	31.7	0	21	1	0	0	16.5	21	1	0	0	19	81	Ns
	13/01/2017	12.37	10:56	30.4	0	5	9	0	0.1	20.4	5	9	0	0.1	20.6	79.3	NS
	27/01/2017	12.40	11:41	24.7	2.5	7	21	0	0.2	19.4	7	21	0	0.2	20.3	79.5	NS
	24/02/2017	12.47	10:49	26.8	2.6	19	14	0	0.2	20.4	19	14	0	0.2	20.5	79.3	75
	31/03/2017	12.44	13:22	22.8	1.6	9	6	0	0.8	18.9	9	6	0	0.8	18.9	80.3	190
	28/04/2017	12.50	12:29	18.8	2.6	6	5	0	0.7	18.9	6	5	0	0.7	18.9	80.4	75
MW204	16/12/2016	13.06	13:20	30.5	0	210	317	0.2	0.1	2.5	210	317	0.2	0.1	3.7	96	NS
	13/01/2017	13.02	10:49	29.2	0	7	14	0	0.1	19.3	7	14	0	0.1	19.9	80	NS
	27/01/2017	13.04	11:35	25.2	0.1	11	23	0	0.4	17.2	11	23	0	0.4	17.2	82.4	NS
	24/02/2017	13.16	10:39	26.9	0.1	54	14	0	0.3	13.5	54	14	0	0.3	17.5	82.2	75
	31/03/2017	13.05	13:30	24.3	0	4	7	0	0.1	21.2	4	7	0	0.1	21.2	78.7	25
	28/04/2017	13.10	12:22	26.9	0.2	8	4	0.2	1.2	11.7	8	4	0.2	1.2	11.7	86.9	50
MW205	16/12/2016	13.14	13:14	28.3	0.1	15	3	0	0	18.8	15	3	0	0	19.3	89.7	NS
	13/01/2017	13.16	10:43	29.3	0	10	18	0	0.1	19.1	10	18	0	0.1	20.1	79.8	NS
	27/01/2017	13.16	11:29	25.5	-1.4	27	15	0	0.2	12.9	27	15	0	0.2	19	80.8	NS
	24/02/2017	13.26	11:22	28.2	3.3	47	45	0	0	15.6	47	45	0	0.3	17.5	82.2	180
	31/03/2017	13.20	13:40	23.6	1.6	12	9	0	0.2	19.8	12	9	0	0.2	19.8	80	60
	28/04/2017	13.21	12:17	25.1	1.7	28	19	0	0.2	17.6	28	19	0	0.2	17.6	82.2	125
MW206	16/12/2016	13.22	13:00	30.6	0	149	202	0.1	0	4.2	149	202	0.1	0	4.2	95.7	NS
	13/01/2017	13.25	10:36	27.7	0	65	52	0.1	0.1	8.8	65	52	0	0	12.3	87.7	NS
	27/01/2017	13.33	11:23	25.7	-0.2	179	250	0.1	0.1	0.4	179	250	0.1	0	0.6	99.3	NS
	24/02/2017	13.53	11:11	27.6	0	185	172	0.1	0	4.9	185	172	0.1	0	4.9	95	>900
	31/03/2017	13.35	13:53	22.6	0	2	4	0	0.1	21.5	2	4	0	0.1	21.6	78.3	50
	28/04/2017	13.24	12:12	26.6	0.3	19	2	0	0.1	20.8	19	2	0	0.1	21.9	78	200

Table C11: Capped Waste Stockpile Vapour Well Gas Data

Hydro Aluminium, Lot1 Hart Rd, Loxford

Well ID	Date	Start Time	Temp	Flow (L/hr)	H2S (ppm)	CO (ppm)	CH4 (%v/v)	CO2 (%v/v)	Min O2 (%v/v)	H2S (ppm)	CO (ppm)	CH4 (%v/v)	CO2 (%v/v)	Min O2 (%v/v)	Balance	Ammonia (ppm)
VW01	16/12/2016	12:50	26.3	0.1	14	2	1.4	0.5	0	14	2	1.4	0.5	0	98.1	NS
	13/01/2017	8:51	28.5	0	3	3	1.3	0.8	0.1	3	3	1.3	0.7	0.1	97.9	NS
	27/01/2017	10:22	22.3	0	14	3	1.2	0.7	0.1	14	3	1.2	0.7	0.1	98	NS
	24/02/2017	9:30	24.8	0	2	1	1	0.7	0.3	2	1	0.9	0.7	0.3	98.1	50
	31/03/2017	14:58	23.1	0.1	10	7	1.1	0.8	0	10	7	1.1	0.8	0	98.1	<50
	28/04/2017	11:20	20.4	0.3	1	1	1.2	0.7	0.1	1	1	1.2	0.7	0.1	98	50
VW02	16/12/2016	12:42	27.1	0.1	107	132	0.6	0	0.1	107	133	0.5	0	0.1	99.4	NS
	13/01/2017	9:06	28.5	0.1	96	62	0.6	0.1	0.1	96	62	0.6	0	0.1	99.3	NS
	27/01/2017	10:28	23.1	0	71	71	0.6	0.3	0.1	71	71	0.6	0	0.1	99.3	NS
	24/02/2017	9:37	25.4	0	85	83	0.6	0.4	0.1	85	83	0.6	0	0.1	99.3	100
	31/03/2017	14:49	23.7	0	76	91	0.6	0.4	0	76	91	0.6	0	0	99.4	40
	28/04/2017	11:27	21.7	0	51	299	0.5	0.1	0.1	51	299	0.5	0	0.1	99.4	50
VW03	16/12/2016	12:35	26.2	0	85	86	0.7	0.4	0.1	85	86	0.7	0	0.1	99.2	NS
	13/01/2017	8:55	27.9	0	75	45	0.7	0.5	0.1	75	45	0.7	0	0.1	99.2	NS
	27/01/2017	10:57	23.9	0	74	52	0.7	0.2	0.1	74	52	0.7	0	0.1	99.2	NS
	24/02/2017	9:44	26.5	0.1	82	68	0.6	0.2	0.1	82	68	0.6	0	0.1	99.3	500
	31/03/2017	14:38	22.6	0	70	61	0.7	1.1	0.1	70	61	0.7	0.1	0.1	99.1	25
	28/04/2017	11:35	17.8	0.1	54	260	0.7	0.5	0	54	260	0.7	0	0	99.3	120
VW04	16/12/2016	12:23	26.4	0.1	212	231	0.4	0	0.1	212	231	0.4	0	0.1	99.5	NS
	13/01/2017	9:25	28.1	0	217	326	0.4	0.1	0.1	217	326	0.4	0.1	0.1	99.4	NS
	27/01/2017	10:51	23.9	0	181	256	0.3	0.1	0.2	181	256	0.3	0.1	0.2	99.4	NS
	24/02/2017	9:51	27.4	0	255	513	0.2	0.1	0.5	255	513	0.2	0	0.5	99.3	150
	31/03/2017	14:27	23.4	0	213	284	0.3	0.1	0	213	284	0.3	0.1	0	99.6	275
	28/04/2017	11:45	21.1	0.1	216	506	0.4	0.1	0	216	506	0.4	0.1	0	99.5	280
VW05	16/12/2016	12:13	24.8	0.1	293	310	0.3	0.1	0.1	293	310	0.3	0	0.1	99.6	Ns
	13/01/2017	9:21	31.8	0	296	428	0.3	0.1	0	296	428	0.3	0	0	99.7	NS
	27/01/2017	10:45	23.6	0.1	254	395	0.2	0.1	0.1	254	395	0.2	0	0.1	99.7	NS
	24/02/2017	10:00	29.2	0.1	311	1227	0.1	0	0.3	311	1227	0	0	0.3	99.7	>900
	31/03/2017	14:16	25.5	0.2	277	447	0.3	0.1	0.1	277	447	0.3	0	0.1	99.6	>900
	28/04/2017	11:52	20.4	0.1	32.5	273	0.3	0	0	325	273	0.3	0	0	99.7	>900
VW06	16/12/2016	12:05	24.8	0.1	205	163	0.2	0.2	0.6	205	163	0.2	0	1	98.8	NS
	13/01/2017	9:12	30.3	0.1	202	253	0.2	0.2	0.3	202	253	0.2	0	1.4	98.4	NS
	27/01/2017	10:34	23.6	0	166	236	0.2	0.1	0.5	166	236	0.2	0	2	97.8	NS
	24/02/2017	10:09	28.7	0	320	980	0.1	0.1	0.8	320	980	0.1	0	2.6	97.3	>900
	31/03/2017	14:02	23	0.1	187	253	0.2	0.2	0.2	187	253	0.2	0	0.3	99.5	300
	28/04/2017	12:00	22.6	0.1	258	65	0.3	0.1	0	258	65	0.2	0	0	99.8	>900

Table C12: Maximum Predicted Acute Particulate and Vapour Data - Onsite

Hydro Aluminium, Lot1 Hart Rd, Loxford

Compound	Unit	Tier 1 Screening Criteria	Tier 1 Screening Criteria Source	Averaging Period	Maximum Predicted Acute Onsite Concentration For CWS Workers
TSP	$\mu g/m^3$	90	NHMRC	Annual	10.41
PM10	$\mu g/m^3$	50	NEPC	24 hours	5.68
PM2.5	$\mu g/m^3$	25	NEPC	24 hours	3.88
SO_2	$\mu g/m^3$	570	NEPC	1 hour	0.04
NO_2	$\mu g/m^3$	246	NEPC	1 hour	69.43
CO	$\mu g/m^3$	30000	NSW EPA	1 hour	28.70
Hydrogen Sulfide	$\mu g/m^3$	2.76**	NSW EPA	1 second	1.14
Ammonia	$\mu g/m^3$	330	NSW EPA	1 hour	2.17
Arsenic	$\mu g/m^3$	0.09	NSW EPA	1 hour	2.87E-05
Cyanide	$\mu g/m^3$	90	NSW EPA	1 hour	5.43E-04
Lead	$\mu g/m^3$	0.5	NEPC	Annual	6.06E-04
Fluoride	$\mu g/m^3$	1	WHO (2000)	Chronic	0.32
Benzene	$\mu g/m^3$	29	NSW EPA	1 hour	0.04
Toluene	$\mu g/m^3$	360	NSW EPA	1 hour	0.08
Ethylbenzene	$\mu g/m^3$	8000	NSW EPA	1 hour	0.02
Xylenes	$\mu g/m^3$	190	NSW EPA	1 hour	0.11
Naphthalene	$\mu g/m^3$	2100*	ATSDR	Acute	5.28E-06
Phenol	$\mu g/m^3$	20	NSW EPA	1 hour	5.87E-05
PAH (BaP)	$\mu g/m^3$	0.4	NSW EPA	1 hour	1.01E-03

Notes:

NSW EPA (2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Department of Environment and Conservation (NSW)

NEPC (2015) Variation to the National Environment Protection (Ambient Air Quality) Measure, National Environmental Protection Council

WHO (2000) Air Quality Guidelines for Europe, 2nd Edition, 2000. World Health Organization Regional Publications, European Series, No. 91.

ATSDR: Agency for Toxic Substances & Disease Registry. Minimal Risk Levels (MRLs) adopted. MRL values converted from ppm to $\mu g/m^3$ using (((ppm x molecular weight)/24.45)x1000)

RAIS: US EPA Risk Assessment Information System. In absence of available Tier 1 screening criteria (reference concentration), toxicity value for the compound was adopted.

*Value was converted from a reference dose (RfD, mg/kg/day) to a reference concentration (RfC, $\mu g/m^3$) using RfC = ((RfD x 70kg)/20m^3) x 1000

**Hydrogen sulphide is based on 1-second 99th percentile criteria for a 125 population of affected community (NSW EPA, 2005)

NHMRC 1996, Ambient Air Quality Goals Recommended by the National Health and Medical Research Council, National Health and Medical Research Council, Canberra.

Table C13: Maximum Predicted Chronic Particulate and Vapour Data - Onsite

Hydro Aluminium, Lot1 Hart Rd, Loxford

Compound	Unit	Tier 1 Screening Criteria	Tier 1 Screening Criteria Source	Averaging Period	Maximum Predicted Chronic Onsite Concentration For CWS Workers
Deposited dust	g/m^2/month	4	NSW EPA	Annual	0.39
TSP	$\mu g/m^3$	90	NHMRC	Annual	4.26
PM10	$\mu g/m^3$	25	NEPC	Annual	2.27
PM2.5	$\mu g/m^3$	8	NEPC	Annual	1.51
SO_2	$\mu g/m^3$	60	NSW EPA	Annual	2.61E-03
NO_2	$\mu g/m^3$	62	NSW EPA	Annual	4.89
CO	$\mu g/m^3$	10000	NSW EPA	8-hour	2.02
Hydrogen Sulfide	$\mu g/m^3$	2	US EPA IRIS	Chronic	0.06
Ammonia	$\mu g/m^3$	69.7	ATSDR	Chronic	0.11
Arsenic	$\mu g/m^3$	0.007	WHO (2000)	Chronic**	4.75E-05
Cyanide	$\mu g/m^3$	0.8	US EPA IRIS	Chronic	4.10E-05
Lead	$\mu g/m^3$	0.5	NEPC	Annual	4.58E-05
Fluoride	$\mu g/m^3$	1	WHO (2000)	Chronic	0.03
Benzene	$\mu g/m^3$	1.7	WHO (2000)	Chronic**	2.79E-03
Toluene	$\mu g/m^3$	3769	ATSDR	Chronic	0.01
Ethylbenzene	$\mu g/m^3$	260.5	ATSDR	Chronic	1.44E-03
Xylenes	$\mu g/m^3$	217	ATSDR	Chronic	0.01
Naphthalene	$\mu g/m^3$	3.7	ATSDR	Chronic	2.73E-07
Phenol	$\mu g/m^3$	200	CAL EPA	Chronic	3.03E-06
PAH (BaP)	$\mu g/m^3$	1.20E-04	WHO (2000)	Chronic**	9.07E-05

Notes:

NSW EPA (2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Department of Environment and Conservation (NSW)

NEPC (2015) Variation to the National Environment Protection (Ambient Air Quality) Measure, National Environmental Protection Council

WHO (2000) Air Quality Guidelines for Europe, 2nd Edition, 2000. World Health Organization Regional Publications, European Series, No. 91.

ATSDR: Agency for Toxic Substances & Disease Registry. Minimal Risk Levels (MRLs) adopted. MRL values converted from ppm to $\mu g/m^3$ using (((ppm x molecular weight)/24.45)x1000)

CAL EPA: California Environmental Protection Agency. In absence of available Tier 1 screening criteria, the toxicity Reference Concentration for the compound was adopted.

US EPA IRIS: United States Environmental Protection Agency, Integrated Risk Information System

Hydrogen sulphide is based on 1-second 99th percentile criteria for a 125 population of affected community (NSW EPA, 2005)

*Value was converted from a reference dose (RfD, mg/kg/day) to a reference concentration (RfC, $\mu g/m^3$) using RfC = ((RfD x 70kg)/20m^3) x 1000

** Value applicable to cancer risk of 1 in 100,000 was adopted.

NHMRC 1996, Ambient Air Quality Goals Recommended by the National Health and Medical Research Council, National Health and Medical Research Council, Canberra.

Table C14: Maximum Predicted Acute Particulate and Vapour Data - Offsite

Hydro Aluminium, Lot1 Hart Rd, Loxford

Compound	Unit	Tier 1 Screening Criteria	Tier 1 Screening Criteria Source	Averaging Period	Maximum Predicted Acute Offsite Concentration For Sensitive Receptors
PM10	g/m^2/month	50	NEPC	24 hours	46.64
PM2.5	µg/m^3	25	NEPC	24 hours	19.92
SO_2	µg/m^3	570	NEPC	1 Hour	81.23
NO_2	µg/m^3	246	NEPC	1 hour	94.83
CO	µg/m^3	30000	NSW EPA	1 hour	9619.77
Hydrogen Sulfide	µg/m^3	2.76	NSW EPA	1 second	1.12
Ammonia	µg/m^3	330	NSW EPA	1 hour	0.95
Arsenic	µg/m^3	0.09	NSW EPA	1 hour	8.25E-05
Cyanide	µg/m^3	90	NSW EPA	1 hour	7.13E-05
Lead	µg/m^3	0.5	NEPC	Annual	7.96E-05
Fluoride	µg/m^3	1	WHO (2000)	Chronic	0.04
Benzene	µg/m^3	29	NSW EPA	1 hour	0.01
Toluene	µg/m^3	360	NSW EPA	1 hour	0.02
Ethylbenzene	µg/m^3	8000	NSW EPA	1 hour	4.50E-03
Xylenes	µg/m^3	190	NSW EPA	1 hour	0.02
Naphthalene	µg/m^3	2100	ATSDR	Acute*	6.78E-07
Phenol	µg/m^3	20	NSW EPA	1 hour	7.54E-06
PAH (BaP)	µg/m^3	0.4	NSW EPA	1 hour	1.21E-04

Notes:

NSW EPA (2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Department of Environment and Conservation (NSW)

NEPC (2015) Variation to the National Environment Protection (Ambient Air Quality) Measure, National Environmental Protection Council

WHO (2000) Air Quality Guidelines for Europe, 2nd Edition, 2000. World Health Organization Regional Publications, European Series, No. 91.

ATSDR: Agency for Toxic Substances & Disease Registry. Minimal Risk Levels (MRLs) adopted. MRL values converted from ppm toµg/m^3 using (((ppm x molecular weight)/24.45)x1000)

RAIS: US EPA Risk Assessment Information System. In absence of available Tier 1 screening criteria (reference concentration), toxicity value for the compound was adopted.

Hydrogen sulphide is based on 1-second 99th percentile criteria for a 125 population of affected community (NSW EPA, 2005)

PPRTV: Provisional Peer-Reviewed Toxicity Values, Oak Ridge National Laboratory. Value obtained from US EPA Regional Screening Levels table.

OEHHA: Office of Environment Health Hazard Assessment (OEHHA), California Environmental Protection Agency (CalEPA)

*Value was converted from a reference dose (RfD, mg/kg/day) to a reference concentration (RfC,µg/m^3) using RfC = ((RfD x 70kg)/20m^3) x 1000

Table C15: Maximum Predicted Acute Particulate and Vapour Data - Offsite

Hydro Aluminium, Lot1 Hart Rd, Loxford

Compound	Unit	Tier 1 Screening Criteria	Tier 1 Screening Criteria Source	Averaging Period	Maximum Chronic Predicted Offsite Concentration For Sensitive Receptors
Deposited dust	g/m^2/month	4	NSW EPA	Annual	0.03
TSP	$\mu g/m^3$	90	NHMRC	Annual	48.31
PM10	$\mu g/m^3$	25	NEPC	Annual	19.44
PM2.5	$\mu g/m^3$	8	NEPC	Annual	7.25
SO_2	$\mu g/m^3$	60	NSW EPA	Annual	3.34
NO_2	$\mu g/m^3$	62	NSW EPA	Annual	17.51
CO	$\mu g/m^3$	10000	NSW EPA	8 hour	2761.87
Hydrogen Sulfide	$\mu g/m^3$	2	US EPA IRIS	Chronic	0.03
Ammonia	$\mu g/m^3$	69.7	ATSDR	Chronic	0.05
Arsenic	$\mu g/m^3$	0.007	WHO (2000)	Chronic**	6.86E-06
Cyanide	$\mu g/m^3$	0.8	US EPA IRIS	Chronic	5.92E-06
Lead	$\mu g/m^3$	0.5	NEPC	Annual	6.62E-06
Fluoride	$\mu g/m^3$	1	WHO (2000)	Chronic	3.90E-03
Benzene	$\mu g/m^3$	1.7	WHO (2000)	Chronic**	4.71E-04
Toluene	$\mu g/m^3$	3769	ATSDR	Chronic	9.56E-04
Ethylbenzene	$\mu g/m^3$	260.5	ATSDR	Chronic	2.43E-04
Xylenes	$\mu g/m^3$	217	ATSDR	Chronic	1.31E-03
Naphthalene	$\mu g/m^3$	3.7	ATSDR	Chronic	2.26E-08
Phenol	$\mu g/m^3$	200	OEHHA	Chronic	2.51E-07
PAH (BaP)	$\mu g/m^3$	1.20E-04	WHO (2000)	Chronic**	1.21E-05

Notes:

NSW EPA (2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Department of Environment and Conservation (NSW)

NEPC (2015) Variation to the National Environment Protection (Ambient Air Quality) Measure, National Environmental Protection Council

WHO (2000) Air Quality Guidelines for Europe, 2nd Edition, 2000. World Health Organization Regional Publications, European Series, No. 91.

ATSDR: Agency for Toxic Substances & Disease Registry. Minimal Risk Levels (MRLs) adopted. MRL values converted from ppm to $\mu g/m^3$ using (((ppm x molecular weight)/24.45)x1000)

US EPA IRIS: United States Environmental Protection Agency, Integrated Risk Information System

Hydrogen sulphide is based on 1-second 99th percentile criteria for a 125 population of affected community (NSW EPA, 2005)

Potency equivalency factors (PEFs) for PAHs, Office of Environment Health Hazard Assessment (OEHHA 1994), California Environmental Protection Agency (CalEPA)

** Value applicable to cancer risk of 1 in 100,000 was adopted.

NHMRC 1996, Ambient Air Quality Goals Recommended by the National Health and Medical Research Council, National Health and Medical Research Council, Canberra.

	Option 2			Option 3			Option 4			Option 5			Option 6			Option 7		
Soil Disturbance Event	**Value per Event**	**Duration (years)**	**Health Value**	**Value per Event**	**Duration (years)**	**Health Value**	**Value per Event**	**Duration (years)**	**Health Value**	**Value per Event**	**Duration (years)**	**Health Value**	**Value per Event**	**Duration (years)**	**Health Value**	**Value per Event**	**Duration (years)**	**Health Value**
Soil in CWS is excavated and loaded onto truck	0.5	0.8	0.42	0.5	3.2	1.62	0.5	0.8	0.42	0.5	1.3	0.63	0.5	3.9	1.97	0.5	3.9	1.97
Soil is transported and placed in onsite/offsite storage or treatment facility	0.5	0.8	0.42	0.5	3.8	1.90	0.5	0.9	0.44	0.5	5.6	2.82	0.5	17.5	8.73	0.5	6.2	3.12
Haul road between CWS and onsite/offsite containment cell is scraped and placed into onsite/offsite containment cell	0.5	0.1	0.04	0.5	0.1	0.04	0.5	0.1	0.04	0.5	0.1	0.05	-		-	-		-
Sorting of CWS recyclable material	-	-	-	0.5	3.2	1.62	-	-	-	0.5	1.5	0.75	0.5	1.3	0.63	0.5	1.3	0.63
Cleaning of steel and carbon recyclable materials	-	-	-	0.5	3.4	1.70	-	-	-	0.5	1.0	0.48	0.5	1.0	0.48	0.5	1.0	0.48
Additional cleaning of carbon recyclable materials	-	-	-	0.5	3.1	1.55	-	-	-	-	-	-	-		-	-	-	-
Additional cleaning of steel recyclable materials	-	-	-	0.5	1.0	0.48	-	-	-	-	-	-	-		-	-	-	-
Crushing of fines and crushable materials	-	-	-	0.5	3.3	1.66	-	-	-	0.5	3.9	1.97	0.5	3.9	1.97	0.5	3.9	1.97
Pug Mill lime treatment of crushed fine materials	-	-	-	0.5	2.8	1.38	-	-	-	0.5	3.3	1.64	-	-	-	-	-	-
Total Asbestos Exposure Risk Estimate			**0.88**			**11.94**			**0.90**			**8.34**			**13.79**			**8.17**

APPENDIX C4
ALGORITHMS

Estimation of Chemical Intakes

The algorithms used to estimate chemical intakes for each receptor and chemical of potential concern are presented below, and the definitions for the variables are presented in **Table C4.1**.

1.1 Incidental Soil Ingestion (US EPA, 1989)

$$Soil\ Ingsetion\ Intake\ \left(\frac{mg}{kg}\ day\right) = \frac{Cs\ \times \mathrm{IRs}\ \times CF\ \times FI\ \times EF\ \times ED}{BW\ \times AT}$$

1.2 Incidental Groundwater Ingestion (US EPA, 1989)

$$Groundwater\ Ingestion\ Intake\ \left(\frac{mg}{kg}\ day\right) = \frac{Cw\ \times IRw\ \times CF\ \times EF\ \times ED}{BW\ \times AT}$$

1.3 Dermal Contact with Soil (US EPA, 2004)

The dermal absorbed dose or dermal intake is estimated using the concept of absorbed dose per event (US EPA, 2004), where the overall absorbed dose depends on the number of events, the adherence factor and the fraction of contaminant absorbed.

$$Soil\ Dermal\ Contact\ Intake\ \left(\frac{mg}{kg}\ day\right) = \frac{Cs\ \times CF \times AF\ \times ABS\ \times EF\ \times EV\ \times ED\ \times SA}{BW\ \times AT}$$

1.4 Dermal Contact with Water (US EPA 2004)

The chemical intake via dermal absorption with water is calculated depending on the exposure duration as follows:

$$Water\ Dermal\ Contact\ Intake\ \left(\frac{mg}{kg}\ day\right) = \frac{DAevent\ \times EF\ \times EV\ \times ED\ \times SA}{BW\ \times AT}$$

For short duration exposures with organic compounds in water ($t_{event} \leq t^*$):

$$DAevent = 2\ \times FA\ \times Kp\ \times Cw\ \times \sqrt{\frac{1+3B+3B^2}{(1+B)^2}}$$

For long duration exposures with organic compounds in water:

$$DAevent = FA\ \times Kp\ \times Cw\ \times \left[\frac{tevent}{1+B} + 2\tau event\ \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

For exposure to inorganic or highly ionized organic chemicals in water:

$$DAevent = Kp\ \times Cw\ \times tevent$$

1.5 Vapour Inhalation (US EPA, 2009)

The US EPA (2009) RAGS-F guidance recommends that when estimating risk via inhalation pathways, the concentration of the chemical in air should be used as the exposure metric (e.g. mg/m^3), rather than inhalation intake of a contaminant in air based on inhalation rate and body weight (e.g. mg/kg-day). This is known as the *Inhalation Dosimetry Methodology* which supersedes the previous US EPA (1989) RAGS, Part A inhalation methodology because "*the internal dose to a chemical from the inhalation pathway is not a simple function of the inhalation rate and body weight….* [and therefore the US EPA (1989) inhalation equation] *does not comply with the principles of EPA's inhalation dosimetry procedures used to determine the human equivalent concentration (HEC) for calculating a Reference Concentration (RfC) or Inhalation Unit Risk (IUR)*") (US EPA, 2003).

The updated inhalation dosimetry methodology calculates a modified exposure concentration (EC, mg/m^3) which is then directly compared with a Reference Concentration (RfC, mg/m^3) or Inhalation Unit Risk (IUR, per mg/m^3) that is derived from toxicological studies.

$$ECvapour\ (indoors)\ \left(\frac{\mu g}{m^3}\right) = \frac{Ca_{indoors} \times RF \times ETindoors\ \times Bio\ \times EF\ \times ED}{AT}$$

$$EDdust\ (outdoors) \left(\frac{\mu g}{m^3}\right) = \frac{Ca_{outoors} \times RF \times EToutdoors\ \times Bio\ \times EF\ \times ED}{AT}$$

Table C4.1 Variables Description for Estimation of Chemical Intakes

Variable	Units	Description
Cs	Mg/kg	Concentration in soil
Cw	mg/L	Concentration in groundwater
IRs	mg soil/day	Soil ingestion rate
IRw	L/day	Groundwater ingestion rate
CF	10^{-6} kg/mg	Unit conversion factor
FI	-	Fraction ingested from contamination source
EF	days/year	Exposure frequency
ED	years	Exposure duration
BW	kg	Body weight
AT	days	Averaging time
		Non-carcinogens AT= ED (yr) x 365 d/yr
		Carcinogens AT = 70yr x 365 d/yr
DAevent	mg/cm^2 - event	Dermally absorbed dose per event per unit exposed skin area
EV	events/day	Event frequency
SA	cm^2	Skin surface area available for contact

Cw	mg/L	Concentration in water
AF	mg/cm^2 - event	Adherence factor of soil to skin
ABS	-	Dermal absorption fraction (chemical-specific)
FA	-	Fraction absorbed from water
Kp	cm/hour	Dermal permeability coefficient of compound in water (chemical-specific)
τevent	hours/event	Lag time per event (chemical-specific, refer to Appendix B of US EPA (2004))
t*	hours	Time to reach steady state = 2.4 τevent
tevent	hours/event	Event duration
B	-	Ration of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across viable epidermis (refer to Equation A.1 in Appendix A of US EPA (2004)).
Bio	-	Bioavailability
ECdust	µg/m^3	Exposure concentration (a time-weighted average concentration) relevant to chemicals present as dust
CA indoors	µg/m^3	Concentration in indoor air (exposure point concentration which has been measured or modeled)
CA outdoors	µg/m^3	Concentration in outdoor air (exposure point concentration which has been measured or modeled)
RF	-	Lung retention factor relevant to the inhalation of dust and includes consideration of a deposition fraction and ciliary clearance
ETindoors	hours/event	Exposure time spent indoors
EToudoors	hours/event	Exposure time spent outdoors

References

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US EPA (2004) *Risk assessment guidance for Superfund, Vol I, Human health evaluation manual (Part E), Supplemental guidance for dermal risk assessment*. United States Environmental Protection Agency, Washington, DC, USA.

US EPA (2009) *Risk assessment guidance for Superfund, Vol 1, Human health evaluation manual (Part F), supplemental guidance for inhalation risk assessment*. EPA/540/R-70/002, United States Environmental Protection Agency, Washington, DC, USA.

APPENDIX C5
TOXICOLOGICAL PROFILES

Asbestos Toxicological Profile

1. General Information

Asbestos is the generic commercial term for a group of naturally occurring mineral silicate fibres of the serpentine and amphibole series. These include the serpentine mineral chrysotile and the five amphibole minerals – actinolite, amosite, anthophylite, crocidolite and tremolite. The physical properties of these asbestos fibres are summarised in **Table 1**.

The term 'asbestos' or 'asbestiform minerals' refer to only those silicate minerals that occur in polyfilamentous bundles, and that are composed of extremely flexible fibres with a relatively small diameter and a large length. These fibre bundles have splaying ends, and the fibres easily separate from one another.

Asbestos fibres tend to possess good strength properties (e.g. high tensile strength, wear and friction characteristics), flexibility (e.g. the ability to be woven), excellent thermal properties (e.g. heat stability, thermal, electrical and acoustic insulation), adsorption capacity and resistance to chemical, thermal and biological degradation (IARC, 2013).

Chrysotile, also known as white asbestos, is the predominant commercial form of asbestos, and amphiboles are of minor importance. Amphibole asbestos fibres are generally brittle and often have a rod- or needle-like shape, whereas chrysotile asbestos fibres are flexible and curved (ATSDR, 2001).

Asbestos fibres do not have any detectable odour or taste, and they do not dissolve in water or evaporate, and are resistance to heat, fire, biological and chemical degradation (ATSDR, 2001).

Except in cases of high occupational or para-occupational, the incidence of asbestos-related disease is low. The belief that 'one fibre can kill' is not supported by scientific evidence and enHealth (2005) states that "*The small burden of fibres resulting from….background exposure appears to be tolerated, so the theory that one asbestos fibre kills is unrealistic*". This statement notwithstanding, it is clear that all practical measures must be taken to reduce the potential for asbestos related diseases and their impacts to human health.

Table 1 **Physical Properties of Asbestos Minerals**

Common name	CAS Number	Synonyms	Colour	
		Serpentine group of minerals		
Chrysotile	12001-29-5*	Serpentine asbestos; white asbestos	White, grey, green, yellowish	Curled sheet silicate, hollow central core; fibre bundle lengths are several mm to more than 10cm; fibres more flexible than amphiboles; net positive surface charge' forms a stable suspension in water; fibres degrade in dilute acids
		Amphibole group of minerals		
Crocidolite	12001-28-4*	Blue asbestos	Lavender, blue green	Double chain silicate; shorter, thinner fibres than other amphiboles, but not as thin as chrysotile; fibre flexibility: fair to good; resistance to acids: good; less heat resistance than other asbestos fibres; usually contains organic impurities, including low levels of PAHs; negative surface charge in water
Amosite	12172-73-5*	Brown asbestos	Brown, grey, greenish	Double chain silicate; long, straight, coarse fibres; fibre flexibility: somewhat; resistance to acids: somewhat; occurs with more iron than magnesium; negative surface charge in water
Anthophyllite	17068-78-9*	Ferroanthophyllit, asbolen asbestos	Grey, white, brown-grey, green	Double chain silicate; short, very brittle fibres; resistance to acids: very; relatively rare; occasionally occurs as contaminant in talc deposits; negative surface charge in water
Actinolite	12172-67-7*	Unspecified	Green	Double chain silicate; brittle fibres; resistance to acids: none; occurs in asbestiform and non-asbestiform habit; iron-substituted derivative of tremolite; common contaminant in amosite deposits; negative surface charge in water.
Tremolite	14567-73-8*	Silicic acid, calcium magnesium salt	White to pale green	Double chain silicate; brittle fibres; acid resistant; occurs in asbestiform and non-asbestiform habit; common contaminant in chrystotile and talc deposits; negative surface charge in water

2. Presence in the Environment

Asbestos is abundant in the environment, with fibre release from natural sources and extensive industrial and commercial use of asbestos in the past.

Asbestos minerals are widespread naturally, and are found in many areas where the original rock mass has undergone metamorphism. They may occur in large natural deposits or as contaminants in other minerals (e.g. tremolite asbestos may occur in deposits of chrysotile, vermiculite, and talc). The most commonly occurring form of asbestos is chrysotile, and its fibres are found as veins in serpentine rock formations. Asbestiform amphiboles occur in relatively low quantities throughout the earth's crust and their chemical composition reflects the environment in which they form (Virta, 2002).

As described above, asbestos has several chemical and physical properties that make it desirable for a wide range of industrial and building applications, such as heat resistance and durability. In Australia, bonded asbestos products were first manufactured in the 1920s and were a common component of residential and commercial building materials (e.g. cement sheeting, pipes, gutters, vinyl floor tiles) from the mid-1940s until the late 1980s (NEPC, 2013). Australia banned the use and import of building asbestos products in the mid-1980s and in December 2003 banned import, manufacture and use of all asbestos products (NEPC, 2013). Today, many older buildings still contain asbestos cement products, commonly in eaves or cladding of internal and external walls and roofs.

When in good condition, bonded asbestos products do not release asbestos fibres into the air and are considered safe for people who are in contact with them, including when carrying and handling these materials (enHealth, 2005). If asbestos materials can be maintained in good condition, enHealth (2005) recommends that these materials are best left alone and periodically checked to monitor their condition.

2.1 Environmental Fate and Transport

Asbestos fibres do not evaporate into air or dissolve in water. However, pieces of fibres can enter the air and water from the weathering of natural deposits and the wearing down of manufactured asbestos products (ATSDR, 2001). Small diameter fibres and fibre-containing particles may remain suspended in the air for a long period of time and can be carried long distances by wind or water currents before settling. Asbestos fibres are not able to move through soil. They are generally not broken down to other compounds in the environment and will remain virtually unchanged over long periods of time (ATSDR, 2001). However, the most common forms of asbestos, chrysotile, may have some minor mineral loss in acidic environments.

Asbestos fibres may break into shorter pieces or separate into a larger number of individual fibres as a result of physical processes such as weathering.

3. Toxicokinetics, Deposition, Clearance and Translocation in Humans

Epidemiological studies of asbestos-exposed workers and supporting animal studies indicate that inhalation of asbestos is the principal route of exposure of public health concern. Since asbestos fibres are widespread in the environment from both natural and anthropogenic sources, normal healthy lungs can contain a significant loading of fibres (enHealth, 2005). For example, in a 70-year-old lung there can be up to one million fibres per gram of lung tissue (Berry *et al*., 1989). Once asbestos enters the lungs, some of the fibres will be deposited in the air passages and on cells that make up the lungs. Most fibres are removed from the lungs via mucociliary clearance or macrophages, where they are swallowed into the stomach.

Once in the stomach, nearly all of the fibres pass along the intestines within a few days and are excreted in the feces (ATDSR, 2001). A small number of fibres may penetrate into the cells that line the stomach or intestines, and a few may penetrate into the blood vessels.

Fibres that are deposited into the deepest parts of the lung are removed more slowly, and may remain in place for many years or may never be removed. Alveolar macrophages, which normally phagocytize foreign bodies deposited in the lungs, seek to engulf the asbestos fibers and remove them. While short fibers may be cleared in this way, fibres longer than the diameter of human alveolar macrophages (approximately 14-25 µm) are less likely to be cleared, and this results in an ongoing focal inflammatory response. Fibres may also interact with lung epithelial cells, penetrate into the interstitium, and translocate to the pleura and peritoneum or more distant sites (IARC, 2012)

Workers who repeatedly inhale asbestos fibres with lengths greater than or equal to 5 µm may develop a slow buildup of scar-like tissue in the lungs and in the membrane that surrounds the lungs. This scar-like tissue does not expand and contract like normal lung tissue and therefore breathing becomes difficult. Blood flow to the lung may also be decreased which causes the heart to enlarge. This disease is known as asbestosis, and people with this disease have a shortness of breath, often accompanied by a cough, and it can eventually lead to disability or death in people exposed to high amounts of asbestos over long periods of time.

Should asbestos deposit onto the skin, very few if any, will pass through the skin layer (ATSDR, 2001).

4. Health Effects of Asbestos

All forms of asbestos can cause cancer and this has been conclusively demonstrated in numerous studies of occupationally exposed workers, and has been confirmed in a number of animal experiments (ATSDR, 2001).

Studies in humans and animals indicate that inhalation exposure to asbestos fibers may lead to the development of pulmonary disease including asbestosis and/or lung cancer and mesothelioma of the pleura or peritoneum. In general, non-cancer effects in other tissues have not been detected; however, the development of cancer in other tissues (e.g., gastrointestinal tissues) in some worker populations may be related to asbestos exposure. Asbestos-related lung diseases (malignant and nonmalignant) or signs of these diseases have been reported in groups of occupationally exposed humans with cumulative exposures ranging from about 5 to 1,200 f-yr/mL. Such cumulative exposures would result from 40 years of occupational exposure to concentrations ranging from 0.125 to 30 f/mL.

Asbestos workers have increased chances of getting cancer of the lung tissue and mesothelioma (cancer of the thin membrane that surrounds the lung and other internal organs). These cancers appear only after a number of years following exposure to asbestos (ATSDR, 2001). Lung cancer is usually fatal, while mesothelioma is almost always fatal, often within a few months of diagnosis. Members of the public who are exposed to lower levels of asbestos may also have increased chances of getting cancer, but the risks are usually small and are difficult to measure directly (ATSDR, 2001).

For lung cancer, the magnitude of the risk appears to be a complex function of a number of parameters, the most important of which are:

- the level and the duration of exposure;
- the time since exposure occurred;
- the age at which exposure occurred;
- the tobacco-smoking history of the exposed person; and
- the type and size distribution of the asbestos fibers.

There is some indication that asbestos exposure may have increased the risk of laryngeal cancer in some groups of asbestos workers, but the evidence is not as strong as that for lung cancer and mesothelioma. There is little evidence for the carcinogenicity of asbestos at other sites, although several cases of malignant mesothelioma of the tunica vaginalis testis have been reported in patients with histories of occupational exposure to asbestos (ATSDR, 2001).

The health effects from swallowing asbestos are unclear. Some groups of people who have been exposed to asbestos fibers in drinking water have higher-than-average death rates from cancer of the esophagus, stomach, and intestines. However, it is very difficult to tell whether this is caused by asbestos or by other factors. Animals that were given very high doses of asbestos in food did not get more fatal cancers than usual, although some extra nonfatal tumors did occur in the intestines of rats in one study (ATSDR, 2001).

While lung cancer and mesothelioma are generally associated with chronic exposure to asbestos, there are several studies that indicate that short-term exposures are also of concern. For example, it has been noted that workers exposed to asbestos for only 1–12 months had an increased risk of developing lung cancer a number of years later. In animals, mesotheliomas developed in two rats exposed to high concentrations of amosite or crocidolite for only 1 day. These data are not extensive enough to define the dose- or time-dependency of health risks from short-term exposure to asbestos, but the data do indicate that short-term exposures should not be disregarded.

Studies of workers suffering from asbestos-related diseases such as asbestosis or mesothelioma indicate that the cellular immune system in such patients can be depressed (ATSDR, 2001). This is an effect of particular interest and concern since impaired immune surveillance may contribute to the increased incidence of cancer in asbestos-exposed people. Moreover, variation in immune system functional capability might be an important determinant of why some people develop cancer or asbestosis while others, with approximately equal exposures, do not.

4.1 IARC Toxicity Classification

The International Agency for Research on Cancer (IARC) has classified Asbestos as Group 1 ‘carcinogenic to humans’ (IARC, 2012). IARC classifies asbestos as “*all forms, including actinolite, amosite, anthophyllite, chrysotile, crocidolite, tremolite. (NB: Mineral substances (e.g. talc or vermiculite) that contain asbestos should also be regarded as carcinogenic to humans*).”

4.2 Dose-Response Values

ATSDR (2001) do not provide minimal risk levels (MRLs) for asbestos via the inhalation route due to the large degree of uncertainty in extrapolating from the available data to levels of exposure that may be several orders of magnitude lower than current U.S. occupational exposure limits (0.1 f/mL). Data regarding the adverse health effects associated with acute- or intermediate-duration exposure to asbestos are lacking or are too limited to support the derivation of an MRL.

The US EPA provides an inhalation unit risk (IUR) of 0.23 f/mL^{-1} based human lung cancer and mesothelioma rates in occupational workers (Selikoff *et al*., 1979; Peto *et al*., 1982; Seidman *et al*., 1979; Peto, 1980; Finkelstein, 1983). This value is published on the US EPA Integrated Risk Information System (IRIS) website, and was last reviewed in 1993. The unit risk value was calculated for the additive combined risk of lung cancer and mesothelioma, and is calculated as a composite value for males and females. The unit risk should not be used if the air concentration exceeds 0.04 fibers/ml (f/ml), since above this concentration the slope factor may differ from that stated.

WHO (2005) state that several authors and working groups have produced estimates indicating that, with a lifetime exposure to 0.0005 f/ml (optically measured) in a population of whom 30% are smokers, the excess risk due to lung cancer would be in the order of 10^{-6} to 10^{-5}. For the same lifetime exposure, the mesothelioma risk for the general population would be in the range 10^{-5} to 10^{-4}.

enHealth (2005) state that dose-response data from epidemiological studies lack the statistical power to detect small effects at low doses, so it is not possible to show empirically whether or not there is a threshold for asbestos-related lung cancer. The dose-response characteristics of the various fibre types have been extensively studied, but there are limitations to many of these studies due to inadequate testing regimes. Nonetheless a number of them indicate that there may be a threshold for the effects of asbestos, casting doubt on the belief that ‘*one fibre can kill*’. The evidence for a threshold is strongest for asbestosis and lung cancer. The data from published occupational studies generally show there is a direct relationship between exposure and risk for all industries and fibre types, although the estimates of risk vary between studies (enHealth, 2005).

In Australia, NEPC (2013) identify that friable asbestos in soil should be below 0.001% w/w for all site land uses and 0.01% w/w for bonded asbestos containing materials for residential land uses. These guidelines are based on research conducted by Swartjes & Tromp (2008) where trial results indicated that a soil level of 0.01% w/w for friable asbestos should keep asbestos fibre levels in air below 0.001 f/ml, which corresponds to a lifetime risk of 10^{-6} to 10^{-5} in the exposed population from airborne asbestos fibres using WHO (2005) risk figures for mesothelioma. Note that NEPC (2013) applied an additional conservative factor of 10 to the Swartjes & Tromp (2008) recommendations to account for dryer soils in Australia that may generate more airborne dust.

4.1 Influence of Fibre Type and Size on Health Effects

There is a scientific debate concerning the differences in the extent of asbestos related disease caused by different fiber types and sizes. Some of these differences may be due to the physical and chemical properties of the different fiber types.

In terms of shape, fibres >8 µm long and <0.25 µm diameter, with an aspect ratio (length/width) ≥10 appear to be most dangerous. In terms of length, fibres >20 µm <100 µm long tend to be more carcinogenic. Fibres >100 µm long are not respirable and hence do not pose a risk, unless they are first broken down into shorter fibres. Fibres <5 µm do not appear to cause asbestos-related disease, or at least are much less potent than longer fibres (enHealth, 2005). Fibers thicker than 3.0 µm are of lesser concern, because they have little chance of penetrating to the lower regions of the lung (ATSDR, 2001).

Amphibole fibres consist of thin, long, needle like fibres; therefore, they readily penetrate into the lower lung. Once inhaled, amphiboles are very durable and resistant to the lung's clearance mechanisms. They are more likely to split longitudinally and macrophages cannot easily engulf the longer amphibole fibres. The increased length and persistence in the lungs is considered to increase their toxicity (enHealth, 2005).

In general, chrysotile comprises curly fibres, which can occur in bundles and are, therefore, more likely to be intercepted in the upper airways or nose. The chrysotile fibres are also less likely to become airborne to the same extent as the straight amphibole fibres. Chrysotile fibres are not as durable as amphibole fibres and are more likely to fragment into shorter fibrils, which are more readily cleared from the lungs by alveolar macrophages (Davis, 1989). In part, this is why chrysotile is considered to be less carcinogenic than amphibole fibres.

Although all forms of asbestos can cause mesothelioma, there is considerable evidence that the potency for the induction of mesothelioma varies by fibre type, and in particular that chrysotile asbestos is less potent than amphibole forms of asbestos (IARC, 2012). Based on a review of toxicological and human studies, Lippmann (1990) suggested that fibres shorter than 0.1 µm and longer than 5 µm are related to mesothelioma in humans.

The role of the aspect ratio and size appears to be different for the three major asbestos-related diseases:

- *asbestosis* was reported as most closely associated with the surface area of retained fibres (NIOSH, 2009) although fibrosis also correlates with fibres > 2 µm long (Dodson et al., 2003);
- *mesothelioma* is better related to the numbers of fibres longer than about 5 µm and thinner than about 0.1 µm; and
- *lung cancer* with fibres longer than about 10 µm and thicker than about 0.15 µm (NIOSH, 2009). Several studies, however, report the presence of very short fibres in lung and pleural tissue from patients with malignant mesothelioma (Dodson *et al*., 2003; Dodson *et al.*, 2005; Suzuki *et al*., 2005; Dodson *et al*., 2007), suggesting caution to exclude short fibres (< 5 µm) in the development of asbestos related diseases (Dodson et al., 2003).

Doll and Peto (1985) report that respirable airborne asbestos fibres of 5 to 100 μm in length, with a diameter of less than 1.5 to 2 μm, and with aspect ratios of more than 5:1, appear to have the greatest adverse effect.

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Naphthalene Toxicological Profile

1. Physical and Chemical Properties

Naphthalene comprises two fused benzene rings and is a white crystalline solid, with the characteristic odour of mothballs. It is the simplest of the many chemical forms of polycyclic aromatic hydrocarbons known to exist in the environment. Naphthalene is slightly soluble in water but soluble in benzene, alcohol, ether and acetone.

The physical and chemical properties of naphthalene are presented in **Table 1** below. Naphthalene is also referred to as mothballs, moth flakes, white tar and tar camphor (ATSDR, 2005). Naphthalene has a strong but not unpleasant smell which can be detected in the air at a concentration of 84 parts per billion (ppb).

Table 1 Physical and Chemical Properties of Naphthalene

Variable	Symbol	Unit	Value	Reference
CAS Number	91-20-3	-	-	-
Chemical Formula	C10H8	-	-	-
Molecular Weight	MW	g/mole	128.16	RAIS
Henry's Law Constant @ 25oC	H'	unitless	0.018	RAIS
Henry's Law Constant @ 25oC	H'	atm-m^3/mol	4.6E-04	ATSDR
Vapour Pressure	ρ	mmHg	0.085	RAIS
Aqueous solubility	S	mg/L	31	RAIS
Soil-water partition coefficient	Kd	cm^3/g	ND	-
Organic carbon partition coefficient	Koc	cm^3/g	1540	RAIS
Log of octanol-water partition coefficient	log Kow	-	3.3	RAIS
Dermal permeability constant	Kp	cm/hr	0.0466	RAIS
Soil dermal absorption factor	DAF	-	0.1	CCME (2008)
Oral bioavailability in soil	Bio	-	-	-
Diffusivity in air	Dair	cm^2/sec	0.0605	RAIS
Diffusivity in water	Dwater	cm^2/sec	8.4 x 10-6	RAIS

ND: No data available

2. Presence in the Environment and Human Exposure

Naphthalene occurs naturally in the environment in fossil fuels such as petroleum and coal, and is produced when organic materials (e.g., fossil fuels, wood, tobacco) are burned. Naphthalene can enter the environment from industrial uses when it is produced commercially from either coal tar or petroleum. Commercially-produced naphthalene is predominately used in the production of phthalic anhydride, which is used as an intermediate for polyvinyl chloride plasticizers such as di(2-ethylhexyl) phthalate. Other uses of naphthalene include production of naphthalene sulfonates (used in concrete additives and synthetic tanning agents), pesticides (e.g., carbaryl insecticides and moth repellents), and dye intermediates.

Naphthalene is frequently present in industrial and automobile emissions and effluents and in various media in the general environment due to its natural occurrence in coal and petroleum products and emissions, its use as an intermediate in the production of plasticizers, resins, and insecticides, and its use in a variety of consumer products such as moth repellents.

The most significant exposure pathway is inhalation of contaminated air and tobacco smoke from both active and passive smoking. Although naphthalene has been detected in certain foods, beverages and tap water, these do not constitute major sources of exposure for most people (ATSDR, 2005). Typical air concentrations for naphthalene are low, 0.2 ppb or less. Studies of outdoor air reported concentrations of 0.09 ppb 1-methylnaphthalene and 0.011 ppb 2-methylnaphthalene. In homes or businesses where cigarettes are smoked, wood is burned, or moth repellents are used, the levels of naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene in the air are higher. Studies of indoor air typically report that average indoor air concentrations of these contaminants are less than 1 ppb (ATSDR, 2005).

The general population may be exposed to naphthalene via ingestion of food and drinking water, however, the contribution from these pathways is considered minor compared to inhalation.

2.1 Environmental Fate and Transport

Naphthalene breaks down fairly rapidly (approximately one day) in air, water and sunshine and biodegrades under aerobic conditions in soil and water. Naphthalene can become weakly attached to soil or pass through the soil particles into groundwater. Naphthalene does not accumulate in fish or animal tissues but can be present in milk and eggs if dairy cows and chickens are exposed to naphthalene.

Although categorised as a semi-volatile compound, naphthalene is quite volatile and readily evaporates from surface soil and surface waters into the atmosphere. Although it binds weakly to soil and sediment particulate matter, which can moderately retard its mobility, naphthalene can migrate from soil into groundwater with relative ease. Naphthalene can change to 1-napthol or 2-napthol which have the same toxic properties as naphthalene.

3. Toxicokinetics

Naphthalene is readily absorbed at all three portals of entry (gastrointestinal tract, lungs, skin), is widely distributed throughout the body, and is relatively quickly metabolised primarily in the liver and other organs. Naphthalene can also be found in fatty tissues and within breast milk. Naphthalene is metabolised in the liver to yield a variety of hydroxy and methylthio derivatives. The initial metabolite is apparently a 1,2-epoxide produced in the liver by mixed function oxidase enzymes which is subsequently converted to naphthalene dihydrodiol and to alphanaphthol. Both compounds are excreted as such and as glucuronide conjugates. Naphthalene dihydrodiol may be further converted in the eye to yield 1,2-naphthoquinone, a known cataractogenic agent.

Human exposure to naphthalene typically occurs via the inhalation route. Following inhalation, naphthalene is rapidly absorbed throughout the whole body with the highest amount of accumulation in fatty tissues, vascular tissues and adipose tissue. Dermal absorption in humans maybe significant especially for infants and it is further enhanced by prior application of oils.

Naphthalene is primarily excreted in the form of water soluble metabolites in urine within 3-4 days of exposure. The faeces and lungs are other routes of elimination, primarily of unmetabolised naphthalene.

4. Threshold (non-carcinogenic) Health Effects (ATSDR, 2005)

Acute exposure to naphthalene can present health effects such as headaches, nausea, vomiting, diarrhoea, malaise, confusion, anaemia, jaundice, convulsion and coma. Cataracts have been reported in humans exposed to naphthalene by inhalation and ingestion. Cataracts and lung injury have also been reported in animals following acute oral exposure. Naphthalene is primarily a skin irritant and is acutely irritating to the eyes of humans. Reports that establish associations between naphthalene exposure and health effects in humans are restricted to numerous reports of hemolytic anemia or cataracts following acute exposure or occupational exposure to naphthalene, either by ingestion or by inhalation of naphthalene vapours.

A relationship appears to exist between an inherited deficiency in the enzyme, glucose 6-phosphate dehydrogenase (G6PD), and susceptibility to naphthalene-induced haemolysis. Newborn infants also appear to be susceptible to naphthalene-induced haemolysis presumably due to a decreased ability to conjugate and excrete naphthalene metabolites (ATSDR, 2005).

Sub-chronic exposure to naphthalene in animals has resulted in changes in body weight, cataracts, lethargy and decrease in weight of the kidneys and spleen.

Chronic exposure of workers has reportedly resulted in cataracts and retinal hemorrhage. In mice chronic exposure to naphthalene via inhalation caused lung and nasal inflammation, hyperplasia of the respiratory epithelium in the nose and metaplasia of the olfactory epithelium. Rats and mice chronically exposed by gavage of naphthalene developed increased proteinosis in the alveolar and increased lung adenomas in males. Neonatal (and presumably foetal) anaemia was reported following transplacental exposure of the foetus to ingested naphthalene. Results from animal studies exposed to naphthalene by oral administration, by inhalation exposure, or by parenteral administration identify several health effects of potential concern for humans, including maternal toxicity during pregnancy with acute oral exposure, decreased body weight (without lesions developing in any tissues or organs) with intermediate oral exposure, and increased incidence of non-neoplastic and neoplastic lesions in the nose (in rats and mice) and the lung (in mice only) with chronic inhalation exposure.

5. Carcinogenic (genotoxic) Health Effects (ATSDR, 2005)

Human data are insufficient with regard to the evaluation of carcinogenicity of naphthalene. Testing in animals has indicated that naphthalene was carcinogenic to rats and mice following inhalation exposure. Review of these studies by the UK (2003) and the EU (2003) indicate that the tumours observed following inhalation exposure did not arise by a direct genotoxic mechanism.

The only known studies of cancer in humans exposed to naphthalene include:

- four laryngeal cancer cases (all of whom were smokers) among workers in a naphthalene purification plant in East Germany, and
- 23 cases of colorectal carcinoma admitted to a hospital in Nigeria.

NTP, USEPA, and IARC concur that these studies provide inadequate evidence of naphthalene carcinogenicity in humans. No cohort mortality or morbidity studies or case-control studies examining possible associations between naphthalene exposure and increased risk of cancer (or other health effects) are available.

Testing in animals has indicated that naphthalene was carcinogenic to rats and mice following inhalation exposure (ATSDR, 2005). It is generally accepted that the tumours observed following inhalation exposure did not arise by a direct genotoxic mechanisms (UK (2003), EU (2003), OEHHA (2004)).

Therefore use of a non-threshold approach in this risk assessment was not considered appropriate for the quantification of risk associated with naphthalene exposure.

5.1 IARC Toxicity Classification

Naphthalene is classified as a "possible" human carcinogen (Category C) by the USEPA for all routes of exposure based upon limited evidence from animal studies.

In 2002, the IARC classified naphthalene in Group 2B (possibly carcinogenic to humans). The classification is based on inadequate data of carcinogenicity in humans exposed to naphthalene via the oral and inhalation routes, and limited evidence of carcinogenicity in animals via the inhalation route. There is evidence of naphthalene carcinogenicity based on observations of benign respiratory tumours and a carcinoma in female mice exposed to naphthalene by inhalation. However, inhalation toxicity values for naphthalene based on its potential carcinogenicity were not available from primary sources and this feature of naphthalene toxicity is under review.

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Total Petroleum Hydrocarbon (TPH) Toxicological Profile

1. General Information

Total Petroleum Hydrocarbons (TPH) is the collective name given to approximately 250 hydrocarbon based compounds which are derived from crude oil (ATSDR, 1999). This should not be confused with the generic term 'petroleum hydrocarbons'. The generic term refers to hydrogen and carbon containing compounds originating from crude oil, whereas the term TPH is specifically associated with environmental sampling and analysis. TPH is essentially a type of analytical method used to estimate the concentration of petroleum hydrocarbons in environmental media. Note that it does not imply a specific analytical method, and estimates of TPH concentration can often vary depending on the analytical method used (ATSDR, 1999). Non-petroleum hydrocarbons are typically removed from a soil solvent extract by passing the extract through a silica gel column.

There are several hundred compounds defined as petroleum-based. Aromatic TPH compounds typically include benzene, toluene, ethylbenzene and xylene (BTEX), a number of other monoaromatic hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs). Typical aliphatic TPH compounds are the alkanes, also referred to as paraffins (eg, pentane, hexane) (ATSDR, 1999).

1.1 TPH Fractions

It is rarely practicable to quantify each chemical constituent contained within a hydrocarbon fuel or oil, and toxicological information is only available for around one tenth of TPH compounds. In order to assess health risks from TPH, it is necessary to group the TPH compounds.

The Massachusetts Department of Environmental Protection (MA DEP) originally introduced a solution to this problem. MA DEP split TPH into a relatively small number of fractions with similar physical-chemical properties, simplifying modelling of their movement in the environment and allowing toxicity characteristics to be assigned to the fractions (MA DEP, 1994).

Independently the TPHCWG, (TPHCWG, 1997a) developed with a similar methodology and grouping, adding support to their conclusions. The MA DEP report was state-specific and has since been updated, whereas the TPHCWG work was more generically applicable and now forms an international basis for TPH evaluation. Thus the TPHCWG volumes (TPHCWG, 1997a; 1997b; 1998) form the basis for the remainder of this toxicity profile.

TPHCWG recommends that TPH be broken down into its aromatic and aliphatic fractions with different toxicity and mobility characteristics. TPHCWG divided TPH compounds into the fractions listed below, and provided physical and chemical data, and toxicological data that the Criteria Working Group considered representative of each fraction. TPHCWG did not consider TPH compounds with carbon numbers greater than 34.

Aliphatic TPH: C_5-C_6, $C_{>6}$-C_8, $C_{>8}$-C_{10}, $C_{>10}$-C_{12}, $C_{>12}$-C_{16}, $C_{>16}$-C_{21}, $C_{>21}$-C_{34}

Aromatic TPH: C_7-C_8, $C_{>8}$-C_{10}, $C_{>10}$-C_{12}, $C_{>12}$-C_{16}, $C_{<16}$-C_{21}, $C_{<21}$-C_{34}

1.2 TPHCWG Fractions

More than 200 hydrocarbons were considered by TPHCWG in the development of fraction specific properties. A simple screening-level partitioning model, based on the ASTM Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, "RBCA" (ASTM, 1995) was applied to each chemical in order to quantify, individually, the chemical's relative ability to leach from soil to groundwater and volatilise from soil to air. Based on the modelling results, the chemicals were grouped into fractions (using an order of magnitude as the cut-off point) (TPHCWG, 1997a).

Within each of the initial fractions the hydrocarbons were then grouped relative to their equivalent carbon (EC) number. The equivalent carbon number, EC, is related to the boiling point of a chemical normalised to the boiling point of the n-alkanes. This can also be determined from retention time in a boiling point gas chromatographic (GC) column. This relationship was empirically determined. Thus, for chemicals where only boiling points are known, an equivalent carbon number can be easily calculated (TPHCWG, 1997a).

For example, hexane contains six carbons and has a boiling point of 69°C. Its equivalent carbon number is six. Benzene, also containing six carbons, has a boiling point of 80°C. Based on benzene's boiling point and its retention time in a boiling point GC column, benzene's equivalent carbon number is 6.5. This approach is consistent with methods routinely used in the petroleum industry for separating complex mixtures and is a more appropriate differentiation technique than the carbon number of the chemical. Additionally this is consistent with the way analytical laboratories report carbon numbers when chemicals are evaluated on a boiling point GC column (TPHCWG, 1997a).

Once the fractions were defined, typical fate and transport properties were assigned to each fraction based on an empirical relationship between fate and transport properties of chemicals within each fraction and boiling point. These properties could be used to estimate fraction-specific exposure potential at petroleum hydrocarbon contaminated sites (TPHCWG, 1997a).

Volume 3 of the TPHCWG series (TPHCWG, 1997a) describes the process of defining the fractions. Fraction-specific properties can then be used to estimate the partitioning of the specific fraction in soil-water-air systems. Fate and transport models (either simple or complex) can then be applied as well. This revolutionary approach is now the accepted international basis for TPH evaluation.

Table 7 in Volume 3 (TPHCWG, 1997a) presents physical parameters for fractions based on simple averaging, composition-weighted averaging, and correlation to relative boiling point index. Although each method yields similar results, the 'averaging of fractions' method to be consistent with the CRC CARE methodology has been adopted. Note that consistent with paragraph 4.3.5 in Volume 3 (TPHCWG, 1997a), the diffusivity in air should be set to 0.1 cm^2/sec for all fractions, and the diffusivity in water should be set to 0.00001 cm^2/sec for all fractions.

2. Physical and Chemical Properties

The physical and chemical properties of the various TPH fractions are presented in **Table 1**, and were sourced from Table 7 (averaging of fractions) in TPHCGW (1997a).

Table 1 Physical and Chemical Properties of Total petroleum Hydrocarbons

Variable	Symbol	Unit	Aliphatic C6-C10[a]	Aliphatic >C10-C16[b]	Aliphatic >C16-C34[c]	Aliphatic >C34-C40[c]	Aromatic C6-C10[d]	Aliphatic >C10-C16[e]	Aliphatic >C16-C34[f]	Aliphatic >C34-C40[g]	Reference
Molecular Weight	MW	g/mole	120	185	280	280	106	145	215	250	TPHCWG
Henry's Law Constant @ 25oC	H'	unitless	119	160	110	110	0.345	0.219	4.99E-03	8.2E-05	TPHCWG
Henry's Law Constant @ 25oC	H'	atm-m^3/mol	2.89	3.90	2.68	2.68	8.41E-03	5.34E-03	1.22E-04	2.0E-06	TPHCWG
Vapour Pressure	ρ	mmHg	29.2	0.288	8.36E-04	8.36E-04	16.7	0.38	8.8E-04	1.2E-05	TPHCWG
Aqueous solubility	S	mg/L	8.35	0.027	1.5E-06	1.50E-06	315	19.7	0.29	2.9E-02	TPHCWG
Soil-water partition coefficient	Kd	cm^3/g	-	-	-	-	-	-	-	-	-
Organic carbon partition coefficient	Koc	cm^3/g	1.0E+04	1.26E+06	3.98E+08	3.98E+08	562	4.47E+03	4.47E+04	1.26E+5	TPHCWG
Log of octanol-water partition coefficient	log Kow	-	3.9	5.65	6.0	6.0	2.13	3.58	5.16	5.16	RAIS
Dermal permeability constant	Kp	cm/hr	0.201	1.7	1.96	1.96	1.49E-02	6.92E-02	0.308	0.308	RAIS
Soil dermal absorption factor	DAF	-	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	CCME (2008)
Oral bioavailability in soil	Bio	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-

Diffusivity in air	Dair	cm^2/sec	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	TPHCWG
Diffusivity in water	Dwater	cm^2/sec	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	TPHCWG

ND: No data available

a) Represents the average value of EC>C6-C8 and EC>C8-C10

b) Represents the average value of EC>C10-C12 and EC<C12-C16

c) Represents the EC>C16-C35 value

d) Represents the average value for EC>C7-C8 and EC>C8-C10

e) Represents the average value for EC>C10-C12 and EC>C12-C16

f) Represents the average value for EC>C16-C21 and EC>C21-C35

g) Represents the EC>C21-C35 values

3. Presence in the Environment

TPH are used extensively and are used in a wide variety of industries. Their main use is as fuel, and they are primarily found in petroleum products including petrol, diesel, fuel and motor oils, household solvents, cleaners and asphalt (ATSDR, 1999).

TPH enters the environment via leaking underground fuel tanks, industrial releases, volatilisation during transport, handling and use, and from accidental spillage of petroleum products during commercial or private uses (ATSDR, 1999). TPH (particularly the PAH compounds) are also released to the atmosphere as a result of incomplete combustion of fuels in boilers, motor vehicles and other petroleum –fuelled machinery (ATSDR, 1999).

4. Environmental Fate and Transport

The fate of TPH compounds varies by fraction: when spilled onto or into soils, lighter fractions are prone to volatilisation. On water, spilled oil will quickly spread out, forming a film less than 1mm thick. In this way the oil may cover a large area very quickly. Some of the heavier fractions, for example some of the PAH compounds are denser than water, making them likely to sink and accumulate in sediments (ATSDR, 1999).

Over time, petroleum products in the environment are broken down by chemical, physical and biological processes, which generally results in a gradual lower of toxicity. This weathering effect is relatively rapid in surface waters and surface soils, however at depth, and particularly in groundwater, weathering processes may operate very slowly (ATSDR, 1999). TPH compounds are variably biodegradable, however as a general rule the lower carbon numbers are likely to biodegrade more quickly, and aerobic degradation is likely to be the dominant process. Anaerobic degradation of TPH is not likely to be significant (ATSDR, 1999). Shorter chain TPH are not likely to bioaccumulate, however some heavier compounds, particularly the PAHs may do so (ATSDR, 1999).

When oil is spilled into the ground it flows as a bulk product with little separation of the various components. In soils, the oil will migrate downwards under the influence of gravity. It leaves behind a residual amount adsorbed to soil particles, which may persist for many years and which is generally immobile. Oils reaching the water table will spread out (most petroleum mixtures are less dense than water and are often referred to as LNAPLs – 'light non-aqueous phase liquids) and may travel some distance on groundwater. The behaviour of LNAPL in groundwater is influenced by the head of the LNAPL, which may force the product to some metres below the water table, where it forms a 'plug' that gradually spreads laterally both beneath and at the water table (LSP, 2005).

From the bulk oil spill, TPH compounds may migrate into the atmosphere through volatilisation. Volatile TPH may also move through unsaturated soils in the vapour phase, and can move laterally in response to pressure gradients. Although the TPH compounds are generally of low water solubility, dissolution of the BTEX and some other short chain compounds does take place and dissolved phase TPH compounds can be mobile in groundwater (ATSDR, 1999).

5. Toxicokinetics

As the petroleum products are highly volatile, inhalation is the primary route of exposure. However ingestion and dermal absorption of TPH via contact with fuel, and contaminated soil and groundwater are also possible routes of exposure to TPH. Little information is available regarding the toxicokinetics of TPH mixtures because the majority of studies focus on individual components of TPH. Human and animal studies indicate that benzene, toluene, ethylbenzene and xylene (BTEX) which are components in the lighter aromatic TPH fractions (>C_5-C_8) are readily absorbed via inhalation and ingestion. BTEX compounds are also absorbed following dermal exposure to a lesser extent (ATSDR, 1999). These compounds are widely distributed in tissue and organs, metabolised via oxidative metabolic pathways to more soluble metabolites and excreted primarily in the urine. Metabolism of BTEX can produced more toxic or less toxic metabolites (ATSDR, 1999).

The absorption of heavy aromatic TPH fractions decreases with increasing weight, however lipophillic delivery vehicles can increase the degree of absorption. The metabolism of polycyclic aromatic hydrocarbons (PAHs), which are components in heavier aromatic TPH fractions (>C_{17}-C_{36}) produce arene oxide, phenols, phenol-diol and phenol-epoxide (ATSDR, 1999). Absorption of aliphatic TPH fractions decreases with increasing weight and aliphatic TPH (>C_{16}-C_{35}) are poorly absorbed regardless of the route of exposure. Aliphatic TPH are preferentially distributed and stored in fatty tissue in the body (ATSDR, 1999). Hexane which is a component of aliphatic TPH (>C_5-C_7) is metabolised oxidatively to alcohol, ketone, carboxylic acid and dihyrodiol whereas aliphatic TPH (>C_{16}-C_{35}) are slowly metabolised to fatty acids and triglycerides (ATSDR, 1999).

In the absence of evidence to the contrary 100% bioavailability via ingestion and inhalation has been assumed. Dermal bioavailability was estimated at 20% for all TPH fractions in accordance with CCME (2008) methodology.

6. Threshold (non-carcinogenic) Health Effects (ATSDR, 1999)

As TPH consists of a vast number of compounds, many different health effects are possible including: central nervous system effects, blood effects, immune effects, lung effects, skin effects, eye effects, reproductive effects, liver effects and kidney effects. The toxicity criteria adopted primarily focuses on liver, kidney, body weight and blood effects.

Generally, the body system most affected by TPH compounds is the central nervous system; other body systems affected include the blood, immune system, lungs, skin and eyes. Effects of TPH compounds include dizziness, headaches, peripheral neuropathy and reproduction impairment. Allergic or idiosyncratic effects may include skin disorders such as dermatitis upon dermal contact. The swallowing of some petroleum products such as gasoline and kerosene causes irritation of the throat and stomach, central nervous system depression, difficulty breathing, and pneumonia from breathing liquid into the lungs.

Children and foetuses may be at increased risk to benzene toxicity because their haematopoietic cell populations are expanding and dividing cells are at greater risk than quiescent cells. In addition, people with sub-clinical and clinical epilepsy are considered at increased risk of seizures from exposure to xylene because of its central nervous system effects. Additional chronic health effects that are specific to particular fractions are summarised in **Table 2** (ATSDR, 1999; TPHCWG, 1998).

Table 2 **Health Effects of Aliphatic and Aromatic TPH fractions**

TPH Fraction	Key Chemicals	Health Effects
Aromatic C6 – C9	Benzene, toluene, ethylbenzene and xylenes	Central Nervous System (CNS) depression, skin/eye irritation, renal & hepatic effects.
Aromatic C10 – C14	Naphthalene, Isopropylbenzene, methylbenzene, butyl.	Anaemia, renal effects & hepatic effects, skin irritation.
Aromatic >C15	Pyrene, various Polycyclic Aromatic Hydrocarbons	Anaemia, immunological effects,
Aliphatic C6 – C9	n- hexane, n-pentane, n-octane.	Neurological and respiratory effects, peripheral neuropathy, reproductive effects, skin and eye irritation.
Aliphatic C10 – C14	Kerosene, nonane, JP-8.	CNS depression, neuropathy, renal and hepatic effects, skin and eye irritation.
Aliphatic >C15	Elcosane, hydraulic fluids, mineral oils.	Hepatic and lymph node effects,

7. Carcinogenic (genotoxic) Health Effects (ATSDR, 1999)

Carcinogenic effects cannot be applied to TPH in general however multiple individual compounds (e.g., benzene and benzo(a)pyrene) have been positively linked to human carcinogenic effects. Benzene is a known human genotoxic carcinogen for all routes of exposure, with epidemiological studies and case reports providing clear evidence of a causal relationship between occupational exposure to benzene and an increase in the occurrence of certain types of leukaemia.

8. IARC Toxicity Classification

The International Agency for Research on Cancer (IARC) determined that the TPH compounds benzene and benzo(a)pyrene are carcinogenic to humans. Most of the other TPH compounds are considered not to be classifiable by IARC (IARC, 1989; ATSDR, 1999).

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Fluoride Toxicological Profile

1. General Information

Fluorides are defined as compounds of fluorine such as hydrogen fluoride, sodium fluoride, calcium fluoride, aluminium fluoride, fluorosilicic acid and fluorosilicates. The toxic effect of these salts are mainly due to the fluoride ion. In this toxicological profile, fluoride refers to common compounds of fluorine. Fluorine is a pale, yellow-green, pungent gas with a strong, sharp odour. It is highly chemically reactive and therefore rarely found in its free state but combines readily with hydrogen or with metals acids or salts. Hydrogen fluoride is a colourless gas and rapidly dissolves in water at room temperature to form hydrofluoric acid. Hydrogen fluoride is used in the petrochemical industry as a component of superacids and is used to manufacture fluorine-based chemicals such as sodium fluoride which is used in the aluminium smelting process. Sodium fluoride is a white solid which dissolves readily in water. Sodium fluoride, fluorosilicic acid and sodium fluorosilicate are frequently added to drinking water supplies, toothpastes and mouthwashes to treat dental cavities. Calcium fluoride is the main constituent of fluorite and fluorspar minerals which are used in the production of hydrogen fluoride, glass and enamel. Aluminium fluoride is used mainly in the production of aluminium (ATSDR 2003).

2. Physical and Chemical properties

Fluorine is the lightest member of the halogen group (i.e. the halogen group comprises fluorine, chlorine, bromine and iodine). Fluorine is the most reactive element in the periodic table due to its high electronegativity and small size which enables the formation of simple and complex forms of fluorides at room temperature or high temperatures. However, fluorine does not react with nitrogen, oxygen and the lighter noble gases. The physical and chemical properties of fluorine (soluble fluoride) are summarised in **Table 1**.

Table 1 Physical and Chemical Properties of Fluoride

Variable	Unit	Value	Reference
CAS Number	-	7782-41-4	RAIS
Chemical Formula	-	F_2	-
Molecular weight	g/mol	38	RAIS
Water solubility	mg/L	1.69	RAIS
Henry's Law Constant	Unitless	No data	-
Vapour pressure	mmHg	No data	-
Density	g/cm^3	1.55	RAIS
Diffusivity in air	cm^2/sec	No data	-
Diffusivity in water	cm^2/sec	No data	-
Solid/Liquid Partition Coefficient (K_d)	cm^3/g	150	RAIS

Notes:
RAIS: Risk Assessment Information System online database

3. Environmental Transport, Distribution and Transformation

Fluorides occur naturally as components of rocks and soil and can also be detected in trace amounts in air, water and plants. Volcanic eruptions, marine aerosols and wind deflations are some of the natural phenomena that introduces fluorides into the atmosphere. Anthropogenic sources of fluoride emission include combustion of coal, alumina smelting, phosphate fertiliser production, production of chemicals and structural products. In addition, fluorides are also released into surface water and groundwater as a result of fluoridation of water and mouth washing products.

Hydrogen fluoride in the atmosphere is normally absorbed by moisture and removed by rain, sleet, snow or hail. Particulate fluorides in the atmosphere are removed by either wet or dry deposition. Fluorides from weathered rocks or atmospheric deposition have the potential to bind to clays or other soil types to form complexes with aluminium, iron and calcium. Fluorides in soil may be taken up and accumulate in plants depending on the type of plant (e.g. tea plant (Fung *et al*. 1999)), soil type, fluoride concentration and form of fluoride. Fluorides occur mostly as aluminum fluorosilicate complexes in acidic soils and calcium fluoride in alkaline soils. The bioavailability of these complexes increases with decreasing pH (Fung *et al*. 1999; Shacklette *et al*. 1974). This explains why acidic soils have both higher water-soluble fluoride and higher extractable aluminum levels. The retention of fluoride in alkaline soils depends largely upon the aluminum content of the soil. Fluorides accumulate in skeletal tissues of animals that consume fluoride-containing foliage but does not accumulate in their milk and edible tissues (NAS 1971).

Fluorides in soil can be transported through leaching or runoff to nearest water bodies where they settle as sediments (Carpenter 1969) or accumulate in some marine aquatic organisms such as brown mussel (*Perna perna*), mullet (*Mugil cephalus*), crab (*Tylodiplax blephariskios*) and shrimp (*Palaemon pacificus*) (Hemens and Warwick 1972). At pH less than 5, fluoride in water bodies almost completely reacts with aluminium to form aluminium fluoride and the free fluoride level is almost zero (Skjelkvale 1994). As the pH increases, aluminium in water reacts more with water to form aluminium hydroxide and the free fluoride levels increase (Skjelkvale 1994). Fluoride can also react with calcium and magnesium salts in water to form stable complexes which precipitate as sediments (Carpenter 1969).

Humans are exposed to fluoride through consumption of drinking water, foods and toothpaste. People who drink large quantities of tea may also be exposed to high fluoride levels in their diets especially when the vegetables and fruits are grown near industrial fluoride sources or near hazardous waste sites. Children and infants are mostly exposed through consumption of fluoridated water mixed with infant formula (Levy *et al*. 1995, 2001).

4. Toxicokinetics

4.1 Absorption

Fluoride can be absorbed into the body via inhalation, oral ingestion and dermal absorption. High levels of fluoride were detected in the plasma 2-4 hours after inhalation exposure (Collings *et al*. 1952) which shows that fluoride is rapidly distributed through the blood. When ingested, it is readily absorbed from the gastrointestinal tract. It is also absorbed from both the stomach and small intestine via passive diffusion. High fluoride levels have been detected in the plasma 30-60 minutes after ingestion (Carlson *et al*. 1960; Ekstrand *et al*. 1977, 1978). Some dietary factors such as delayed gastric emptying (Messer and Ophaug 1993), ingestion of fluoride with food (Shulman and Vallejo 1990; Trautner and Einwag 1987), ingestion of sodium fluoride with milk (Ekstrand and Ehrnebo 1979; Shulman and Vallejo 1990; Trautner and Seibert 1986), consumption of high calcium diets (Jowsey and Riggs 1978; Whitford 1994), increased exposure to magnesium or aluminium (Stookey *et al*. 1964;) slows the rate of fluoride absorption. Other dietary factors such as ingestion of calcium fluoride with food significantly increased the rate of fluoride absorption (Trautner and Einwag 1987). Hydrogen fluoride can be absorbed through the skin of human and animals but the rate of absorption is unknown. It is expected though that the duration of contact and concentration of the compound will be directly proportional to the rate of absorption and will therefore influence the corrosivity of hydrogen fluoride.

4.2 Distribution

In rabbits, guinea pigs and monkeys, inhaled hydrogen fluorides were found to distribute to the rest of the body and accumulate in the skeleton (Machle and Scott 1935). In humans, reports of skeletal fluorosis (Czerwinski *et al*. 1988) and high bone fluoride levels (Boivin *et al*. 1988) suggest that hydrogen fluoride is distributed to all around the body and accumulates in the bones and skeleton. Fluoride level in the bone reduce once the source of exposure has been removed. No data were found regarding fluorine inhalation and distribution in humans but animal studies show that inhalation of fluorine elevated fluoride levels in teeth and bone (Stokinger 1949).

Once fluoride is absorbed, it is distributed around the body via the plasma and blood cells with plasma levels being two times higher than in blood (Whitford 1990). The half-life of fluoride in human plasma is 2-9 hours (Ekstrand *et al* 1977a); 0.88 hours in pig plasma (Richards *et al.* 1982). Fluoride does not accumulate in soft tissues and it was also found that the blood brain barrier helps to prevent high fluoride levels in the central nervous system (Spak *et al*. 1986; Whitford *et al*. 1979). Sometimes the concentration of fluoride levels in renal tubules exceed plasma levels. The highest fluoride levels in the body is found in calcium containing tissues such as the skeleton, bones and teeth and 99 % of fluoride in the body are found in these calcified tissues (Hamilton 1990). The biological half-life of fluoride in pigs orally exposed to 2 mg fluoride/kg/day for six months is 58.5 days (Richards *et al*. 1985).

Fluoride can be easily transferred to the placenta. As maternal fluoride levels increase, cord fluoride levels also increase but the concentration in the cord is significantly lower (Armstrong *et al*. 1970; Gupta *et al.* 1993). As maternal fluoride levels increase significantly, the placenta forms a barrier regulating the transfer of high fluoride levels to the foetus (Gedalia 1970).

Fluoride is poorly transferred from plasma to milk, however, significantly higher breast milk fluoride levels have been found in women living in areas with high naturally occurring fluoride levels (1-7 ppm) than in women in areas of low fluoride levels in tap water (0.2 ppm) (Esala *et al*. 1982).

4.3 Metabolism

Fluoride displaces the hydroxyl ion and bicarbonate ion in hydroxyapatite in the bone to form hydroxyfluroapatite (McCann and Bullock 1957) but this process can be reversed during bone remodelling (lifelong replacement of old bones with new bone tissues in the skeleton) to yield lower fluoride levels in the bone (Turner *et al*. 1993). Once absorbed by the bone, a portion is deposited in the skeleton, and most of the remaining fluoride is excreted in the urine, with smaller amounts in faeces, and sweat and saliva within 24 hours (Dinman *et al.* 1976). A part of the inorganic fluoride alters enzyme activities especially those requiring a metal ion co-factor by reacting with the enzymes and substrates or by forming metallic fluoro-phosphate complexes. This inhibition of enzyme activities can result in a reduction in cell energy production (Guminska and Sterkowicz 1975).

4.4 Elimination and Excretion

The main route for fluoride excretion is via the kidneys and urine; other minor routes are feces, sweat, and saliva. Fluoride absorbed via inhalation was found to be excreted via urine during exposure and peaking at 2-4 hours after cessation of exposure (Collings *et al*. 1951). High fluoride levels were found in dogs' urine exposed to 0.8 mg/m^3 fluorine for 5-6 hours/day, 6 days/week for 35 days (Stokinger 1949). About 35-70 % of ingested fluoride is excreted via urine (Ekstrand *et al*. 1978); ≤ 1 % of ingested fluoride was excreted via saliva (Carlson 1960) and 19 % of ingested fluoride was excreted via sweat (McClure *et al.* 1945) under normal conditions of atmospheric temperature and humidity. Low pH levels in the renal tubules can lead to fluoride reabsorption because at lower pH levels, fluorides exist mostly in their combined form (hydrogen fluoride) which can easily diffuse through the tubular epithelium into the blood stream (Ekstrand *et al*. 1980).

5. Non-threshold / Carcinogenic Health Effects

5.1 Mutagenicity

Human *in vivo* experiments on the genotoxicity of fluorine, hydrogen fluoride, or fluoride could not be found. Female white rats were observed to have cell damages after inhalation exposure to hydrogen fluoride for six hours, six days a week, for one month, at 1.0 mg/m^3 (Voroshilin *et al*. 1975). The same researchers tested for genetic mutations in C57Bl mice and found that the number of developing embryos did not change considerably from those of the controls. *Drosophila melanogaster* eggs collected from adults of two different strains were exposed to 1-2.2 mg fluoride as hydrogen fluoride for 3-6 weeks and reproductive factors were assessed for genotoxicity. Both the number of ova per female and male sperm cells were significantly reduced, but the experiment did not indicate the exposure level or duration at which the reduction was maximum (Gerdes *et al*. 1971).

Chromosomal aberrations have been observed in the oral exposure of 59 mg fluoride/kg body weight to Chinese hamsters. Even though genotoxicity was observed, the dose is high enough to be toxic and even lethal (Li *et al*. 1987). It appears that oral exposure to fluoride may be fatal but the dose required for such fatal effects are usually high. No adverse effect of fluoride on body weight was observed in the oral exposure of 22.8 mg fluoride/kg/day. Frequent chromatid breaks was observed after an oral dose of 18 mg fluoride/kg was administered to Swiss mice (Pati and Bhunya 1987). Similarly, three out of eight animals died when Chinese hamsters were administered 59 mg fluoride/kg body weight. Although sister chromatid exchange did not increase, the cell cycle progression was hindered implying that fluoride's main effect at this concentration is cellular toxicity rather than DNA alteration (Li *et al*. 1987). While the mechanism genotoxicity of fluoride is still being investigated, a generally-accepted mode of fluoride genotoxicity is that at high doses, fluoride inhibits DNA proteins which eventually reduced the effectiveness of the DNA in repairing dead cells (Caspary *et al*. 1987, 1988).

5.2 Carcinogenicity

High cancer occurrence has been observed in workers that have been exposed to high levels of fluoride. However, these studies were not controlled to ensure there are no synergistic effects due to exposure to other toxic compounds (Andersen *et al*. 1982; Cecilioni 1972; Gibbs and Horowitz 1979; Milham 1979; Rockette and Arena 1983).

Cancer death rates have been studied in areas with low or high fluoride levels in drinking water (Griffith 1985; Hoover *et al.* 1976; Kinlen 1975; Oldham and Newell 1977). A comparative analysis showed that there was no statistically substantial evidence that high water fluoride levels is associated with an increase in cancer mortality.

An ambiguous evidence of bone cancer osteosarcoma in male rats and non-carcinogenicity in female rats and mice have been observed in a long term oral exposure of sodium fluoride to rats and mice (Bucher *et al*. 1991; NTP 1990). The relevance of this study to human health may be questioned based on the fact that administered doses in this animal study were much higher than those to which humans are exposed. However, because fluoride accumulates in the bone over time, the fluoride levels in the high dose male rats after a 2-year exposure was similar to the levels reported in people with a lifetime exposure of fluoride in water at 4 ppm (Zipkin *et al*. 1958). In another study, a low fluoride diet fed to male and female rats showed no sign of carcinogenicity. The study is however limited based on the high mortality observed in treatment and control groups, inadequate diet and inadequate pathological examination (Maurer *et al.* 1990).

5.3 IARC Classification

After rigorous literature studies in 1982, the International Agency for Research on Cancer (IARC) concluded that "t*here is no evidence from epidemiological studies of an association between fluoride ingestion and human cancer mortality, and the available data are inadequate for an evaluation of the carcinogenicity of sodium fluoride in experimental animals* (IARC 1982)". Since the IARC resolution in 1982, various investigations have been undertaken on fluoride carcinogenicity (Rockette and Arena 1983; Griffith 1985; NTP 1990; Maurer *et al.* 1990; Bucher *et al*. 1991).

6. Threshold Non-Carcinogenic Health Effects

Short-term high dose exposure of sodium chloride can affect the intestine and even cause death. An accidental exposure of 16 mg/kg dose to a child resulted in death (Eichler *et al*. 1982). Long-term exposure to fluoride can cause teeth discolouration and skeletal fluorosis. The extent of discolouration increases with an increase in fluoride dose. Studies have found that 20 % of children exposed to 1 ppm of fluoride had spots on their teeth (DHHS 1991). Elderly people living in communities with high fluoridated water are more likely to be more vulnerable to hip fractures according to an epidemiological study (Danielson *et al*. 1992). A guideline value of 1.5 mg/L in drinking water equivalent to a total daily intake (TDI) of 0.04 mg/kg/day has been set by the Australian National Health Medical Research Council NHMRC and World Health Organisation (NHMRC 2016, WHO 2006).

A minimal risk level (MRL) of 0.05 mg/kg/day has been estimated for chronic oral exposure based on a Lowest Observed After Effect Level (LOAEL) of 0.48 mg/kg/day to reduce the risk of non-vertebral fracture in women suffering from osteoporosis (Riggs *et al*. 1990). No oral or inhalation MRL has been derived based on exposure durations because the data from human exposure were not derived from a properly controlled experiment and also the animal data lacked reliable LOAELs and the reliable animal data are obtained based on a maximum of one hour exposure. No MRLs have been derived for dermal exposure to fluorides because suitable MRL methodology has not been derived.

Animal data show that short-term high-level exposure to fluorine can cause death due to its corrosive effect on the respiratory tract (Stokinger 1949). The lethality of fluorine on humans would depend on concentration, percentage of the body exposed (dermal route) and duration of exposure and treatment utilised (Chela *et al*. 1989). Even though such effects are expected based on fluoride chemical properties as well as its irritating effect, no experiments on the lethality of fluorine on humans have been found (Keplinger and Suissa 1968). Some animal studies suggest that a pre-exposure to low fluorine levels may hinder or reduce death effects (Keplinger 1969).

Exposure of hydrofluoric acid via the dermal and inhalation pathway can lead to death due to pulmonary edema (Tepperman 1980). Exposure via the dermal route can cause death due to cardiac arrhythmias (Mullett *et al*. 1987). Oral exposure to small amounts of hydrofluoric acid can cause fatality or injury to the gastrointestinal tract and vascular organs (Menchel and Dunn 1984).

Sever poisoning effects have been observed in humans at 14 mg/kg of sodium fluoride (Greenwood 1940) while fatality has been observed at 32-64 mg fluoride kg body weight (Hodge and Smith 1965). Clinical case studies in humans suggest that drinking water levels of fluoride as low as approximately 40 ppm cause nausea, vomiting, and diarrhea and hospitalisation at higher concentrations. It is hard to predict the fluoride fatality levels in humans because of the nauseating effect of high fluoride levels in drinking water.

Swiss-Webster mice have been observed to show signs of coagulation necrosis in the renal cortex after exposure to fluorine (Keplinger and Suissa 1968). Renal effects such as anuria and elevated serum creatinine levels has been observed on workers face that was splashed with hydrofluoric acid (Braun *et al*. 1984).

People with inhibited renal clearance may likely be more vulnerable to high fluoride effects according to studies conducted by Spencer *et al* (1980). Mice administered with 26-52 mg fluoride/kg/day as fluoride in water was found dead due to kidney inflammation (NTP 1990).

Since high levels of fluoride are found in the kidney after exposure (Whitford and Taves 1973) and the kidney is a major organ for elimination of fluoride (Spencer et al. 1970), it is reasonable to assume that the kidney is a major target organ for fluoride toxicity. However, kidney damages due to exposure to fluorine and fluorides have not yet been reported in normal healthy people. However, animal studies have reported kidney damages due to high fluoride exposure levels (NTP 1990).

Skin and eye irritation and damages have been observed on people exposed to hydrogen fluoride. Hydrofluoric acid is corrosive and can cause skin burns, tissue damage and death due to a rapid absorption of the fluoride ion through the skin (Chela *et al*. 1989).

Although fluoride can penetrate the placenta in small amounts (Theuer *et al*. 1971), epidemiological studies found no increased birth defects in people living in water fluoridated areas (Erickson et al. 1976). No control studies on human developmental toxicity of fluoride exposure have been found. One animal study showed no change in the number of abnormal baby rats born to mother rats orally exposed to 21 mg fluoride/kg/day (Ream *et al*. 1983). However, stunted growth has been observed on calves exposed to fluoride deposited forages (Maylin and Krook 1982).

There is currently no controlled experimental data on human reproductive effects of fluoride exposure. Data from animal experiments are not conclusive. In one study, the reproductive organs of male rats was found to be a target (Araibi *et al.* 1989). In another study, fluoride did not accumulate in the male reproductive organs (Skare *et al.* 1986) or cause decreased sperm mortality (Dunipace *et al*. 1989). Severe reproductive effects of fluoride exposure have been observed in cows (Van Rensburg and de Vos 1966), dogs (Shellenberg *et al.* 1990), and birds (Guenter and Hahn 1986).

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APPENDIX C6
MODEL PARAMETERS AND RESULTS

Human Health Risk Assessment
Chemical Parameters, Toxicity Information and Exposure Point Concentrations

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	26-May-17

Chemical Specific Physio-Chemical Parameters

Chemical	H'	Koc	Aqueous Solubility	Molecular Weight	Vapour Pressure	Dair	Dwater	Log Kow	Soil Dermal Absorption Factor	Oral Bioavailability	Dermal Permeability (Kp)	DAevent	Gastrointestional Absorption Factor
	unitless	cm^3/g	mg/L	g/mol	mm Hg	cm^2/sec	cm^2/sec	unitless	unitless	unitless	cm/h	mg/cm^2-event	unitless
Fluoride (soluble)	0	0	1.69	38	0	0	0	0	0.001	1	0.001	0.00252151	1
Benzo(a)pyrene	0.0000187	587000	0.00162	252	5.49E-09	0.0476	0.00000556	6.13	0.06	1	0.713	3.1123E-05	1
Benz(a)anthracene	0.000491	177000	0.0094	228	0.00000021	0.0509	0.00000594	5.76	0.06	1	0.552	1.9781E-05	1
Benzo(b)fluoranthene	0.0000269	599000	0.0015	252	0.0000005	0.0476	0.00000556	5.78	0.06	1	0.417	2.3322E-05	1
Benzo(k)fluoranthene	0.0000239	587000	0.0008	252	9.65E-10	0.0476	0.00000556	6.11	0.06	1	0.691	1.2254E-05	1
Indeno(1,2,3-c,d)pyrene	0.0000656	3470000	0.000022	276	1.25E-10	0.0448	0.00000523	6.7	0.06	1	1.04	2.3185E-05	1
Dibenz(a,h)anthracene	0.00000576	1910000	0.00249	278	9.55E-10	0.0446	0.00000521	6.75	0.06	1	0.953	8.711E-06	1
Naphthalene	0.018	1540	31	128	0.085	0.0605	0.00000838	3.3	0.1	1	0.0466	5.5251E-06	1
TRH Aliphatic >C6-C10	118.5	10000	8.345	120	29.2	0	0	3.9	0.2	1	0.201	0.00012878	1
TRH Aromatic >C6-C10	0.345	562	315	106	16.72	0	0	2.13	0.2	1	0.0149	8.9319E-06	1
Chrysene	0.000214	181000	0.002	228	6.23E-09	0	0	5.81	0.06	1	0.596	0	1
Benzo(g,h,i)perylene	0.0000135	1950000	0.00026	276	1E-10	0	0	6.63	0.06	1	1.12	0	1
Arsenic	0	11	0	74.9	0	0		0	0.005	0.8	0.001	0	1
TRH Aliphatic >C10-C16	160	1258925	0.0267	185	0	0	0	5.65	0.2	1	1.7	0	1
TRH Aromatic >C10-C16	0.219	4466.8	19.65	145	0	0	0	3.58	0.2	1	0.0692	0	1
TRH Aliphatic >C16-C34	110	398107170	0.0000015	280	0	0	0	6	0.2	1	1.96	0	1
TRH Aromatic >C16-C34	0.00499	44668.36	0.29	215	0	0	0	5.16	0.2	1	0.308	0	1

Chemical Toxicological Information

Chemical	Oral Reference Dose*	Dermal Reference Dose*	Reference Concentration*	Oral Slope Factor	Dermal Slope Factor	Inhalation Unit Risk
	mg/kg/day	mg/kg/day	mg/m^3	$(mg/kg/day)^{-1}$	$(mg/kg/day)^{-1}$	$(mg/m^3)^{-1}$
Fluoride (soluble)	0.04	0.04	0	0	0	0
Benzo(a)pyrene	0.0003	0.0003	0.000002	1	1	0.087
Benz(a)anthracene	0	0	0	0.1	0.1	0.0087
Benzo(b)fluoranthene	0	0	0	0.1	0.1	0.0087
Benzo(k)fluoranthene	0	0	0	0.1	0.1	0.0087
Indeno(1,2,3-c,d)pyrene	0	0	0	0.1	0.1	0.0087
Dibenz(a,h)anthracene	0	0	0	1	1	0.087
Naphthalene	0.02	0.02	0.003	0	0	0
TRH Aliphatic >C6-C10	4.5	4.5	16.56	0	0	0
TRH Aromatic >C6-C10	0.036	0.036	0.18	0	0	0
Chrysene	0	0	0	0.01	0.01	0.00087
Benzo(g,h,i)perylene	0	0	0	0.01	0.01	0.00087
Arsenic	0.001	0.001	0.001	0	0	0
TRH Aliphatic >C10-C16	0.09	0.09	0.9	0	0	0
TRH Aromatic >C10-C16	0.036	0.036	0.18	0	0	0
TRH Aliphatic >C16-C34	1.8	1.8	0	0	0	0
TRH Aromatic >C16-C34	0.027	0.027	0	0	0	0

Notes:
** Toxicity reference value includes allocation to background*

Exposure Point Concentrations (EPC)

Chemical	Soil EPC for direct contact pathways	Modelled vapour concentration within the CWS Excavation	Groundwater EPC	Surface water EPC
	mg/kg	mg/m3	mg/L	mg/L
Fluoride (soluble)	14304	-	1880	1880
Benzo(a)pyrene	176.4	-	0.0096	0.0096
Benz(a)anthracene	162.2	-	0.0092	0.0092
Benzo(b)fluoranthene	297	-	0.0123	0.0123
Benzo(k)fluoranthene	305.1	-	0.0039	0.0039
Indeno(1,2,3-c,d)pyrene	87.8	-	0.007	0.007
Dibenz(a,h)anthracene	31.2	-	0.0017	0.0017
Naphthalene	-	1.02E-03	0.058	0.058
TRH Aliphatic >C6-C10	-	6.78E-03	0.33	0.33
TRH Aromatic >C6-C10	-	7.16E-03	0.33	0.33
Chrysene	136.6	-	-	-
Benzo(g,h,i)perylene	93.9	-	-	-
Arsenic	151.5	-	-	-
TRH Aliphatic >C10-C16	119.7	-	-	-
TRH Aromatic >C10-C16	119.7	-	-	-
TRH Aliphatic >C16-C34	5988	-	-	-
TRH Aromatic >C16-C34	5988	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 1: Surface water contact by Offsite Recreational Receptors in the Semi-Permanent Dam
Risk Assessor	B.Goldsworthy, N Ahubelem

Chemical Specific Physio-Chemical Parameters

Chemical	H'	Koc	Aqueous Solubility	Molecular Weight	Vapour Pressure	Dair	Dwater	Log Kow	Soil Dermal Absorption Factor	Oral Bioavailability	Dermal Permeability (Kp)	DAevent	Gastrointestional Absorption Factor
	unitless	cm^3/g	mg/L	g/mol	mm Hg	cm^2/sec	cm^2/sec	unitless	unitless	unitless	cm/h	mg/cm^2-event	unitless
Fluoride (soluble)	-	-	1.69	38	-	-	-	-	0.001	1	0.001	0.00047895	1

Chemical Toxicological Information

Chemical	Oral Reference Dose*	Dermal Reference Dose*	Reference Concentration*	Oral Slope Factor	Dermal Slope Factor	Inhalation Unit Risk
	mg/kg/day	mg/kg/day	mg/m^3	$(mg/kg/day)^{-1}$	$(mg/kg/day)^{-1}$	$(mg/m^3)^{-1}$
Fluoride (soluble)	0.04	0.04	-	-	-	-

Notes:
** Toxicity reference value includes allocation to background*

Exposure Point Concentrations (EPC)

Chemical	Soil EPC for vapour pathways	Soil EPC for direct contact pathways	Predicted particulate concentration	Groundwater EPC	PSH Mol Fraction	Surface water EPC	Indoor air EPC	Outdoor air EPC
	mg/kg	mg/kg	mg/m3	mg/L	%	mg/L	mg/m^3	mg/m^3
Fluoride (soluble)	-	-	-	-	-	357.1	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 1: Surface water contact by Offsite Recreational Receptors in the Semi-Permanent Dam
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	3-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	29	NEPM (2013)	6	NEPM (2013)
Exposure frequency to site (days/year)	EF	104	every weekend	104	every weekend
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	-	-	-	0
Soil Dermal Contact					
Exposed skin surface (cm^2/day)	SA	-	-	-	-
Soil skin adherence (mg/cm^2)	SL	-	-	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	-	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	-	-	-	-
Inhalation of Dust and Vapours					
Exposure time spent indoors/ground floor (hrs)	$t_{o\ in}$	-	-	-	-
Exposure time spent in a basement (hrs)	$t_{basement}$	-	-	-	-
Expsoure time spent outdoors (hrs)	$t_{o\ out}$	-	-	-	-
Exposure time spent within a trench (hrs)	t_{trench}	-	-	-	-
Dust lung retention factor (-)	LR	-	-	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	104	every weekend	104	every weekend
Surface water ingestion rate (L/day)	IR_{sw}	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ET_{sw}	1	site assumption	1	site assumption
Exposed skin surface area (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs exposed
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1		1	

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Op
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 1: Surface water contact by Offsite Recreational Receptors
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	3-May-17

	ADULT Oral/Dermal Mean Daily Intake (mg/kg-day)				CHILD Oral/Dermal Mean Daily Intake (mg/kg-day)			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)			9.74E-03	1.82E-02			1.83E-02	1.70E-01

	ADULT Oral/Dermal Chronic Daily Intake (mg/kg-day)				CHILD Oral/Dermal Chronic Daily Intake (mg/kg-day)			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)			4.03E-03	7.53E-03			1.57E-03	1.45E-02

	Adult Hazard Quotients (-) Direct Contact Pathways				CHILD Hazard Quotients (-) Direct Contact Pathways			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	2.43E-01	4.54E-01	-	-	4.58E-01	4.24E+00

	Increased Lifetime Cancer Risk (ILCR) EstimatesDirect Contact Pathways			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option1 offsite - direct contact by future intrusive maintenance worker
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	26-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	30	NEPM (2013) commerical	-	-
Exposure frequency to site (days/year)	EF	20	Assume four weeks for major repairs	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	20	Assume four weeks for major repairs	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option1 offsite - direct contact by future intrusive maintenance worker
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	26-May-17

	ADULT Oral/Dermal Mean Daily Intake (mg/kg-day)			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)			4.05E-04	1.40E-03

	Adult Hazard Quotients (-) Direct Contact Pathways			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	-	-	1.01E-02	3.49E-02

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 1 onsite - direct contact with groundwater during monitoring of CWS leachate.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	16-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	30	NEPM (2013) commerical	-	-
Exposure frequency to site (days/year)	EF	5	Site-specific, assumed time to repair cap	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	-	-	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	-	-	-	-
Soil skin adherence (mg/cm^2)	SL	-	-	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	-	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	-	-	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	4	assumes quarterly monitoring, and sample collection takes one day	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 1 onsite - direct contact with groundwater during monitoring of CWS leachate.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	16-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)			4.27E-04	1.47E-03
Benzo(a)pyrene			7.07E-06	7.51E-09
Benz(a)anthracene			4.49E-06	7.20E-09
Benzo(b)fluoranthene			5.29E-06	9.63E-09
Benzo(k)fluoranthene			2.78E-06	3.05E-09
Indeno(1,2,3-c,d)pyrene			5.26E-06	5.48E-09
Dibenz(a,h)anthracene			1.98E-06	1.33E-09
Naphthalene			1.25E-06	4.54E-08
TRH Aliphatic >C6-C10			2.92E-05	2.58E-07
TRH Aromatic >C6-C10			2.03E-06	2.58E-07

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)			1.83E-04	6.31E-04
Benzo(a)pyrene			3.03E-06	3.22E-09
Benz(a)anthracene			1.92E-06	3.09E-09
Benzo(b)fluoranthene			2.27E-06	4.13E-09
Benzo(k)fluoranthene			1.19E-06	1.31E-09
Indeno(1,2,3-c,d)pyrene			2.26E-06	2.35E-09
Dibenz(a,h)anthracene			8.47E-07	5.70E-10
Naphthalene			5.38E-07	1.95E-08
TRH Aliphatic >C6-C10			1.25E-05	1.11E-07
TRH Aromatic >C6-C10			8.69E-07	1.11E-07

	Adult Hazard Quotients (-) Direct Contact Pathways			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	-	-	1.07E-02	3.68E-02
Benzo(a)pyrene	-	-	2.36E-02	2.50E-05
Benz(a)anthracene	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-
Naphthalene	-	-	6.27E-05	2.27E-06
TRH Aliphatic >C6-C10	-	-	6.50E-06	5.74E-08
TRH Aromatic >C6-C10	-	-	5.63E-05	7.18E-06

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways			
Chemical	Soil ingestion	Dermal contact with soil	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	-	-	-	-
Benzo(a)pyrene	-	-	3.03E-06	3.22E-09
Benz(a)anthracene	-	-	1.92E-07	3.09E-10
Benzo(b)fluoranthene	-	-	2.27E-07	4.13E-10
Benzo(k)fluoranthene	-	-	1.19E-07	1.31E-10
Indeno(1,2,3-c,d)pyrene	-	-	2.26E-07	2.35E-10
Dibenz(a,h)anthracene	-	-	8.47E-07	5.70E-10
Naphthalene	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	30	Site-specific for Option 2	-	-
Exposure frequency to site (days/year)	EF	4	Assumes an ongoing quarterly monitoring of the leachate capture system	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	4	Assumes an ongoing quarterly monitoring of the leachate capture system	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)				4.27E-04	1.47E-03
Benzo(a)pyrene				7.07E-06	7.51E-09
Benz(a)anthracene				4.49E-06	7.20E-09
Benzo(b)fluoranthene				5.29E-06	9.63E-09
Benzo(k)fluoranthene				2.78E-06	3.05E-09
Indeno(1,2,3-c,d)pyrene				5.26E-06	5.48E-09
Dibenz(a,h)anthracene				1.98E-06	1.33E-09
Naphthalene				1.25E-06	4.54E-08
TRH Aliphatic >C6-C10				2.92E-05	2.58E-07
TRH Aromatic >C6-C10				2.03E-06	2.58E-07

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)				1.83E-04	6.31E-04
Benzo(a)pyrene				3.03E-06	3.22E-09
Benz(a)anthracene				1.92E-06	3.09E-09
Benzo(b)fluoranthene				2.27E-06	4.13E-09
Benzo(k)fluoranthene				1.19E-06	1.31E-09
Indeno(1,2,3-c,d)pyrene				2.26E-06	2.35E-09
Dibenz(a,h)anthracene				8.47E-07	5.70E-10
Naphthalene				5.38E-07	1.95E-08
TRH Aliphatic >C6-C10				1.25E-05	1.11E-07
TRH Aromatic >C6-C10				8.69E-07	1.11E-07

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	1.07E-02	3.68E-02
Benzo(a)pyrene	-	-	-	2.36E-02	2.50E-05
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	-	6.27E-05	2.27E-06
TRH Aliphatic >C6-C10	-	-	-	6.50E-06	5.74E-08
TRH Aromatic >C6-C10	-	-	-	5.63E-05	7.18E-06

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.03E-06	3.22E-09
Benz(a)anthracene	-	-	-	1.92E-07	3.09E-10
Benzo(b)fluoranthene	-	-	-	2.27E-07	4.13E-10
Benzo(k)fluoranthene	-	-	-	1.19E-07	1.31E-10
Indeno(1,2,3-c,d)pyrene	-	-	-	2.26E-07	2.35E-10
Dibenz(a,h)anthracene	-	-	-	8.47E-07	5.70E-10
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	1.6	Site-specific for Option 2	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	1	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	240	Assume 5 days per week with 4 weeks holiday	-	-
Inhalation of Vapours					
Exposure time spent within CWS excavation (hrs/day)	t_{trench}	8	NEPM (2013) commerical	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	ADULT Oral/Dermal Mean Daily Intake (mg/kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	3.36E-03	1.17E-04		2.56E-02	8.83E-02
Benzo(a)pyrene	4.14E-05	8.65E-05		4.24E-04	4.51E-07
Benz(a)anthracene	3.81E-05	7.95E-05		2.69E-04	4.32E-07
Benzo(b)fluoranthene	6.97E-05	1.46E-04		3.18E-04	5.78E-07
Benzo(k)fluoranthene	7.16E-05	1.50E-04		1.67E-04	1.83E-07
Indeno(1,2,3-c,d)pyrene	2.06E-05	4.31E-05		3.16E-04	3.29E-07
Dibenz(a,h)anthracene	7.33E-06	1.53E-05		1.19E-04	7.98E-08
Naphthalene			2.24E-04	7.53E-05	2.72E-06
TRH Aliphatic >C6-C10			1.49E-03	1.75E-03	1.55E-05
TRH Aromatic >C6-C10			1.57E-03	1.22E-04	1.55E-05
Chrysene	3.21E-05	6.70E-05			
Benzo(g,h,i)perylene	2.21E-05	4.60E-05			
Arsenic	2.85E-05	6.19E-06			
TRH Aliphatic >C10-C16	2.81E-05	1.96E-04			
TRH Aromatic >C10-C16	2.81E-05	1.96E-04			
TRH Aliphatic >C16-C34	1.41E-03	9.79E-03			
TRH Aromatic >C16-C34	1.41E-03	9.79E-03			

	ADULT Oral/Dermal Chronic Daily Intake (mg/kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	7.68E-05	2.67E-06		5.85E-04	2.02E-03
Benzo(a)pyrene	9.47E-07	1.98E-06		9.69E-06	1.03E-08
Benz(a)anthracene	8.71E-07	1.82E-06		6.16E-06	9.88E-09
Benzo(b)fluoranthene	1.59E-06	3.33E-06		7.26E-06	1.32E-08
Benzo(k)fluoranthene	1.64E-06	3.42E-06		3.81E-06	4.19E-09
Indeno(1,2,3-c,d)pyrene	4.71E-07	9.84E-07		7.22E-06	7.51E-09
Dibenz(a,h)anthracene	1.67E-07	3.50E-07		2.71E-06	1.82E-09
Naphthalene			5.12E-06	1.72E-06	6.23E-08
TRH Aliphatic >C6-C10			3.40E-05	4.01E-05	3.54E-07
TRH Aromatic >C6-C10			3.59E-05	2.78E-06	3.54E-07
Chrysene	7.33E-07	1.53E-06			
Benzo(g,h,i)perylene	5.04E-07	1.05E-06			
Arsenic	6.51E-07	1.41E-07			
TRH Aliphatic >C10-C16	6.43E-07	4.47E-06			
TRH Aromatic >C10-C16	6.43E-07	4.47E-06			
TRH Aliphatic >C16-C34	3.21E-05	2.24E-04			
TRH Aromatic >C16-C34	3.21E-05	2.24E-04			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 2 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	8.40E-02	2.92E-03	-	6.40E-01	2.21E+00
Benzo(a)pyrene	1.38E-01	2.88E-01	-	1.41E+00	1.50E-03
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	7.46E-02	3.76E-03	1.36E-04
TRH Aliphatic >C6-C10	-	-	8.97E-05	3.90E-04	3.44E-06
TRH Aromatic >C6-C10	-	-	8.72E-03	3.38E-03	4.31E-04
Chrysene	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-
Arsenic	2.85E-02	6.19E-03	-	-	-
TRH Aliphatic >C10-C16	3.12E-04	2.17E-03	-	-	-
TRH Aromatic >C10-C16	7.81E-04	5.43E-03	-	-	-
TRH Aliphatic >C16-C34	7.81E-04	5.44E-03	-	-	-
TRH Aromatic >C16-C34	5.21E-02	3.62E-01	-	-	-

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	9.47E-07	1.98E-06	-	9.69E-06	1.03E-08
Benz(a)anthracene	8.71E-08	1.82E-07	-	6.16E-07	9.88E-10
Benzo(b)fluoranthene	1.59E-07	3.33E-07	-	7.26E-07	1.32E-09
Benzo(k)fluoranthene	1.64E-07	3.42E-07	-	3.81E-07	4.19E-10
Indeno(1,2,3-c,d)pyrene	4.71E-08	9.84E-08	-	7.22E-07	7.51E-10
Dibenz(a,h)anthracene	1.67E-07	3.50E-07	-	2.71E-06	1.82E-09
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	7.33E-09	1.53E-08	-	-	-
Benzo(g,h,i)perylene	5.04E-09	1.05E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 3 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	30	Site-specific for Option 3	-	-
Exposure frequency to site (days/year)	EF	4	Assumes an ongoing quarterly monitoring of the leachate capture system	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	4	Assumes an ongoing quarterly monitoring of the leachate capture system	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:

enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 3 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)				4.27E-04	1.47E-03
Benzo(a)pyrene				7.07E-06	7.51E-09
Benz(a)anthracene				4.49E-06	7.20E-09
Benzo(b)fluoranthene				5.29E-06	9.63E-09
Benzo(k)fluoranthene				2.78E-06	3.05E-09
Indeno(1,2,3-c,d)pyrene				5.26E-06	5.48E-09
Dibenz(a,h)anthracene				1.98E-06	1.33E-09
Naphthalene				1.25E-06	4.54E-08
TRH Aliphatic >C6-C10				2.92E-05	2.58E-07
TRH Aromatic >C6-C10				2.03E-06	2.58E-07

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)				1.83E-04	6.31E-04
Benzo(a)pyrene				3.03E-06	3.22E-09
Benz(a)anthracene				1.92E-06	3.09E-09
Benzo(b)fluoranthene				2.27E-06	4.13E-09
Benzo(k)fluoranthene				1.19E-06	1.31E-09
Indeno(1,2,3-c,d)pyrene				2.26E-06	2.35E-09
Dibenz(a,h)anthracene				8.47E-07	5.70E-10
Naphthalene				5.38E-07	1.95E-08
TRH Aliphatic >C6-C10				1.25E-05	1.11E-07
TRH Aromatic >C6-C10				8.69E-07	1.11E-07

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 3 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	**Soil ingestion**	**Dermal contact with soil**	**Inhalation of Vapours within the CWS excavation (GW enters trench)**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	1.07E-02	3.68E-02
Benzo(a)pyrene	-	-	-	2.36E-02	2.50E-05
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	-	6.27E-05	2.27E-06
TRH Aliphatic >C6-C10	-	-	-	6.50E-06	5.74E-08
TRH Aromatic >C6-C10	-	-	-	5.63E-05	7.18E-06

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	**Soil ingestion**	**Dermal contact with soil**	**Inhalation of Vapours within the CWS excavation (GW enters trench)**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.03E-06	3.22E-09
Benz(a)anthracene	-	-	-	1.92E-07	3.09E-10
Benzo(b)fluoranthene	-	-	-	2.27E-07	4.13E-10
Benzo(k)fluoranthene	-	-	-	1.19E-07	1.31E-10
Indeno(1,2,3-c,d)pyrene	-	-	-	2.26E-07	2.35E-10
Dibenz(a,h)anthracene	-	-	-	8.47E-07	5.70E-10
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 3 onsite - direct contact with groundwater and soil during CWS remediatior
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	5.5	Site-specific for Option 3	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	1	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	240	Assume 5 days per week with 4 weeks holiday	-	-
Inhalation of Vapours					
Exposure time spent within the CWS excavation (hrs/day)	t_{trench}	8	NEPM (2013) commerical	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessmen
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 3 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	3.36E-03	1.17E-04		2.56E-02	8.83E-02
Benzo(a)pyrene	4.14E-05	8.65E-05		4.24E-04	4.51E-07
Benz(a)anthracene	3.81E-05	7.95E-05		2.69E-04	4.32E-07
Benzo(b)fluoranthene	6.97E-05	1.46E-04		3.18E-04	5.78E-07
Benzo(k)fluoranthene	7.16E-05	1.50E-04		1.67E-04	1.83E-07
Indeno(1,2,3-c,d)pyrene	2.06E-05	4.31E-05		3.16E-04	3.29E-07
Dibenz(a,h)anthracene	7.33E-06	1.53E-05		1.19E-04	7.98E-08
Naphthalene			2.24E-04	7.53E-05	2.72E-06
TRH Aliphatic >C6-C10			1.49E-03	1.75E-03	1.55E-05
TRH Aromatic >C6-C10			1.57E-03	1.22E-04	1.55E-05
Chrysene	3.21E-05	6.70E-05			
Benzo(g,h,i)perylene	2.21E-05	4.60E-05			
Arsenic	2.85E-05	6.19E-06			
TRH Aliphatic >C10-C16	2.81E-05	1.96E-04			
TRH Aromatic >C10-C16	2.81E-05	1.96E-04			
TRH Aliphatic >C16-C34	1.41E-03	9.79E-03			
TRH Aromatic >C16-C34	1.41E-03	9.79E-03			

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	2.64E-04	9.18E-06		2.01E-03	6.94E-03
Benzo(a)pyrene	3.25E-06	6.80E-06		3.33E-05	3.54E-08
Benz(a)anthracene	2.99E-06	6.25E-06		2.12E-05	3.40E-08
Benzo(b)fluoranthene	5.48E-06	1.14E-05		2.50E-05	4.54E-08
Benzo(k)fluoranthene	5.63E-06	1.18E-05		1.31E-05	1.44E-08
Indeno(1,2,3-c,d)pyrene	1.62E-06	3.38E-06		2.48E-05	2.58E-08
Dibenz(a,h)anthracene	5.76E-07	1.20E-06		9.32E-06	6.27E-09
Naphthalene			1.76E-05	5.91E-06	2.14E-07
TRH Aliphatic >C6-C10			1.17E-04	1.38E-04	1.22E-06
TRH Aromatic >C6-C10			1.23E-04	9.56E-06	1.22E-06
Chrysene	2.52E-06	5.26E-06			
Benzo(g,h,i)perylene	1.73E-06	3.62E-06			
Arsenic	2.24E-06	4.86E-07			
TRH Aliphatic >C10-C16	2.21E-06	1.54E-05			
TRH Aromatic >C10-C16	2.21E-06	1.54E-05			
TRH Aliphatic >C16-C34	1.10E-04	7.69E-04			
TRH Aromatic >C16-C34	1.10E-04	7.69E-04			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 3 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	**Soil ingestion**	**Dermal contact with soil**	**Inhalation of Vapours within the CWS excavation (GW enters trench)**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	8.40E-02	2.92E-03	-	6.40E-01	2.21E+00
Benzo(a)pyrene	1.38E-01	2.88E-01	-	1.41E+00	1.50E-03
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	7.46E-02	3.76E-03	1.36E-04
TRH Aliphatic >C6-C10	-	-	8.97E-05	3.90E-04	3.44E-06
TRH Aromatic >C6-C10	-	-	8.72E-03	3.38E-03	4.31E-04
Chrysene	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-
Arsenic	2.85E-02	6.19E-03	-	-	-
TRH Aliphatic >C10-C16	3.12E-04	2.17E-03	-	-	-
TRH Aromatic >C10-C16	7.81E-04	5.43E-03	-	-	-
TRH Aliphatic >C16-C34	7.81E-04	5.44E-03	-	-	-
TRH Aromatic >C16-C34	5.21E-02	3.62E-01	-	-	-

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	**Soil ingestion**	**Dermal contact with soil**	**Inhalation of Vapours within the CWS excavation (GW enters trench)**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	3.25E-06	6.80E-06	-	3.33E-05	3.54E-08
Benz(a)anthracene	2.99E-07	6.25E-07	-	2.12E-06	3.40E-09
Benzo(b)fluoranthene	5.48E-07	1.14E-06	-	2.50E-06	4.54E-09
Benzo(k)fluoranthene	5.63E-07	1.18E-06	-	1.31E-06	1.44E-09
Indeno(1,2,3-c,d)pyrene	1.62E-07	3.38E-07	-	2.48E-06	2.58E-09
Dibenz(a,h)anthracene	5.76E-07	1.20E-06	-	9.32E-06	6.27E-09
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.52E-08	5.26E-08	-	-	-
Benzo(g,h,i)perylene	1.73E-08	3.62E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 4 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	30	Site-specific for Option 4	-	-
Exposure frequency to site (days/year)	EF	4	Assumes an ongoing quarterly monitoring of the leachate capture system	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	4	Assumes an ongoing quarterly monitoring of the leachate capture system	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 4 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)				4.27E-04	1.47E-03
Benzo(a)pyrene				7.07E-06	7.51E-09
Benz(a)anthracene				4.49E-06	7.20E-09
Benzo(b)fluoranthene				5.29E-06	9.63E-09
Benzo(k)fluoranthene				2.78E-06	3.05E-09
Indeno(1,2,3-c,d)pyrene				5.26E-06	5.48E-09
Dibenz(a,h)anthracene				1.98E-06	1.33E-09
Naphthalene				1.25E-06	4.54E-08
TRH Aliphatic >C6-C10				2.92E-05	2.58E-07
TRH Aromatic >C6-C10				2.03E-06	2.58E-07

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)				1.83E-04	6.31E-04
Benzo(a)pyrene				3.03E-06	3.22E-09
Benz(a)anthracene				1.92E-06	3.09E-09
Benzo(b)fluoranthene				2.27E-06	4.13E-09
Benzo(k)fluoranthene				1.19E-06	1.31E-09
Indeno(1,2,3-c,d)pyrene				2.26E-06	2.35E-09
Dibenz(a,h)anthracene				8.47E-07	5.70E-10
Naphthalene				5.38E-07	1.95E-08
TRH Aliphatic >C6-C10				1.25E-05	1.11E-07
TRH Aromatic >C6-C10				8.69E-07	1.11E-07

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 4 onsite - direct contact with groundwater during monitoring of leachate from proposed containment cell
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	1.07E-02	3.68E-02
Benzo(a)pyrene	-	-	-	2.36E-02	2.50E-05
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	-	6.27E-05	2.27E-06
TRH Aliphatic >C6-C10	-	-	-	6.50E-06	5.74E-08
TRH Aromatic >C6-C10	-	-	-	5.63E-05	7.18E-06

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.03E-06	3.22E-09
Benz(a)anthracene	-	-	-	1.92E-07	3.09E-10
Benzo(b)fluoranthene	-	-	-	2.27E-07	4.13E-10
Benzo(k)fluoranthene	-	-	-	1.19E-07	1.31E-10
Indeno(1,2,3-c,d)pyrene	-	-	-	2.26E-07	2.35E-10
Dibenz(a,h)anthracene	-	-	-	8.47E-07	5.70E-10
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 4 onsite - direct contact with groundwater and soil during CWS remediatior
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	1.6	Site-specific for Option 4	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	1	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	240	Assume 5 days per week with 4 weeks holiday	-	-
Vapour Inhalation					
Exposure time spent within CWS excavation (hrs/day)	t_{trench}	8	NEPM (2013) commerical	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessmen
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 4 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	ADULT Oral/Dermal Mean Daily Intake (mg/kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	3.36E-03	1.17E-04		2.56E-02	8.83E-02
Benzo(a)pyrene	4.14E-05	8.65E-05		4.24E-04	4.51E-07
Benz(a)anthracene	3.81E-05	7.95E-05		2.69E-04	4.32E-07
Benzo(b)fluoranthene	6.97E-05	1.46E-04		3.18E-04	5.78E-07
Benzo(k)fluoranthene	7.16E-05	1.50E-04		1.67E-04	1.83E-07
Indeno(1,2,3-c,d)pyrene	2.06E-05	4.31E-05		3.16E-04	3.29E-07
Dibenz(a,h)anthracene	7.33E-06	1.53E-05		1.19E-04	7.98E-08
Naphthalene			2.24E-04	7.53E-05	2.72E-06
TRH Aliphatic >C6-C10			1.49E-03	1.75E-03	1.55E-05
TRH Aromatic >C6-C10			1.57E-03	1.22E-04	1.55E-05
Chrysene	3.21E-05	6.70E-05			
Benzo(g,h,i)perylene	2.21E-05	4.60E-05			
Arsenic	2.85E-05	6.19E-06			
TRH Aliphatic >C10-C16	2.81E-05	1.96E-04			
TRH Aromatic >C10-C16	2.81E-05	1.96E-04			
TRH Aliphatic >C16-C34	1.41E-03	9.79E-03			
TRH Aromatic >C16-C34	1.41E-03	9.79E-03			

	ADULT Oral/Dermal Chronic Daily Intake (mg/kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	7.68E-05	2.67E-06		5.85E-04	2.02E-03
Benzo(a)pyrene	9.47E-07	1.98E-06		9.69E-06	1.03E-08
Benz(a)anthracene	8.71E-07	1.82E-06		6.16E-06	9.88E-09
Benzo(b)fluoranthene	1.59E-06	3.33E-06		7.26E-06	1.32E-08
Benzo(k)fluoranthene	1.64E-06	3.42E-06		3.81E-06	4.19E-09
Indeno(1,2,3-c,d)pyrene	4.71E-07	9.84E-07		7.22E-06	7.51E-09
Dibenz(a,h)anthracene	1.67E-07	3.50E-07		2.71E-06	1.82E-09
Naphthalene			5.12E-06	1.72E-06	6.23E-08
TRH Aliphatic >C6-C10			3.40E-05	4.01E-05	3.54E-07
TRH Aromatic >C6-C10			3.59E-05	2.78E-06	3.54E-07
Chrysene	7.33E-07	1.53E-06			
Benzo(g,h,i)perylene	5.04E-07	1.05E-06			
Arsenic	6.51E-07	1.41E-07			
TRH Aliphatic >C10-C16	6.43E-07	4.47E-06			
TRH Aromatic >C10-C16	6.43E-07	4.47E-06			
TRH Aliphatic >C16-C34	3.21E-05	2.24E-04			
TRH Aromatic >C16-C34	3.21E-05	2.24E-04			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 4 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	09-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	8.40E-02	2.92E-03	-	6.40E-01	2.21E+00
Benzo(a)pyrene	1.38E-01	2.88E-01	-	1.41E+00	1.50E-03
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	7.46E-02	3.76E-03	1.36E-04
TRH Aliphatic >C6-C10	-	-	8.97E-05	3.90E-04	3.44E-06
TRH Aromatic >C6-C10	-	-	8.72E-03	3.38E-03	4.31E-04
Chrysene	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-
Arsenic	2.85E-02	6.19E-03	-	-	-
TRH Aliphatic >C10-C16	3.12E-04	2.17E-03	-	-	-
TRH Aromatic >C10-C16	7.81E-04	5.43E-03	-	-	-
TRH Aliphatic >C16-C34	7.81E-04	5.44E-03	-	-	-
TRH Aromatic >C16-C34	5.21E-02	3.62E-01	-	-	-

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	9.47E-07	1.98E-06	-	9.69E-06	1.03E-08
Benz(a)anthracene	8.71E-08	1.82E-07	-	6.16E-07	9.88E-10
Benzo(b)fluoranthene	1.59E-07	3.33E-07	-	7.26E-07	1.32E-09
Benzo(k)fluoranthene	1.64E-07	3.42E-07	-	3.81E-07	4.19E-10
Indeno(1,2,3-c,d)pyrene	4.71E-08	9.84E-08	-	7.22E-07	7.51E-10
Dibenz(a,h)anthracene	1.67E-07	3.50E-07	-	2.71E-06	1.82E-09
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	7.33E-09	1.53E-08	-	-	-
Benzo(g,h,i)perylene	5.04E-09	1.05E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 5 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	6.1	Site-specific for Option 5	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	1	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	240	Assume 5 days per week with 4 weeks holiday	-	-
Vapour Inhalation				-	-
Exposure time spent within CWS excavation (hrs/day)	t_{trench}	8	NEPM (2013) commerical	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 5 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	3.36E-03	1.17E-04		2.56E-02	8.83E-02
Benzo(a)pyrene	4.14E-05	8.65E-05		4.24E-04	4.51E-07
Benz(a)anthracene	3.81E-05	7.95E-05		2.69E-04	4.32E-07
Benzo(b)fluoranthene	6.97E-05	1.46E-04		3.18E-04	5.78E-07
Benzo(k)fluoranthene	7.16E-05	1.50E-04		1.67E-04	1.83E-07
Indeno(1,2,3-c,d)pyrene	2.06E-05	4.31E-05		3.16E-04	3.29E-07
Dibenz(a,h)anthracene	7.33E-06	1.53E-05		1.19E-04	7.98E-08
Naphthalene			2.24E-04	7.53E-05	2.72E-06
TRH Aliphatic >C6-C10			1.49E-03	1.75E-03	1.55E-05
TRH Aromatic >C6-C10			1.57E-03	1.22E-04	1.55E-05
Chrysene	3.21E-05	6.70E-05			
Benzo(g,h,i)perylene	2.21E-05	4.60E-05			
Arsenic	2.85E-05	6.19E-06			
TRH Aliphatic >C10-C16	2.81E-05	1.96E-04			
TRH Aromatic >C10-C16	2.81E-05	1.96E-04			
TRH Aliphatic >C16-C34	1.41E-03	9.79E-03			
TRH Aromatic >C16-C34	1.41E-03	9.79E-03			

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	2.93E-04	1.02E-05		2.23E-03	7.69E-03
Benzo(a)pyrene	3.61E-06	7.54E-06		3.69E-05	3.93E-08
Benz(a)anthracene	3.32E-06	6.93E-06		2.35E-05	3.77E-08
Benzo(b)fluoranthene	6.08E-06	1.27E-05		2.77E-05	5.03E-08
Benzo(k)fluoranthene	6.24E-06	1.30E-05		1.45E-05	1.60E-08
Indeno(1,2,3-c,d)pyrene	1.80E-06	3.75E-06		2.75E-05	2.86E-08
Dibenz(a,h)anthracene	6.38E-07	1.33E-06		1.03E-05	6.96E-09
Naphthalene			1.95E-05	6.56E-06	2.37E-07
TRH Aliphatic >C6-C10			1.29E-04	1.53E-04	1.35E-06
TRH Aromatic >C6-C10			1.37E-04	1.06E-05	1.35E-06
Chrysene	2.80E-06	5.84E-06			
Benzo(g,h,i)perylene	1.92E-06	4.01E-06			
Arsenic	2.48E-06	5.39E-07			
TRH Aliphatic >C10-C16	2.45E-06	1.70E-05			
TRH Aromatic >C10-C16	2.45E-06	1.70E-05			
TRH Aliphatic >C16-C34	1.23E-04	8.53E-04			
TRH Aromatic >C16-C34	1.23E-04	8.53E-04			

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 5 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	8.40E-02	2.92E-03	-	6.40E-01	2.21E+00
Benzo(a)pyrene	1.38E-01	2.88E-01	-	1.41E+00	1.50E-03
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	7.46E-02	3.76E-03	1.36E-04
TRH Aliphatic >C6-C10	-	-	8.97E-05	3.90E-04	3.44E-06
TRH Aromatic >C6-C10	-	-	8.72E-03	3.38E-03	4.31E-04
Chrysene	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-
Arsenic	2.85E-02	6.19E-03	-	-	-
TRH Aliphatic >C10-C16	3.12E-04	2.17E-03	-	-	-
TRH Aromatic >C10-C16	7.81E-04	5.43E-03	-	-	-
TRH Aliphatic >C16-C34	7.81E-04	5.44E-03	-	-	-
TRH Aromatic >C16-C34	5.21E-02	3.62E-01	-	-	-

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	3.61E-06	7.54E-06	-	3.69E-05	3.93E-08
Benz(a)anthracene	3.32E-07	6.93E-07	-	2.35E-06	3.77E-09
Benzo(b)fluoranthene	6.08E-07	1.27E-06	-	2.77E-06	5.03E-09
Benzo(k)fluoranthene	6.24E-07	1.30E-06	-	1.45E-06	1.60E-09
Indeno(1,2,3-c,d)pyrene	1.80E-07	3.75E-07	-	2.75E-06	2.86E-09
Dibenz(a,h)anthracene	6.38E-07	1.33E-06	-	1.03E-05	6.96E-09
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.80E-08	5.84E-08	-	-	-
Benzo(g,h,i)perylene	1.92E-08	4.01E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 6 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	17	Site-specific for Option 6	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	1	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	240	Assume 5 days per week with 4 weeks holiday	-	-
Vapour Inhalation					
Exposure time spent within CWS excavation (hrs/day)	DW	t_{trench}	NEPM (20130	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessment
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 6 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	ADULT Oral / Dermal Mean Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	3.36E-03	1.17E-04		2.56E-02	8.83E-02
Benzo(a)pyrene	4.14E-05	8.65E-05		4.24E-04	4.51E-07
Benz(a)anthracene	3.81E-05	7.95E-05		2.69E-04	4.32E-07
Benzo(b)fluoranthene	6.97E-05	1.46E-04		3.18E-04	5.78E-07
Benzo(k)fluoranthene	7.16E-05	1.50E-04		1.67E-04	1.83E-07
Indeno(1,2,3-c,d)pyrene	2.06E-05	4.31E-05		3.16E-04	3.29E-07
Dibenz(a,h)anthracene	7.33E-06	1.53E-05		1.19E-04	7.98E-08
Naphthalene			2.24E-04	7.53E-05	2.72E-06
TRH Aliphatic >C6-C10			1.49E-03	1.75E-03	1.55E-05
TRH Aromatic >C6-C10			1.57E-03	1.22E-04	1.55E-05
Chrysene	3.21E-05	6.70E-05			
Benzo(g,h,i)perylene	2.21E-05	4.60E-05			
Arsenic	2.85E-05	6.19E-06			
TRH Aliphatic >C10-C16	2.81E-05	1.96E-04			
TRH Aromatic >C10-C16	2.81E-05	1.96E-04			
TRH Aliphatic >C16-C34	1.41E-03	9.79E-03			
TRH Aromatic >C16-C34	1.41E-03	9.79E-03			

	ADULT Oral / Dermal Chronic Daily Intake (mg / kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	8.16E-04	2.84E-05		6.22E-03	2.14E-02
Benzo(a)pyrene	1.01E-05	2.10E-05		1.03E-04	1.09E-07
Benz(a)anthracene	9.25E-06	1.93E-05		6.54E-05	1.05E-07
Benzo(b)fluoranthene	1.69E-05	3.54E-05		7.71E-05	1.40E-07
Benzo(k)fluoranthene	1.74E-05	3.63E-05		4.05E-05	4.45E-08
Indeno(1,2,3-c,d)pyrene	5.01E-06	1.05E-05		7.67E-05	7.98E-08
Dibenz(a,h)anthracene	1.78E-06	3.72E-06		2.88E-05	1.94E-08
Naphthalene			5.44E-05	1.83E-05	6.62E-07
TRH Aliphatic >C6-C10			3.61E-04	4.26E-04	3.76E-06
TRH Aromatic >C6-C10			3.81E-04	2.95E-05	3.76E-06
Chrysene	7.79E-06	1.63E-05			
Benzo(g,h,i)perylene	5.36E-06	1.12E-05			
Arsenic	6.91E-06	1.50E-06			
TRH Aliphatic >C10-C16	6.83E-06	4.75E-05			
TRH Aromatic >C10-C16	6.83E-06	4.75E-05			
TRH Aliphatic >C16-C34	3.42E-04	2.38E-03			
TRH Aromatic >C16-C34	3.42E-04	2.38E-03			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 6 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	8.40E-02	2.92E-03	-	6.40E-01	2.21E+00
Benzo(a)pyrene	1.38E-01	2.88E-01	-	1.41E+00	1.50E-03
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	7.46E-02	3.76E-03	1.36E-04
TRH Aliphatic >C6-C10	-	-	8.97E-05	3.90E-04	3.44E-06
TRH Aromatic >C6-C10	-	-	8.72E-03	3.38E-03	4.31E-04
Chrysene	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-
Arsenic	2.85E-02	6.19E-03	-	-	-
TRH Aliphatic >C10-C16	3.12E-04	2.17E-03	-	-	-
TRH Aromatic >C10-C16	7.81E-04	5.43E-03	-	-	-
TRH Aliphatic >C16-C34	7.81E-04	5.44E-03	-	-	-
TRH Aromatic >C16-C34	5.21E-02	3.62E-01	-	-	-

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	1.01E-05	2.10E-05	-	1.03E-04	1.09E-07
Benz(a)anthracene	9.25E-07	1.93E-06	-	6.54E-06	1.05E-08
Benzo(b)fluoranthene	1.69E-06	3.54E-06	-	7.71E-06	1.40E-08
Benzo(k)fluoranthene	1.74E-06	3.63E-06	-	4.05E-06	4.45E-09
Indeno(1,2,3-c,d)pyrene	5.01E-07	1.05E-06	-	7.67E-06	7.98E-09
Dibenz(a,h)anthracene	1.78E-06	3.72E-06	-	2.88E-05	1.94E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	7.79E-08	1.63E-07	-	-	-
Benzo(g,h,i)perylene	5.36E-08	1.12E-07	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 7 onsite - direct contact with groundwater and soil during CWS remediatior
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days)	L	25550	US EPA (1989)	-	-
Exposure duration (years)	ED	7.2	Site-specific for Option 7	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Exposed skin surface area (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Event frequency for dermal exposure to soil (events/day)	EV_{soil}	1	-	-	-
Exposure frequency to surface soil (days/year)	EF_{soil}	240	Assume 5 days per week with 4 weeks holiday	-	-
Vapour Inhalation				-	-
Exposure time spent within CWS excavation (hrs/day)	t_{trench}	8	NEPM (2013) commercial	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EF_{sw}	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IR_{sw}	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ET_{sw}	1	assume 1hr exposed to water each day	-	-
Exposed skin surface area (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Ev_{water}	1	assume a total of 1hr contact per day	-	-

References:
enHealth (2012) Australian Exposure Factor Guidance. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia
NEPM (2013) National Environment Protection (Assessment of Site Contamination) Measure, Schedule B4, Site-Specific Health Risk Assessmen
US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A).

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 7 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	ADULT Oral/Dermal Mean Daily Intake (mg/kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	3.36E-03	1.17E-04		2.56E-02	8.83E-02
Benzo(a)pyrene	4.14E-05	8.65E-05		4.24E-04	4.51E-07
Benz(a)anthracene	3.81E-05	7.95E-05		2.69E-04	4.32E-07
Benzo(b)fluoranthene	6.97E-05	1.46E-04		3.18E-04	5.78E-07
Benzo(k)fluoranthene	7.16E-05	1.50E-04		1.67E-04	1.83E-07
Indeno(1,2,3-c,d)pyrene	2.06E-05	4.31E-05		3.16E-04	3.29E-07
Dibenz(a,h)anthracene	7.33E-06	1.53E-05		1.19E-04	7.98E-08
Naphthalene			2.24E-04	7.53E-05	2.72E-06
TRH Aliphatic >C6-C10			1.49E-03	1.75E-03	1.55E-05
TRH Aromatic >C6-C10			1.57E-03	1.22E-04	1.55E-05
Chrysene	3.21E-05	6.70E-05			
Benzo(g,h,i)perylene	2.21E-05	4.60E-05			
Arsenic	2.85E-05	6.19E-06			
TRH Aliphatic >C10-C16	2.81E-05	1.96E-04			
TRH Aromatic >C10-C16	2.81E-05	1.96E-04			
TRH Aliphatic >C16-C34	1.41E-03	9.79E-03			
TRH Aromatic >C16-C34	1.41E-03	9.79E-03			

	ADULT Oral/Dermal Chronic Daily Intake (mg/kg-day)				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	3.46E-04	1.20E-05		2.63E-03	9.08E-03
Benzo(a)pyrene	4.26E-06	8.90E-06		4.36E-05	4.64E-08
Benz(a)anthracene	3.92E-06	8.18E-06		2.77E-05	4.44E-08
Benzo(b)fluoranthene	7.17E-06	1.50E-05		3.27E-05	5.94E-08
Benzo(k)fluoranthene	7.37E-06	1.54E-05		1.72E-05	1.88E-08
Indeno(1,2,3-c,d)pyrene	2.12E-06	4.43E-06		3.25E-05	3.38E-08
Dibenz(a,h)anthracene	7.54E-07	1.57E-06		1.22E-05	8.21E-09
Naphthalene			2.30E-05	7.74E-06	2.80E-07
TRH Aliphatic >C6-C10			1.53E-04	1.80E-04	1.59E-06
TRH Aromatic >C6-C10			1.61E-04	1.25E-05	1.59E-06
Chrysene	3.30E-06	6.89E-06			
Benzo(g,h,i)perylene	2.27E-06	4.74E-06			
Arsenic	2.93E-06	6.37E-07			
TRH Aliphatic >C10-C16	2.89E-06	2.01E-05			
TRH Aromatic >C10-C16	2.89E-06	2.01E-05			
TRH Aliphatic >C16-C34	1.45E-04	1.01E-03			
TRH Aromatic >C16-C34	1.45E-04	1.01E-03			

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Site Address	Hart Rd, Loxford, NSW
Exposure Scenario	Option 7 onsite - direct contact with groundwater and soil during CWS remediation
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	9-Jun-17

	Adult Hazard Quotients (-) Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	8.40E-02	2.92E-03	-	6.40E-01	2.21E+00
Benzo(a)pyrene	1.38E-01	2.88E-01	-	1.41E+00	1.50E-03
Benz(a)anthracene	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-
Naphthalene	-	-	7.46E-02	3.76E-03	1.36E-04
TRH Aliphatic >C6-C10	-	-	8.97E-05	3.90E-04	3.44E-06
TRH Aromatic >C6-C10	-	-	8.72E-03	3.38E-03	4.31E-04
Chrysene	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-
Arsenic	2.85E-02	6.19E-03	-	-	-
TRH Aliphatic >C10-C16	3.12E-04	2.17E-03	-	-	-
TRH Aromatic >C10-C16	7.81E-04	5.43E-03	-	-	-
TRH Aliphatic >C16-C34	7.81E-04	5.44E-03	-	-	-
TRH Aromatic >C16-C34	5.21E-02	3.62E-01	-	-	-

	Increased Lifetime Cancer Risk (ILCR) Estimates - Direct Contact Pathways				
Chemical	Soil ingestion	Dermal contact with soil	Inhalation of Vapours within the CWS excavation (GW enters trench)	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	4.26E-06	8.90E-06	-	4.36E-05	4.64E-08
Benz(a)anthracene	3.92E-07	8.18E-07	-	2.77E-06	4.44E-09
Benzo(b)fluoranthene	7.17E-07	1.50E-06	-	3.27E-06	5.94E-09
Benzo(k)fluoranthene	7.37E-07	1.54E-06	-	1.72E-06	1.88E-09
Indeno(1,2,3-c,d)pyrene	2.12E-07	4.43E-07	-	3.25E-06	3.38E-09
Dibenz(a,h)anthracene	7.54E-07	1.57E-06	-	1.22E-05	8.21E-09
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	3.30E-08	6.89E-08	-	-	-
Benzo(g,h,i)perylene	2.27E-08	4.74E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

APPENDIX C7
ADDITIONAL SCENARIOS AND RESULTS

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing, Additional Exposure Scenario (Do Nothing_AEE1): leachate removal and treatment for three years.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	19-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	3	Event assumption	-	-
Exposure frequency to site (days/year)	EF	240	Assume 5 days per week with 4 weeks holiday	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	-	-	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	-	-	-	-
Soil skin adherence (mg/cm^2)	SL	-	-	-	-
Exposure frequency to surface soil (days/year)	EFsoil	-	-	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	240	Assume 5 days per week with 4 weeks holiday	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	3	assume 3hr exposed to water each day during removal and treatment	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				7.68E-02	8.83E-02					
Benzo(a)pyrene				7.34E-04	4.51E-07					
Benz(a)anthracene				4.67E-04	4.32E-07					
Benzo(b)fluoranthene				5.50E-04	5.78E-07					
Benzo(k)fluoranthene				2.89E-04	1.83E-07					
Indeno(1,2,3-c,d)pyrene				5.47E-04	3.29E-07					
Dibenz(a,h)anthracene				2.06E-04	7.98E-08					
Naphthalene				1.40E-04	2.72E-06					
TRH Aliphatic >C6-C10				2.96E-03	1.55E-05					
TRH Aromatic >C6-C10				2.48E-04	1.55E-05					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				3.29E-03	3.78E-03					
Benzo(a)pyrene				3.15E-05	1.93E-08					
Benz(a)anthracene				2.00E-05	1.85E-08					
Benzo(b)fluoranthene				2.36E-05	2.48E-08					
Benzo(k)fluoranthene				1.24E-05	7.85E-09					
Indeno(1,2,3-c,d)pyrene				2.34E-05	1.41E-08					
Dibenz(a,h)anthracene				8.81E-06	3.42E-09					
Naphthalene				6.00E-06	1.17E-07					
TRH Aliphatic >C6-C10				1.27E-04	6.64E-07					
TRH Aromatic >C6-C10				1.06E-05	6.64E-07					

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing, Additional Exposure Scenario (Do Nothing_AEE1): leachate removal and treatment for three years.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	19-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.92E+00	2.21E+00	-	-	-	-	-
Benzo(a)pyrene	-	-	-	2.45E+00	1.50E-03	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.00E-03	1.36E-04	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	6.57E-04	3.44E-06	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.89E-03	4.31E-04	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.15E-05	1.93E-08
Benz(a)anthracene	-	-	-	2.00E-06	1.85E-09
Benzo(b)fluoranthene	-	-	-	2.36E-06	2.48E-09
Benzo(k)fluoranthene	-	-	-	1.24E-06	7.85E-10
Indeno(1,2,3-c,d)pyrene	-	-	-	2.34E-06	1.41E-09
Dibenz(a,h)anthracene	-	-	-	8.81E-06	3.42E-09
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE2): Moderate repairs to Cap (2% - <10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	19-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	20	Assumes repairs take one month	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	20	Assumes repairs take one month	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	-	-	-	-
Surface water ingestion rate (L/day)	IRsw	-	-	-	-
Exposure time (surface water) (hrs/event)	ETsw	-	-	-	-
Skin surface area exposed (cm^2)	SA	-	-	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.77E-05	9.74E-06								
Benzo(a)pyrene	3.41E-07	7.21E-06								
Benz(a)anthracene	3.14E-07	6.63E-06								
Benzo(b)fluoranthene	5.74E-07	1.21E-05								
Benzo(k)fluoranthene	5.90E-07	1.25E-05								
Indeno(1,2,3-c,d)pyrene	1.70E-07	3.59E-06								
Dibenz(a,h)anthracene	6.03E-08	1.27E-06								
Chrysene	2.64E-07	5.58E-06								
Benzo(g,h,i)perylene	1.82E-07	3.84E-06								
Arsenic	2.34E-07	5.16E-07								
TRH Aliphatic >C10-C16	2.31E-07	1.63E-05								
TRH Aromatic >C10-C16	2.31E-07	1.63E-05								
TRH Aliphatic >C16-C34	1.16E-05	8.16E-04								
TRH Aromatic >C16-C34	1.16E-05	8.16E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.00E-06	1.39E-07				0.00E+00				
Benzo(a)pyrene	4.93E-08	1.03E-07								
Benz(a)anthracene	4.53E-08	9.47E-08								
Benzo(b)fluoranthene	8.30E-08	1.73E-07								
Benzo(k)fluoranthene	8.53E-08	1.78E-07								
Indeno(1,2,3-c,d)pyrene	2.45E-08	5.13E-08								
Dibenz(a,h)anthracene	8.72E-09	1.82E-08								
Chrysene	3.82E-08	7.97E-08								
Benzo(g,h,i)perylene	2.63E-08	5.48E-08								
Arsenic	3.39E-08	7.37E-09								
TRH Aliphatic >C10-C16	3.35E-08	2.33E-07								
TRH Aromatic >C10-C16	3.35E-08	2.33E-07								
TRH Aliphatic >C16-C34	1.67E-06	1.17E-05								
TRH Aromatic >C16-C34	1.67E-06	1.17E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE2): Moderate repairs to Cap (2% - <10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	19-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.91E-04	2.44E-04	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.14E-03	2.40E-02	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	2.34E-04	5.16E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	2.57E-06	1.81E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	4.29E-04	3.02E-02	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	4.93E-08	1.03E-07	-	-	-
Benz(a)anthracene	4.53E-09	9.47E-09	-	-	-
Benzo(b)fluoranthene	8.30E-09	1.73E-08	-	-	-
Benzo(k)fluoranthene	8.53E-09	1.78E-08	-	-	-
Indeno(1,2,3-c,d)pyrene	2.45E-09	5.13E-09	-	-	-
Dibenz(a,h)anthracene	8.72E-09	1.82E-08	-	-	-
Chrysene	3.82E-10	7.97E-10	-	-	-
Benzo(g,h,i)perylene	2.63E-10	5.48E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing: Additional Exposure Scenario (Do Nothing_AEE3): Community access capped waste stockpile. Direct contact not considered due to presence of capping layer over CWS material. EPC represents the 50% of the average ammonia and H2S concentration in the CWS with an attenuation factor of 0.05 adopted to represent outdoor air concentration (in accordance with NEPM (2013) Schedule B7, Section 5.5.3 approaches).
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	29	NEPM (2013) recreational	-	-
Exposure frequency to site (days/year)	EF	12	assume once per month	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	1	Assume 1hr exposed to gas from CWS air vents	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia					7.77E-03
Hydrogen sulfide (H2S)					7.12E-03

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	-	1.12E-01
Hydrogen sulfide (H2S)	-	-	-	-	2.55E-01

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE4): Future Construction worker on surrounding properties encounters leachate and gas in a single event. EPC represents the average ammonia and H2S concentration measured in vapour wells and gas vents installed through the CWS with an attenuation factor of 0.005 adopted to represent indoor air building concentration (in accordance with CRC CARE (2011) approaches). An additional two orders of magnitude was applied to the attenuation factor due too additional outdoor air attenuation.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	06-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	Assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes event takes place once	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	8	NEPM (2013) commercial	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	Assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	4	assume 4hr exposed to water each day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assume a total of 4hr contact per day	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)			
Chemical	**Incidental Groundwater Ingestion**	**Dermal contact with groundwater**	**Outdoor Vapour Inhalation**
Ammonia			1.00E-05
Hydrogen sulfide (H2S)			9.13E-06
Fluoride (soluble)	3.68E-04	4.27E-04	
Benzo(a)pyrene	1.88E-09	3.53E-06	
Benz(a)anthracene	1.80E-09	2.25E-06	
Benzo(b)fluoranthene	2.41E-09	2.65E-06	
Benzo(k)fluoranthene	7.63E-10	1.39E-06	
Indeno(1,2,3-c,d)pyrene	1.37E-09	2.63E-06	
Dibenz(a,h)anthracene	3.33E-10	9.89E-07	
Naphthalene	1.14E-08	7.11E-07	
TRH Aliphatic >C6-C10	6.46E-08	1.44E-05	
TRH Aromatic >C6-C10	6.46E-08	1.30E-06	

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)			
Chemical	**Incidental Groundwater Ingestion**	**Dermal contact with groundwater**	**Outdoor Vapour Inhalation**
Ammonia			1.44E-07
Hydrogen sulfide (H2S)			1.30E-07
Fluoride (soluble)	5.26E-06	6.10E-06	
Benzo(a)pyrene	2.68E-11	5.05E-08	
Benz(a)anthracene	2.57E-11	3.21E-08	
Benzo(b)fluoranthene	3.44E-11	3.78E-08	
Benzo(k)fluoranthene	1.09E-11	1.99E-08	
Indeno(1,2,3-c,d)pyrene	1.96E-11	3.76E-08	
Dibenz(a,h)anthracene	4.75E-12	1.41E-08	
Naphthalene	1.62E-10	1.02E-08	
TRH Aliphatic >C6-C10	9.23E-10	2.05E-07	
TRH Aromatic >C6-C10	9.23E-10	1.85E-08	

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_ALL4). Future Construction worker on surrounding properties encounters leachate and gas in a single event. EPC represents the average ammonia and H2S concentration measured in vapour wells and gas vents installed through the CWS with an attenuation factor of 0.005 adopted to represent indoor air building concentration (in accordance with CRC CARE (2011) approaches). An additional two orders of magnitude was applied to the attenuation factor due too additional outdoor air attenuation.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	06-Jun-17

Hazard Index (HI)

Chemical	Incidental Groundwater Ingestion	Dermal contact with groundwater	Outdoor Vapour Inhalation
Ammonia	-	-	1.45E-04
Hydrogen sulfide (H2S)	-	-	3.27E-04
Fluoride (soluble)	9.20E-03	1.07E-02	-
Benzo(a)pyrene	6.26E-06	1.18E-02	-
Benz(a)anthracene	-	-	-
Benzo(b)fluoranthene	-	-	-
Benzo(k)fluoranthene	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-
Dibenz(a,h)anthracene	-	-	-
Naphthalene	5.68E-07	3.55E-05	-
TRH Aliphatic >C6-C10	1.44E-08	3.19E-06	-
TRH Aromatic >C6-C10	1.79E-06	3.60E-05	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Groundwater Ingestion	Dermal contact with groundwater	Outdoor Vapour Inhalation
Ammonia	-	-	-
Hydrogen sulfide (H2S)	-	-	-
Fluoride (soluble)	-	-	-
Benzo(a)pyrene	2.68E-11	5.05E-08	-
Benz(a)anthracene	2.57E-12	3.21E-09	-
Benzo(b)fluoranthene	3.44E-12	3.78E-09	-
Benzo(k)fluoranthene	1.09E-12	1.99E-09	-
Indeno(1,2,3-c,d)pyrene	1.96E-12	3.76E-09	-
Dibenz(a,h)anthracene	4.75E-12	1.41E-08	-
Naphthalene	-	-	-
TRH Aliphatic >C6-C10	-	-	-
TRH Aromatic >C6-C10	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE5): Future Construction worker on surrounding properties encounters leachate and gas in a single event. The gas EPC represents the 50% of the average ammonia and H2S concentration in the CWS with an attenuation factor of 0.05 adopted to represent outdoor air concentration (in accordance with NEPM (2013) Schedule B7, Section 5.5.3 approaches).
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	06-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	Assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes event takes place once	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	8	NEPM (2013) commercial	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	Assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	4	assume 4hr exposed to water each day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assume a total of 4hr contact per day	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Groundwater Ingestion	Dermal contact with groundwater	Outdoor Vapour Inhalation
Ammonia			5.18E-03
Hydrogen sulfide (H2S)			4.74E-03
Fluoride (soluble)	3.68E-04	4.27E-04	
Benzo(a)pyrene	1.88E-09	3.53E-06	
Benz(a)anthracene	1.80E-09	2.25E-06	
Benzo(b)fluoranthene	2.41E-09	2.65E-06	
Benzo(k)fluoranthene	7.63E-10	1.39E-06	
Indeno(1,2,3-c,d)pyrene	1.37E-09	2.63E-06	
Dibenz(a,h)anthracene	3.33E-10	9.89E-07	
Naphthalene	1.14E-08	7.11E-07	
TRH Aliphatic >C6-C10	6.46E-08	1.44E-05	
TRH Aromatic >C6-C10	6.46E-08	1.30E-06	

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Groundwater Ingestion	Dermal contact with groundwater	Outdoor Vapour Inhalation
Ammonia			7.40E-05
Hydrogen sulfide (H2S)			6.78E-05
Fluoride (soluble)	5.26E-06	6.10E-06	
Benzo(a)pyrene	2.68E-11	5.05E-08	
Benz(a)anthracene	2.57E-11	3.21E-08	
Benzo(b)fluoranthene	3.44E-11	3.78E-08	
Benzo(k)fluoranthene	1.09E-11	1.99E-08	
Indeno(1,2,3-c,d)pyrene	1.96E-11	3.76E-08	
Dibenz(a,h)anthracene	4.75E-12	1.41E-08	
Naphthalene	1.62E-10	1.02E-08	
TRH Aliphatic >C6-C10	9.23E-10	2.05E-07	
TRH Aromatic >C6-C10	9.23E-10	1.85E-08	

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE5): Future Construction worker on surrounding properties encounters leachate and gas in a single event. The gas EPC represents the 50% of the average ammonia and H2S concentration in the CWS with an attenuation factor of 0.05 adopted to represent outdoor air concentration (in accordance with NEPM (2013) Schedule B7, Section 5.5.3 approaches).
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	06-Jun-17

Hazard Index (HI)

Chemical	Incidental Groundwater Ingestion	Dermal contact with groundwater	Outdoor Vapour Inhalation
Ammonia	-	-	7.46E-02
Hydrogen sulfide (H2S)	-	-	1.70E-01
Fluoride (soluble)	9.20E-03	1.07E-02	-
Benzo(a)pyrene	6.26E-06	1.18E-02	-
Benz(a)anthracene	-	-	-
Benzo(b)fluoranthene	-	-	-
Benzo(k)fluoranthene	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-
Dibenz(a,h)anthracene	-	-	-
Naphthalene	5.68E-07	3.55E-05	-
TRH Aliphatic >C6-C10	1.44E-08	3.19E-06	-
TRH Aromatic >C6-C10	1.79E-06	3.60E-05	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Groundwater Ingestion	Dermal contact with groundwater	Outdoor Vapour Inhalation
Ammonia	-	-	-
Hydrogen sulfide (H2S)	-	-	-
Fluoride (soluble)	-	-	-
Benzo(a)pyrene	2.68E-11	5.05E-08	-
Benz(a)anthracene	2.57E-12	3.21E-09	-
Benzo(b)fluoranthene	3.44E-12	3.78E-09	-
Benzo(k)fluoranthene	1.09E-12	1.99E-09	-
Indeno(1,2,3-c,d)pyrene	1.96E-12	3.76E-09	-
Dibenz(a,h)anthracene	4.75E-12	1.41E-08	-
Naphthalene	-	-	-
TRH Aliphatic >C6-C10	-	-	-
TRH Aromatic >C6-C10	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE6): gas migration to future commerical building, EPC represents the average ammonia and H2S concentration measured in vapour wells and gas vents installed through the CWS with an attenuation factor of 0.005 adopted to represent indoor air building concentration (in accordance with CRC CARE (2011) approaches). An additional two orders of magnitude was applied to the attenuation factor due too additional outdoor air attenuation.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	30	NEPM (2013) commercial	-	-
Exposure frequency to site (days/year)	EF	240	NEPM (2013) commercial	-	-
Vapour Inhalation					
Exposure time spent indoors/ground floor (hrs)	timein	8	NEPM (2013) commercial	-	-
Expsoure time spent outdoors (hrs)	timeout	1	NEPM (2013) commercial	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia				2.49E-01	3.01E-04
Hydrogen sulfide (H2S)				2.28E-01	2.74E-04

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	3.58E+00	4.34E-03
Hydrogen sulfide (H2S)	-	-	-	8.16E+00	9.82E-03

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing: Additional Exposure Scenario (Do Nothing_AEE7_offsite): Leachate reaches downstream receptors. Leachate requires removal and treatment. Involves groundwater/subsurface leachate extraction and treatment through a treatment plant (onsite or offsite) with an assumed duration of three years. Exposure scenario assumes an adult and child recreational user in the down-gradient area.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	3	assumes leachate remains for 3 years prior to cleanup	3	assumes leachate remains for 3 years prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				2.20E-03	4.10E-03				4.13E-03	3.83E-02
Benzo(a)pyrene				3.64E-05	2.09E-08				6.84E-05	1.95E-07
Benz(a)anthracene				2.31E-05	2.01E-08				4.35E-05	1.87E-07
Benzo(b)fluoranthene				2.73E-05	2.68E-08				5.13E-05	2.50E-07
Benzo(k)fluoranthene				1.43E-05	8.50E-09				2.69E-05	7.94E-08
Indeno(1,2,3-c,d)pyrene				2.71E-05	1.53E-08				5.10E-05	1.42E-07
Dibenz(a,h)anthracene				1.02E-05	3.71E-09				1.91E-05	3.46E-08
Naphthalene				6.46E-06	1.26E-07				1.21E-05	1.18E-06
TRH Aliphatic >C6-C10				1.51E-04	7.20E-07				2.83E-04	6.72E-06
TRH Aromatic >C6-C10				1.04E-05	7.20E-07				1.96E-05	6.72E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing: Additional Exposure Scenario (Do Nothing_AEE7_offsite): Leachate reaches downstream receptors. Leachate requires removal and treatment. Involves groundwater/subsurface leachate extraction and treatment through a treatment plant (onsite or offsite) with an assumed duration of three years. Exposure scenario assumes an adult and child recreational user in the down-gradient area.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.05E-04	2.16E-07
Benz(a)anthracene	-	-	-	6.66E-06	2.07E-08
Benzo(b)fluoranthene	-	-	-	7.85E-06	2.77E-08
Benzo(k)fluoranthene	-	-	-	4.13E-06	8.79E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	7.81E-06	1.58E-08
Dibenz(a,h)anthracene	-	-	-	2.93E-05	3.83E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE8): Major stockpile failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	19-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	NEPM (2013) recreational	1	NEPM (2013) recreational
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) recreational	50	NEPM (2013) recreational
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.3	2700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.5 for a 3-6yr old child
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child
Exposure time (surface water) (hrs/event)	ETsw	1	Site assumption	1	Site assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs exposed

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.46E-03	1.95E-04		5.13E-02	9.57E-02	1.36E-02	3.67E-04		9.64E-02	8.93E-01
Benzo(a)pyrene	1.80E-05	1.44E-04		8.49E-04	4.88E-07	1.68E-04	2.71E-04		1.60E-03	4.56E-06
Benz(a)anthracene	1.65E-05	1.33E-04		5.39E-04	4.68E-07	1.54E-04	2.50E-04		1.01E-03	4.37E-06
Benzo(b)fluoranthene	3.02E-05	2.43E-04		6.36E-04	6.26E-07	2.82E-04	4.57E-04		1.20E-03	5.84E-06
Benzo(k)fluoranthene	3.10E-05	2.50E-04		3.34E-04	1.98E-07	2.90E-04	4.69E-04		6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene	8.93E-06	7.18E-05		6.32E-04	3.56E-07	8.34E-05	1.35E-04		1.19E-03	3.32E-06
Dibenz(a,h)anthracene	3.17E-06	2.55E-05		2.38E-04	8.65E-08	2.96E-05	4.80E-05		4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04
Chrysene	1.39E-05	1.12E-04				1.30E-04	2.10E-04			
Benzo(g,h,i)perylene	9.56E-06	7.68E-05				8.92E-05	1.44E-04			
Arsenic	1.23E-05	1.03E-05				1.15E-04	1.94E-05			
TRH Aliphatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aromatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aliphatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			
TRH Aromatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.08E-05	2.79E-06		7.32E-04	1.37E-03	1.94E-04	5.24E-06		1.38E-03	1.28E-02
Benzo(a)pyrene	2.56E-07	2.06E-06		1.21E-05	6.98E-09	2.39E-06	3.88E-06		2.28E-05	6.51E-08
Benz(a)anthracene	2.36E-07	1.90E-06		7.71E-06	6.69E-09	2.20E-06	3.57E-06		1.45E-05	6.24E-08
Benzo(b)fluoranthene	4.32E-07	3.47E-06		9.09E-06	8.94E-09	4.03E-06	6.53E-06		1.71E-05	8.34E-08
Benzo(k)fluoranthene	4.44E-07	3.57E-06		4.77E-06	2.83E-09	4.14E-06	6.71E-06		8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene	1.28E-07	1.03E-06		9.03E-06	5.09E-09	1.19E-06	1.93E-06		1.70E-05	4.75E-08
Dibenz(a,h)anthracene	4.54E-08	3.65E-07		3.39E-06	1.24E-09	4.23E-07	6.86E-07		6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06
Chrysene	1.99E-07	1.60E-06				1.85E-06	3.00E-06			
Benzo(g,h,i)perylene	1.37E-07	1.10E-06				1.27E-06	2.06E-06			
Arsenic	1.76E-07	1.48E-07				1.64E-06	2.78E-07			
TRH Aliphatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aromatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aliphatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			
TRH Aromatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Do Nothing Additional Exposure Scenario (Do Nothing_AEE8): Major stockpile failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	19-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.64E-02	4.88E-03	-	1.28E+00	2.39E+00	3.40E-01	9.17E-03	-	2.41E+00	2.23E+01
Benzo(a)pyrene	5.98E-02	4.81E-01	-	2.83E+00	1.63E-03	5.58E-01	9.05E-01	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.23E-02	1.03E-02	-	-	-	1.15E-01	1.94E-02	-	-	-
TRH Aliphatic >C10-C16	1.35E-04	3.63E-03	-	-	-	1.26E-03	6.82E-03	-	-	-
TRH Aromatic >C10-C16	3.38E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aliphatic >C16-C34	3.39E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aromatic >C16-C34	2.26E-02	6.05E-01	-	-	-	2.11E-01	1.14E+00	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.65E-06	5.94E-06	-	3.49E-05	7.21E-08
Benz(a)anthracene	2.44E-07	5.46E-07	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	4.46E-07	1.00E-06	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	4.58E-07	1.03E-06	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	1.32E-07	2.96E-07	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	4.69E-07	1.05E-06	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.05E-08	4.60E-08	-	-	-
Benzo(g,h,i)perylene	1.41E-08	3.16E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE1): Heavy rainfall causes leachate to discharge to onsite surface water
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	assumes event takes place once	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25mL/hr for >15hrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	4	Assumes direct contact with surface water for 4hrs each day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				4.27E-04	3.68E-04					
Benzo(a)pyrene				3.53E-06	1.88E-09					
Benz(a)anthracene				2.25E-06	1.80E-09					
Benzo(b)fluoranthene				2.65E-06	2.41E-09					
Benzo(k)fluoranthene				1.39E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				2.63E-06	1.37E-09					
Dibenz(a,h)anthracene				9.89E-07	3.33E-10					
Naphthalene				7.11E-07	1.14E-08					
TRH Aliphatic >C6-C10				1.44E-05	6.46E-08					
TRH Aromatic >C6-C10				1.30E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				6.10E-06	5.26E-06					
Benzo(a)pyrene				5.05E-08	2.68E-11					
Benz(a)anthracene				3.21E-08	2.57E-11					
Benzo(b)fluoranthene				3.78E-08	3.44E-11					
Benzo(k)fluoranthene				1.99E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				3.76E-08	1.96E-11					
Dibenz(a,h)anthracene				1.41E-08	4.75E-12					
Naphthalene				1.02E-08	1.62E-10					
TRH Aliphatic >C6-C10				2.05E-07	9.23E-10					
TRH Aromatic >C6-C10				1.85E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE1): Heavy rainfall causes leachate to discharge to onsite surface water
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.07E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.18E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	3.55E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	3.19E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	3.60E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	5.05E-08	2.68E-11
Benz(a)anthracene	-	-	-	3.21E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	3.78E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	1.99E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	3.76E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	1.41E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE2): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	5	Assumes repairs take one week	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	5	Assumes repairs take one week	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.91E-06	2.44E-06								
Benzo(a)pyrene	8.53E-08	1.80E-06								
Benz(a)anthracene	7.84E-08	1.66E-06								
Benzo(b)fluoranthene	1.44E-07	3.03E-06								
Benzo(k)fluoranthene	1.47E-07	3.12E-06								
Indeno(1,2,3-c,d)pyrene	4.24E-08	8.97E-07								
Dibenz(a,h)anthracene	1.51E-08	3.19E-07								
Chrysene	6.60E-08	1.40E-06								
Benzo(g,h,i)perylene	4.54E-08	9.59E-07								
Arsenic	5.86E-08	1.29E-07								
TRH Aliphatic >C10-C16	5.78E-08	4.08E-06								
TRH Aromatic >C10-C16	5.78E-08	4.08E-06								
TRH Aliphatic >C16-C34	2.89E-06	2.04E-04								
TRH Aromatic >C16-C34	2.89E-06	2.04E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.00E-06	3.48E-08				0.00E+00				
Benzo(a)pyrene	1.23E-08	2.57E-08								
Benz(a)anthracene	1.13E-08	2.37E-08								
Benzo(b)fluoranthene	2.08E-08	4.33E-08								
Benzo(k)fluoranthene	2.13E-08	4.45E-08								
Indeno(1,2,3-c,d)pyrene	6.14E-09	1.28E-08								
Dibenz(a,h)anthracene	2.18E-09	4.55E-09								
Chrysene	9.55E-09	1.99E-08								
Benzo(g,h,i)perylene	6.56E-09	1.37E-08								
Arsenic	8.47E-09	1.84E-09								
TRH Aliphatic >C10-C16	8.37E-09	5.82E-08								
TRH Aromatic >C10-C16	8.37E-09	5.82E-08								
TRH Aliphatic >C16-C34	4.19E-07	2.91E-06								
TRH Aromatic >C16-C34	4.19E-07	2.91E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE2): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	1.73E-04	6.09E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	2.84E-04	6.01E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	5.86E-05	1.29E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	6.43E-07	4.53E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	1.07E-04	7.55E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	1.23E-08	2.57E-08	-	-	-
Benz(a)anthracene	1.13E-09	2.37E-09	-	-	-
Benzo(b)fluoranthene	2.08E-09	4.33E-09	-	-	-
Benzo(k)fluoranthene	2.13E-09	4.45E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	6.14E-10	1.28E-09	-	-	-
Dibenz(a,h)anthracene	2.18E-09	4.55E-09	-	-	-
Chrysene	9.55E-11	1.99E-10	-	-	-
Benzo(g,h,i)perylene	6.56E-11	1.37E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE4): Heavy rainfall causes leachate discharge offsite to surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE4): Heavy rainfall causes leachate discharge offsite to surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE5): Moderate repairs to Cap (2-<10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	20	Assumes repairs take one month	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	20	Assumes repairs take one month	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	-	-	-	-
Surface water ingestion rate (L/day)	IRsw	-	-	-	-
Exposure time (surface water) (hrs/event)	ETsw	-	-	-	-
Skin surface area exposed (cm^2)	SA	-	-	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.77E-05	9.74E-06								
Benzo(a)pyrene	3.41E-07	7.21E-06								
Benz(a)anthracene	3.14E-07	6.63E-06								
Benzo(b)fluoranthene	5.74E-07	1.21E-05								
Benzo(k)fluoranthene	5.90E-07	1.25E-05								
Indeno(1,2,3-c,d)pyrene	1.70E-07	3.59E-06								
Dibenz(a,h)anthracene	6.03E-08	1.27E-06								
Chrysene	2.64E-07	5.58E-06								
Benzo(g,h,i)perylene	1.82E-07	3.84E-06								
Arsenic	2.34E-07	5.16E-07								
TRH Aliphatic >C10-C16	2.31E-07	1.63E-05								
TRH Aromatic >C10-C16	2.31E-07	1.63E-05								
TRH Aliphatic >C16-C34	1.16E-05	8.16E-04								
TRH Aromatic >C16-C34	1.16E-05	8.16E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.00E-06	1.39E-07				0.00E+00				
Benzo(a)pyrene	4.93E-08	1.03E-07								
Benz(a)anthracene	4.53E-08	9.47E-08								
Benzo(b)fluoranthene	8.30E-08	1.73E-07								
Benzo(k)fluoranthene	8.53E-08	1.78E-07								
Indeno(1,2,3-c,d)pyrene	2.45E-08	5.13E-08								
Dibenz(a,h)anthracene	8.72E-09	1.82E-08								
Chrysene	3.82E-08	7.97E-08								
Benzo(g,h,i)perylene	2.63E-08	5.48E-08								
Arsenic	3.39E-08	7.37E-09								
TRH Aliphatic >C10-C16	3.35E-08	2.33E-07								
TRH Aromatic >C10-C16	3.35E-08	2.33E-07								
TRH Aliphatic >C16-C34	1.67E-06	1.17E-05								
TRH Aromatic >C16-C34	1.67E-06	1.17E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE5): Moderate repairs to Cap (2-<10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.91E-04	2.44E-04	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.14E-03	2.40E-02	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	2.34E-04	5.16E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	2.57E-06	1.81E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	4.29E-04	3.02E-02	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	4.93E-08	1.03E-07	-	-	-
Benz(a)anthracene	4.53E-09	9.47E-09	-	-	-
Benzo(b)fluoranthene	8.30E-09	1.73E-08	-	-	-
Benzo(k)fluoranthene	8.53E-09	1.78E-08	-	-	-
Indeno(1,2,3-c,d)pyrene	2.45E-09	5.13E-09	-	-	-
Dibenz(a,h)anthracene	8.72E-09	1.82E-08	-	-	-
Chrysene	3.82E-10	7.97E-10	-	-	-
Benzo(g,h,i)perylene	2.63E-10	5.48E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE6): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.00E-07	2.09E-08				0.00E+00				
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE6): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE7): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes cleanup takes 1 day	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidential ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	8	Assumes direct contact all day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				8.54E-04	3.68E-04					
Benzo(a)pyrene				5.00E-06	1.88E-09					
Benz(a)anthracene				3.18E-06	1.80E-09					
Benzo(b)fluoranthene				3.74E-06	2.41E-09					
Benzo(k)fluoranthene				1.97E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				3.72E-06	1.37E-09					
Dibenz(a,h)anthracene				1.40E-06	3.33E-10					
Naphthalene				1.22E-06	1.14E-08					
TRH Aliphatic >C6-C10				2.25E-05	6.46E-08					
TRH Aromatic >C6-C10				2.35E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				1.22E-05	5.26E-06					
Benzo(a)pyrene				7.14E-08	2.68E-11					
Benz(a)anthracene				4.54E-08	2.57E-11					
Benzo(b)fluoranthene				5.35E-08	3.44E-11					
Benzo(k)fluoranthene				2.81E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				5.32E-08	1.96E-11					
Dibenz(a,h)anthracene				2.00E-08	4.75E-12					
Naphthalene				1.74E-08	1.62E-10					
TRH Aliphatic >C6-C10				3.21E-07	9.23E-10					
TRH Aromatic >C6-C10				3.36E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE7): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	2.13E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.67E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	6.11E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	5.00E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.53E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	7.14E-08	2.68E-11
Benz(a)anthracene	-	-	-	4.54E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	5.35E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	2.81E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	5.32E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	2.00E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE8): Containment cell leaks causing leachate migration to groundwater. Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure scenario. Assumes leachate is present for 1yr prior to cleanup.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	Conservative assumption	1	Conservative assumption
Skin surface area exposed (cm^2)	SA	6700	Hands, feet, forearms, lower legs exposed - mean value from Table 3.2.3 (enHealth, 2012)	2700	Hands, feet, forearms, lower legs exposed - mean value 3-6yr old, from Table 3.2.5

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03	0.00E+00			1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE8): Containment cell leaks causing leachate migration to groundwater. Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure scenario. Assumes leachate is present for 1yr prior to cleanup.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE9): Major cap repair (10-<20%)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	120	Assumes repairs takes 6 months	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	120	Assumes repairs takes 6 months	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.66E-04	5.84E-05								
Benzo(a)pyrene	2.05E-06	4.32E-05								
Benz(a)anthracene	1.88E-06	3.98E-05								
Benzo(b)fluoranthene	3.44E-06	7.28E-05								
Benzo(k)fluoranthene	3.54E-06	7.48E-05								
Indeno(1,2,3-c,d)pyrene	1.02E-06	2.15E-05								
Dibenz(a,h)anthracene	3.62E-07	7.65E-06								
Chrysene	1.58E-06	3.35E-05								
Benzo(g,h,i)perylene	1.09E-06	2.30E-05								
Arsenic	1.41E-06	3.10E-06								
TRH Aliphatic >C10-C16	1.39E-06	9.78E-05								
TRH Aromatic >C10-C16	1.39E-06	9.78E-05								
TRH Aliphatic >C16-C34	6.95E-05	4.89E-03								
TRH Aromatic >C16-C34	6.95E-05	4.89E-03								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.40E-05	8.35E-07								
Benzo(a)pyrene	2.96E-07	6.18E-07								
Benz(a)anthracene	2.72E-07	5.68E-07								
Benzo(b)fluoranthene	4.98E-07	1.04E-06								
Benzo(k)fluoranthene	5.12E-07	1.07E-06								
Indeno(1,2,3-c,d)pyrene	1.47E-07	3.08E-07								
Dibenz(a,h)anthracene	5.23E-08	1.09E-07								
Chrysene	2.29E-07	4.78E-07								
Benzo(g,h,i)perylene	1.58E-07	3.29E-07								
Arsenic	2.03E-07	4.42E-08								
TRH Aliphatic >C10-C16	2.01E-07	1.40E-06								
TRH Aromatic >C10-C16	2.01E-07	1.40E-06								
TRH Aliphatic >C16-C34	1.00E-05	6.99E-05								
TRH Aromatic >C16-C34	1.00E-05	6.99E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE9): Major cap repair (10-<20%)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	4.15E-03	1.46E-03	-	-	-	-	-	-	-	-
Benzo(a)pyrene	6.82E-03	1.44E-01	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.41E-03	3.10E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	1.54E-05	1.09E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	2.57E-03	1.81E-01	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.96E-07	6.18E-07	-	-	-
Benz(a)anthracene	2.72E-08	5.68E-08	-	-	-
Benzo(b)fluoranthene	4.98E-08	1.04E-07	-	-	-
Benzo(k)fluoranthene	5.12E-08	1.07E-07	-	-	-
Indeno(1,2,3-c,d)pyrene	1.47E-08	3.08E-08	-	-	-
Dibenz(a,h)anthracene	5.23E-08	1.09E-07	-	-	-
Chrysene	2.29E-09	4.78E-09	-	-	-
Benzo(g,h,i)perylene	1.58E-09	3.29E-09	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE10): Major containment cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes cleanup takes 1 yr	1	assumes cleanup takes 1yr
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) recreational	50	NEPM (2013) recreational
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.3	2700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.5 for
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	1.46E-03	1.95E-04		5.13E-02	9.57E-02	1.36E-02	3.67E-04		9.64E-02	8.93E-01
Benzo(a)pyrene	1.80E-05	1.44E-04		8.49E-04	4.88E-07	1.68E-04	2.71E-04		1.60E-03	4.56E-06
Benz(a)anthracene	1.65E-05	1.33E-04		5.39E-04	4.68E-07	1.54E-04	2.50E-04		1.01E-03	4.37E-06
Benzo(b)fluoranthene	3.02E-05	2.43E-04		6.36E-04	6.26E-07	2.82E-04	4.57E-04		1.20E-03	5.84E-06
Benzo(k)fluoranthene	3.10E-05	2.50E-04		3.34E-04	1.98E-07	2.90E-04	4.69E-04		6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene	8.93E-06	7.18E-05		6.32E-04	3.56E-07	8.34E-05	1.35E-04		1.19E-03	3.32E-06
Dibenz(a,h)anthracene	3.17E-06	2.55E-05		2.38E-04	8.65E-08	2.96E-05	4.80E-05		4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04
Chrysene	1.39E-05	1.12E-04				1.30E-04	2.10E-04			
Benzo(g,h,i)perylene	9.56E-06	7.68E-05				8.92E-05	1.44E-04			
Arsenic	1.23E-05	1.03E-05				1.15E-04	1.94E-05			
TRH Aliphatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aromatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aliphatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			
TRH Aromatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	2.08E-05	2.79E-06		7.32E-04	1.37E-03	1.94E-04	5.24E-06		1.38E-03	1.28E-02
Benzo(a)pyrene	2.56E-07	2.06E-06		1.21E-05	6.98E-09	2.39E-06	3.88E-06		2.28E-05	6.51E-08
Benz(a)anthracene	2.36E-07	1.90E-06		7.71E-06	6.69E-09	2.20E-06	3.57E-06		1.45E-05	6.24E-08
Benzo(b)fluoranthene	4.32E-07	3.47E-06		9.09E-06	8.94E-09	4.03E-06	6.53E-06		1.71E-05	8.34E-08
Benzo(k)fluoranthene	4.44E-07	3.57E-06		4.77E-06	2.83E-09	4.14E-06	6.71E-06		8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene	1.28E-07	1.03E-06		9.03E-06	5.09E-09	1.19E-06	1.93E-06		1.70E-05	4.75E-08
Dibenz(a,h)anthracene	4.54E-08	3.65E-07		3.39E-06	1.24E-09	4.23E-07	6.86E-07		6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06
Chrysene	1.99E-07	1.60E-06				1.85E-06	3.00E-06			
Benzo(g,h,i)perylene	1.37E-07	1.10E-06				1.27E-06	2.06E-06			
Arsenic	1.76E-07	1.48E-07				1.64E-06	2.78E-07			
TRH Aliphatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aromatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aliphatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			
TRH Aromatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 2 Additional Exposure Scenario (Opt2_AEE10): Major containment cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.64E-02	4.88E-03	-	1.28E+00	2.39E+00	3.40E-01	9.17E-03	-	2.41E+00	2.23E+01
Benzo(a)pyrene	5.98E-02	4.81E-01	-	2.83E+00	1.63E-03	5.58E-01	9.05E-01	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.23E-02	1.03E-02	-	-	-	1.15E-01	1.94E-02	-	-	-
TRH Aliphatic >C10-C16	1.35E-04	3.63E-03	-	-	-	1.26E-03	6.82E-03	-	-	-
TRH Aromatic >C10-C16	3.38E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aliphatic >C16-C34	3.39E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aromatic >C16-C34	2.26E-02	6.05E-01	-	-	-	2.11E-01	1.14E+00	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.65E-06	5.94E-06	-	3.49E-05	7.21E-08
Benz(a)anthracene	2.44E-07	5.46E-07	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	4.46E-07	1.00E-06	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	4.58E-07	1.03E-06	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	1.32E-07	2.96E-07	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	4.69E-07	1.05E-06	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.05E-08	4.60E-08	-	-	-
Benzo(g,h,i)perylene	1.41E-08	3.16E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE1): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	5	Assumes repairs take one week	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	5	Assumes repairs take one week	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.91E-06	2.44E-06								
Benzo(a)pyrene	8.53E-08	1.80E-06								
Benz(a)anthracene	7.84E-08	1.66E-06								
Benzo(b)fluoranthene	1.44E-07	3.03E-06								
Benzo(k)fluoranthene	1.47E-07	3.12E-06								
Indeno(1,2,3-c,d)pyrene	4.24E-08	8.97E-07								
Dibenz(a,h)anthracene	1.51E-08	3.19E-07								
Chrysene	6.60E-08	1.40E-06								
Benzo(g,h,i)perylene	4.54E-08	9.59E-07								
Arsenic	5.86E-08	1.29E-07								
TRH Aliphatic >C10-C16	5.78E-08	4.08E-06								
TRH Aromatic >C10-C16	5.78E-08	4.08E-06								
TRH Aliphatic >C16-C34	2.89E-06	2.04E-04								
TRH Aromatic >C16-C34	2.89E-06	2.04E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.00E-06	3.48E-08								
Benzo(a)pyrene	1.23E-08	2.57E-08								
Benz(a)anthracene	1.13E-08	2.37E-08								
Benzo(b)fluoranthene	2.08E-08	4.33E-08								
Benzo(k)fluoranthene	2.13E-08	4.45E-08								
Indeno(1,2,3-c,d)pyrene	6.14E-09	1.28E-08								
Dibenz(a,h)anthracene	2.18E-09	4.55E-09								
Chrysene	9.55E-09	1.99E-08								
Benzo(g,h,i)perylene	6.56E-09	1.37E-08								
Arsenic	8.47E-09	1.84E-09								
TRH Aliphatic >C10-C16	8.37E-09	5.82E-08								
TRH Aromatic >C10-C16	8.37E-09	5.82E-08								
TRH Aliphatic >C16-C34	4.19E-07	2.91E-06								
TRH Aromatic >C16-C34	4.19E-07	2.91E-06								

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE1): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	1.73E-04	6.09E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	2.84E-04	6.01E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	5.86E-05	1.29E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	6.43E-07	4.53E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	1.07E-04	7.55E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	1.23E-08	2.57E-08	-	-	-
Benz(a)anthracene	1.13E-09	2.37E-09	-	-	-
Benzo(b)fluoranthene	2.08E-09	4.33E-09	-	-	-
Benzo(k)fluoranthene	2.13E-09	4.45E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	6.14E-10	1.28E-09	-	-	-
Dibenz(a,h)anthracene	2.18E-09	4.55E-09	-	-	-
Chrysene	9.55E-11	1.99E-10	-	-	-
Benzo(g,h,i)perylene	6.56E-11	1.37E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE4): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE4): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE9): Leachate activates lime which crystallises and clogs leachate capture system resulting in increased gas emissions due to water content. EPC represents the average ammonia and H2S concentration measured in vapour wells and gas vents installed through the CWS with an attenuation factor of 0.005 adopted to represent indoor air building concentration (in accordance with CRC CARE (2011) approaches). An additional two orders of magnitude was applied to the attenuation factor due too additional outdoor air attenuation.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	30	NEPM (2013) commercial	-	-
Exposure frequency to site (days/year)	EF	4	Quarterly monitoring	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	1	NEPM (2013) commercial	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia					4.02E-05
Hydrogen sulfide (H2S)					3.65E-05

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	-	5.78E-04
Hydrogen sulfide (H2S)	-	-	-	-	1.31E-03

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE10): Moderate repairs to Cap (2-10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	20	Assumes repairs take one month	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	20	Assumes repairs take one month	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	-	-	-	-
Surface water ingestion rate (L/day)	IRsw	-	-	-	-
Exposure time (surface water) (hrs/event)	ETsw	-	-	-	-
Skin surface area exposed (cm^2)	SA	-	-	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	2.77E-05	9.74E-06								
Benzo(a)pyrene	3.41E-07	7.21E-06								
Benz(a)anthracene	3.14E-07	6.63E-06								
Benzo(b)fluoranthene	5.74E-07	1.21E-05								
Benzo(k)fluoranthene	5.90E-07	1.25E-05								
Indeno(1,2,3-c,d)pyrene	1.70E-07	3.59E-06								
Dibenz(a,h)anthracene	6.03E-08	1.27E-06								
Chrysene	2.64E-07	5.58E-06								
Benzo(g,h,i)perylene	1.82E-07	3.84E-06								
Arsenic	2.34E-07	5.16E-07								
TRH Aliphatic >C10-C16	2.31E-07	1.63E-05								
TRH Aromatic >C10-C16	2.31E-07	1.63E-05								
TRH Aliphatic >C16-C34	1.16E-05	8.16E-04								
TRH Aromatic >C16-C34	1.16E-05	8.16E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	4.00E-06	1.39E-07								
Benzo(a)pyrene	4.93E-08	1.03E-07								
Benz(a)anthracene	4.53E-08	9.47E-08								
Benzo(b)fluoranthene	8.30E-08	1.73E-07								
Benzo(k)fluoranthene	8.53E-08	1.78E-07								
Indeno(1,2,3-c,d)pyrene	2.45E-08	5.13E-08								
Dibenz(a,h)anthracene	8.72E-09	1.82E-08								
Chrysene	3.82E-08	7.97E-08								
Benzo(g,h,i)perylene	2.63E-08	5.48E-08								
Arsenic	3.39E-08	7.37E-09								
TRH Aliphatic >C10-C16	3.35E-08	2.33E-07								
TRH Aromatic >C10-C16	3.35E-08	2.33E-07								
TRH Aliphatic >C16-C34	1.67E-06	1.17E-05								
TRH Aromatic >C16-C34	1.67E-06	1.17E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE10): Moderate repairs to Cap (2-10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.91E-04	2.44E-04	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.14E-03	2.40E-02	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	2.34E-04	5.16E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	2.57E-06	1.81E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	4.29E-04	3.02E-02	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	4.93E-08	1.03E-07	-	-	-
Benz(a)anthracene	4.53E-09	9.47E-09	-	-	-
Benzo(b)fluoranthene	8.30E-09	1.73E-08	-	-	-
Benzo(k)fluoranthene	8.53E-09	1.78E-08	-	-	-
Indeno(1,2,3-c,d)pyrene	2.45E-09	5.13E-09	-	-	-
Dibenz(a,h)anthracene	8.72E-09	1.82E-08	-	-	-
Chrysene	3.82E-10	7.97E-10	-	-	-
Benzo(g,h,i)perylene	2.63E-10	5.48E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE11): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.00E-07	2.09E-08				0.00E+00				
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE11): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE12): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes cleanup takes 1 day	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidential ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	8	Assumes direct contact all day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				8.54E-04	3.68E-04					
Benzo(a)pyrene				5.00E-06	1.88E-09					
Benz(a)anthracene				3.18E-06	1.80E-09					
Benzo(b)fluoranthene				3.74E-06	2.41E-09					
Benzo(k)fluoranthene				1.97E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				3.72E-06	1.37E-09					
Dibenz(a,h)anthracene				1.40E-06	3.33E-10					
Naphthalene				1.22E-06	1.14E-08					
TRH Aliphatic >C6-C10				2.25E-05	6.46E-08					
TRH Aromatic >C6-C10				2.35E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				1.22E-05	5.26E-06					
Benzo(a)pyrene				7.14E-08	2.68E-11					
Benz(a)anthracene				4.54E-08	2.57E-11					
Benzo(b)fluoranthene				5.35E-08	3.44E-11					
Benzo(k)fluoranthene				2.81E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				5.32E-08	1.96E-11					
Dibenz(a,h)anthracene				2.00E-08	4.75E-12					
Naphthalene				1.74E-08	1.62E-10					
TRH Aliphatic >C6-C10				3.21E-07	9.23E-10					
TRH Aromatic >C6-C10				3.36E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE12): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	2.13E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.67E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	6.11E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	5.00E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.53E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	7.14E-08	2.68E-11
Benz(a)anthracene	-	-	-	4.54E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	5.35E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	2.81E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	5.32E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	2.00E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE13): Containment cell leaks causing leachate migration to groundwater (assumes fluoride is removed via treatment prior to disposal into containment cell). Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure scenario. Assumes leachate is present for 1yr prior to cleanup.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	07-Jul-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	Conservative assumption	1	Conservative assumption
Skin surface area exposed (cm^2)	SA	6700	Hands, feet, forearms, lower legs exposed - mean value from Table 3.2.3 (enHealth, 2012)	2700	Hands, feet, forearms, lower legs exposed - mean value 3-6yr old, from Table

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE13): Containment cell leaks causing leachate migration to groundwater (assumes fluoride is removed via treatment prior to disposal into containment cell). Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure scenario. Assumes leachate is present for 1yr prior to cleanup.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	07-Jul-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE14): Major repairs to Cap (10-<20% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	120	Assumes repairs takes 6 months	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	120	Assumes repairs takes 6 months	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	1.66E-04	5.84E-05								
Benzo(a)pyrene	2.05E-06	4.32E-05								
Benz(a)anthracene	1.88E-06	3.98E-05								
Benzo(b)fluoranthene	3.44E-06	7.28E-05								
Benzo(k)fluoranthene	3.54E-06	7.48E-05								
Indeno(1,2,3-c,d)pyrene	1.02E-06	2.15E-05								
Dibenz(a,h)anthracene	3.62E-07	7.65E-06								
Chrysene	1.58E-06	3.35E-05								
Benzo(g,h,i)perylene	1.09E-06	2.30E-05								
Arsenic	1.41E-06	3.10E-06								
TRH Aliphatic >C10-C16	1.39E-06	9.78E-05								
TRH Aromatic >C10-C16	1.39E-06	9.78E-05								
TRH Aliphatic >C16-C34	6.95E-05	4.89E-03								
TRH Aromatic >C16-C34	6.95E-05	4.89E-03								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	2.40E-05	8.35E-07								
Benzo(a)pyrene	2.96E-07	6.18E-07								
Benz(a)anthracene	2.72E-07	5.68E-07								
Benzo(b)fluoranthene	4.98E-07	1.04E-06								
Benzo(k)fluoranthene	5.12E-07	1.07E-06								
Indeno(1,2,3-c,d)pyrene	1.47E-07	3.08E-07								
Dibenz(a,h)anthracene	5.23E-08	1.09E-07								
Chrysene	2.29E-07	4.78E-07								
Benzo(g,h,i)perylene	1.58E-07	3.29E-07								
Arsenic	2.03E-07	4.42E-08								
TRH Aliphatic >C10-C16	2.01E-07	1.40E-06								
TRH Aromatic >C10-C16	2.01E-07	1.40E-06								
TRH Aliphatic >C16-C34	1.00E-05	6.99E-05								
TRH Aromatic >C16-C34	1.00E-05	6.99E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE14): Major repairs to Cap (10-<20% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	4.15E-03	1.46E-03	-	-	-	-	-	-	-	-
Benzo(a)pyrene	6.82E-03	1.44E-01	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.41E-03	3.10E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	1.54E-05	1.09E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	2.57E-03	1.81E-01	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.96E-07	6.18E-07	-	-	-
Benz(a)anthracene	2.72E-08	5.68E-08	-	-	-
Benzo(b)fluoranthene	4.98E-08	1.04E-07	-	-	-
Benzo(k)fluoranthene	5.12E-08	1.07E-07	-	-	-
Indeno(1,2,3-c,d)pyrene	1.47E-08	3.08E-08	-	-	-
Dibenz(a,h)anthracene	5.23E-08	1.09E-07	-	-	-
Chrysene	2.29E-09	4.78E-09	-	-	-
Benzo(g,h,i)perylene	1.58E-09	3.29E-09	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE16): Major Containment Cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes cleanup takes 1 yr	1	assumes cleanup takes 1yr
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) recreational	50	NEPM (2013) recreational
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.3	2700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.5 for
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.46E-03	1.95E-04		5.13E-02	9.57E-02	1.36E-02	3.67E-04		9.64E-02	8.93E-01
Benzo(a)pyrene	1.80E-05	1.44E-04		8.49E-04	4.88E-07	1.68E-04	2.71E-04		1.60E-03	4.56E-06
Benz(a)anthracene	1.65E-05	1.33E-04		5.39E-04	4.68E-07	1.54E-04	2.50E-04		1.01E-03	4.37E-06
Benzo(b)fluoranthene	3.02E-05	2.43E-04		6.36E-04	6.26E-07	2.82E-04	4.57E-04		1.20E-03	5.84E-06
Benzo(k)fluoranthene	3.10E-05	2.50E-04		3.34E-04	1.98E-07	2.90E-04	4.69E-04		6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene	8.93E-06	7.18E-05		6.32E-04	3.56E-07	8.34E-05	1.35E-04		1.19E-03	3.32E-06
Dibenz(a,h)anthracene	3.17E-06	2.55E-05		2.38E-04	8.65E-08	2.96E-05	4.80E-05		4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04
Chrysene	1.39E-05	1.12E-04				1.30E-04	2.10E-04			
Benzo(g,h,i)perylene	9.56E-06	7.68E-05				8.92E-05	1.44E-04			
Arsenic	1.23E-05	1.03E-05				1.15E-04	1.94E-05			
TRH Aliphatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aromatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aliphatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			
TRH Aromatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.08E-05	2.79E-06		7.32E-04	1.37E-03	1.94E-04	5.24E-06		1.38E-03	1.28E-02
Benzo(a)pyrene	2.56E-07	2.06E-06		1.21E-05	6.98E-09	2.39E-06	3.88E-06		2.28E-05	6.51E-08
Benz(a)anthracene	2.36E-07	1.90E-06		7.71E-06	6.69E-09	2.20E-06	3.57E-06		1.45E-05	6.24E-08
Benzo(b)fluoranthene	4.32E-07	3.47E-06		9.09E-06	8.94E-09	4.03E-06	6.53E-06		1.71E-05	8.34E-08
Benzo(k)fluoranthene	4.44E-07	3.57E-06		4.77E-06	2.83E-09	4.14E-06	6.71E-06		8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene	1.28E-07	1.03E-06		9.03E-06	5.09E-09	1.19E-06	1.93E-06		1.70E-05	4.75E-08
Dibenz(a,h)anthracene	4.54E-08	3.65E-07		3.39E-06	1.24E-09	4.23E-07	6.86E-07		6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06
Chrysene	1.99E-07	1.60E-06				1.85E-06	3.00E-06			
Benzo(g,h,i)perylene	1.37E-07	1.10E-06				1.27E-06	2.06E-06			
Arsenic	1.76E-07	1.48E-07				1.64E-06	2.78E-07			
TRH Aliphatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aromatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aliphatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			
TRH Aromatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 3 Additional Exposure Scenario (Opt3_AEE16): Major Containment Cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.64E-02	4.88E-03	-	1.28E+00	2.39E+00	3.40E-01	9.17E-03	-	2.41E+00	2.23E+01
Benzo(a)pyrene	5.98E-02	4.81E-01	-	2.83E+00	1.63E-03	5.58E-01	9.05E-01	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.23E-02	1.03E-02	-	-	-	1.15E-01	1.94E-02	-	-	-
TRH Aliphatic >C10-C16	1.35E-04	3.63E-03	-	-	-	1.26E-03	6.82E-03	-	-	-
TRH Aromatic >C10-C16	3.38E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aliphatic >C16-C34	3.39E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aromatic >C16-C34	2.26E-02	6.05E-01	-	-	-	2.11E-01	1.14E+00	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.65E-06	5.94E-06	-	3.49E-05	7.21E-08
Benz(a)anthracene	2.44E-07	5.46E-07	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	4.46E-07	1.00E-06	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	4.58E-07	1.03E-06	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	1.32E-07	2.96E-07	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	4.69E-07	1.05E-06	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.05E-08	4.60E-08	-	-	-
Benzo(g,h,i)perylene	1.41E-08	3.16E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE1): Heavy rainfall causes leachate discharge to onsite surface water
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	assumes event takes place once	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25mL/hr for >15hrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	4	Assumes direct contact with surface water for 4hrs each	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				4.27E-04	3.68E-04					
Benzo(a)pyrene				3.53E-06	1.88E-09					
Benz(a)anthracene				2.25E-06	1.80E-09					
Benzo(b)fluoranthene				2.65E-06	2.41E-09					
Benzo(k)fluoranthene				1.39E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				2.63E-06	1.37E-09					
Dibenz(a,h)anthracene				9.89E-07	3.33E-10					
Naphthalene				7.11E-07	1.14E-08					
TRH Aliphatic >C6-C10				1.44E-05	6.46E-08					
TRH Aromatic >C6-C10				1.30E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				6.10E-06	5.26E-06					
Benzo(a)pyrene				5.05E-08	2.68E-11					
Benz(a)anthracene				3.21E-08	2.57E-11					
Benzo(b)fluoranthene				3.78E-08	3.44E-11					
Benzo(k)fluoranthene				1.99E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				3.76E-08	1.96E-11					
Dibenz(a,h)anthracene				1.41E-08	4.75E-12					
Naphthalene				1.02E-08	1.62E-10					
TRH Aliphatic >C6-C10				2.05E-07	9.23E-10					
TRH Aromatic >C6-C10				1.85E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE1): Heavy rainfall causes leachate discharge to onsite surface water
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.07E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.18E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	3.55E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	3.19E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	3.60E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	5.05E-08	2.68E-11
Benz(a)anthracene	-	-	-	3.21E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	3.78E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	1.99E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	3.76E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	1.41E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE2): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	5	Assumes repairs take one week	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	5	Assumes repairs take one week	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.91E-06	2.44E-06								
Benzo(a)pyrene	8.53E-08	1.80E-06								
Benz(a)anthracene	7.84E-08	1.66E-06								
Benzo(b)fluoranthene	1.44E-07	3.03E-06								
Benzo(k)fluoranthene	1.47E-07	3.12E-06								
Indeno(1,2,3-c,d)pyrene	4.24E-08	8.97E-07								
Dibenz(a,h)anthracene	1.51E-08	3.19E-07								
Chrysene	6.60E-08	1.40E-06								
Benzo(g,h,i)perylene	4.54E-08	9.59E-07								
Arsenic	5.86E-08	1.29E-07								
TRH Aliphatic >C10-C16	5.78E-08	4.08E-06								
TRH Aromatic >C10-C16	5.78E-08	4.08E-06								
TRH Aliphatic >C16-C34	2.89E-06	2.04E-04								
TRH Aromatic >C16-C34	2.89E-06	2.04E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.00E-06	3.48E-08								
Benzo(a)pyrene	1.23E-08	2.57E-08								
Benz(a)anthracene	1.13E-08	2.37E-08								
Benzo(b)fluoranthene	2.08E-08	4.33E-08								
Benzo(k)fluoranthene	2.13E-08	4.45E-08								
Indeno(1,2,3-c,d)pyrene	6.14E-09	1.28E-08								
Dibenz(a,h)anthracene	2.18E-09	4.55E-09								
Chrysene	9.55E-09	1.99E-08								
Benzo(g,h,i)perylene	6.56E-09	1.37E-08								
Arsenic	8.47E-09	1.84E-09								
TRH Aliphatic >C10-C16	8.37E-09	5.82E-08								
TRH Aromatic >C10-C16	8.37E-09	5.82E-08								
TRH Aliphatic >C16-C34	4.19E-07	2.91E-06								
TRH Aromatic >C16-C34	4.19E-07	2.91E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE2): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	1.73E-04	6.09E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	2.84E-04	6.01E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	5.86E-05	1.29E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	6.43E-07	4.53E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	1.07E-04	7.55E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	1.23E-08	2.57E-08	-	-	-
Benz(a)anthracene	1.13E-09	2.37E-09	-	-	-
Benzo(b)fluoranthene	2.08E-09	4.33E-09	-	-	-
Benzo(k)fluoranthene	2.13E-09	4.45E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	6.14E-10	1.28E-09	-	-	-
Dibenz(a,h)anthracene	2.18E-09	4.55E-09	-	-	-
Chrysene	9.55E-11	1.99E-10	-	-	-
Benzo(g,h,i)perylene	6.56E-11	1.37E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE4): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE4): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidentialn Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE6): Leachate activates lime which crystallises and clogs leachate capture system resulting in increased gas emissions due to water content. EPC represents the average ammonia and H2S concentration measured in vapour wells and gas vents installed through the CWS with an attenuation factor of 0.005 adopted to represent indoor air building concentration (in accordance with CRC CARE (2011) approaches). An additional two orders of magnitude was applied to the attenuation factor due too additional outdoor air attenuation.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	30	NEPM (2013) commercial	-	-
Exposure frequency to site (days/year)	EF	4	Quarterly monitoring	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	8	Conservative assumption	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia					4.02E-05
Hydrogen sulfide (H2S)					3.65E-05

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	-	5.78E-04
Hydrogen sulfide (H2S)	-	-	-	-	1.31E-03

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE7): Moderate repairs to Cap (<2-10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	20	Assumes repairs take one month	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	20	Assumes repairs take one month	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	-	-	-	-
Surface water ingestion rate (L/day)	IRsw	-	-	-	-
Exposure time (surface water) (hrs/event)	ETsw	-	-	-	-
Skin surface area exposed (cm^2)	SA	-	-	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.77E-05	9.74E-06								
Benzo(a)pyrene	3.41E-07	7.21E-06								
Benz(a)anthracene	3.14E-07	6.63E-06								
Benzo(b)fluoranthene	5.74E-07	1.21E-05								
Benzo(k)fluoranthene	5.90E-07	1.25E-05								
Indeno(1,2,3-c,d)pyrene	1.70E-07	3.59E-06								
Dibenz(a,h)anthracene	6.03E-08	1.27E-06								
Chrysene	2.64E-07	5.58E-06								
Benzo(g,h,i)perylene	1.82E-07	3.84E-06								
Arsenic	2.34E-07	5.16E-07								
TRH Aliphatic >C10-C16	2.31E-07	1.63E-05								
TRH Aromatic >C10-C16	2.31E-07	1.63E-05								
TRH Aliphatic >C16-C34	1.16E-05	8.16E-04								
TRH Aromatic >C16-C34	1.16E-05	8.16E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.00E-06	1.39E-07								
Benzo(a)pyrene	4.93E-08	1.03E-07								
Benz(a)anthracene	4.53E-08	9.47E-08								
Benzo(b)fluoranthene	8.30E-08	1.73E-07								
Benzo(k)fluoranthene	8.53E-08	1.78E-07								
Indeno(1,2,3-c,d)pyrene	2.45E-08	5.13E-08								
Dibenz(a,h)anthracene	8.72E-09	1.82E-08								
Chrysene	3.82E-08	7.97E-08								
Benzo(g,h,i)perylene	2.63E-08	5.48E-08								
Arsenic	3.39E-08	7.37E-09								
TRH Aliphatic >C10-C16	3.35E-08	2.33E-07								
TRH Aromatic >C10-C16	3.35E-08	2.33E-07								
TRH Aliphatic >C16-C34	1.67E-06	1.17E-05								
TRH Aromatic >C16-C34	1.67E-06	1.17E-05								

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE7): Moderate repairs to Cap (<2-10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.91E-04	2.44E-04	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.14E-03	2.40E-02	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	2.34E-04	5.16E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	2.57E-06	1.81E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	4.29E-04	3.02E-02	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	4.93E-08	1.03E-07	-	-	-
Benz(a)anthracene	4.53E-09	9.47E-09	-	-	-
Benzo(b)fluoranthene	8.30E-09	1.73E-08	-	-	-
Benzo(k)fluoranthene	8.53E-09	1.78E-08	-	-	-
Indeno(1,2,3-c,d)pyrene	2.45E-09	5.13E-09	-	-	-
Dibenz(a,h)anthracene	8.72E-09	1.82E-08	-	-	-
Chrysene	3.82E-10	7.97E-10	-	-	-
Benzo(g,h,i)perylene	2.63E-10	5.48E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE8): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.00E-07	2.09E-08								
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE8): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE9): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes cleanup takes 1 day	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidential ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	8	Assumes direct contact all day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				8.54E-04	3.68E-04					
Benzo(a)pyrene				5.00E-06	1.88E-09					
Benz(a)anthracene				3.18E-06	1.80E-09					
Benzo(b)fluoranthene				3.74E-06	2.41E-09					
Benzo(k)fluoranthene				1.97E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				3.72E-06	1.37E-09					
Dibenz(a,h)anthracene				1.40E-06	3.33E-10					
Naphthalene				1.22E-06	1.14E-08					
TRH Aliphatic >C6-C10				2.25E-05	6.46E-08					
TRH Aromatic >C6-C10				2.35E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)				1.22E-05	5.26E-06					
Benzo(a)pyrene				7.14E-08	2.68E-11					
Benz(a)anthracene				4.54E-08	2.57E-11					
Benzo(b)fluoranthene				5.35E-08	3.44E-11					
Benzo(k)fluoranthene				2.81E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				5.32E-08	1.96E-11					
Dibenz(a,h)anthracene				2.00E-08	4.75E-12					
Naphthalene				1.74E-08	1.62E-10					
TRH Aliphatic >C6-C10				3.21E-07	9.23E-10					
TRH Aromatic >C6-C10				3.36E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE9): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	2.13E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.67E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	6.11E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	5.00E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.53E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	7.14E-08	2.68E-11
Benz(a)anthracene	-	-	-	4.54E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	5.35E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	2.81E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	5.32E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	2.00E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE10): Containment cell leaks causing leachate migration to groundwater (assumes fluoride is removed via treatment prior to placement in containment cell). Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure scenario. Assumes leachate is present for 1yr prior to cleanup.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	07-Jul-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	Conservative assumption	1	Conservative assumption
Skin surface area exposed (cm^2)	SA	6700	Hands, feet, forearms, lower legs exposed - mean value from Table 3.2.3 (enHealth, 2012)	2700	Hands, feet, forearms, lower legs exposed - mean value 3-6yr old, from Table

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE10): Containment cell leaks causing leachate migration to groundwater (assumes fluoride is removed via treatment prior to placement in containment cell). Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	07-Jul-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE11): Major repairs to Cap (10-<20% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	120	Assumes repairs takes 6 months	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	120	Assumes repairs takes 6 months	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.66E-04	5.84E-05								
Benzo(a)pyrene	2.05E-06	4.32E-05								
Benz(a)anthracene	1.88E-06	3.98E-05								
Benzo(b)fluoranthene	3.44E-06	7.28E-05								
Benzo(k)fluoranthene	3.54E-06	7.48E-05								
Indeno(1,2,3-c,d)pyrene	1.02E-06	2.15E-05								
Dibenz(a,h)anthracene	3.62E-07	7.65E-06								
Chrysene	1.58E-06	3.35E-05								
Benzo(g,h,i)perylene	1.09E-06	2.30E-05								
Arsenic	1.41E-06	3.10E-06								
TRH Aliphatic >C10-C16	1.39E-06	9.78E-05								
TRH Aromatic >C10-C16	1.39E-06	9.78E-05								
TRH Aliphatic >C16-C34	6.95E-05	4.89E-03								
TRH Aromatic >C16-C34	6.95E-05	4.89E-03								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.40E-05	8.35E-07								
Benzo(a)pyrene	2.96E-07	6.18E-07								
Benz(a)anthracene	2.72E-07	5.68E-07								
Benzo(b)fluoranthene	4.98E-07	1.04E-06								
Benzo(k)fluoranthene	5.12E-07	1.07E-06								
Indeno(1,2,3-c,d)pyrene	1.47E-07	3.08E-07								
Dibenz(a,h)anthracene	5.23E-08	1.09E-07								
Chrysene	2.29E-07	4.78E-07								
Benzo(g,h,i)perylene	1.58E-07	3.29E-07								
Arsenic	2.03E-07	4.42E-08								
TRH Aliphatic >C10-C16	2.01E-07	1.40E-06								
TRH Aromatic >C10-C16	2.01E-07	1.40E-06								
TRH Aliphatic >C16-C34	1.00E-05	6.99E-05								
TRH Aromatic >C16-C34	1.00E-05	6.99E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE11): Major repairs to Cap (10-<20% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.15E-03	1.46E-03	-	-	-	-	-	-	-	-
Benzo(a)pyrene	6.82E-03	1.44E-01	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.41E-03	3.10E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	1.54E-05	1.09E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	2.57E-03	1.81E-01	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion from Surface Water
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.96E-07	6.18E-07	-	-	-
Benz(a)anthracene	2.72E-08	5.68E-08	-	-	-
Benzo(b)fluoranthene	4.98E-08	1.04E-07	-	-	-
Benzo(k)fluoranthene	5.12E-08	1.07E-07	-	-	-
Indeno(1,2,3-c,d)pyrene	1.47E-08	3.08E-08	-	-	-
Dibenz(a,h)anthracene	5.23E-08	1.09E-07	-	-	-
Chrysene	2.29E-09	4.78E-09	-	-	-
Benzo(g,h,i)perylene	1.58E-09	3.29E-09	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE12): Major Containment Cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes cleanup takes 1 yr	1	assumes cleanup takes 1yr
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) recreational	50	NEPM (2013) recreational
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.3	2700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.5 for
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.46E-03	1.95E-04		5.13E-02	9.57E-02	1.36E-02	3.67E-04		9.64E-02	8.93E-01
Benzo(a)pyrene	1.80E-05	1.44E-04		8.49E-04	4.88E-07	1.68E-04	2.71E-04		1.60E-03	4.56E-06
Benz(a)anthracene	1.65E-05	1.33E-04		5.39E-04	4.68E-07	1.54E-04	2.50E-04		1.01E-03	4.37E-06
Benzo(b)fluoranthene	3.02E-05	2.43E-04		6.36E-04	6.26E-07	2.82E-04	4.57E-04		1.20E-03	5.84E-06
Benzo(k)fluoranthene	3.10E-05	2.50E-04		3.34E-04	1.98E-07	2.90E-04	4.69E-04		6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene	8.93E-06	7.18E-05		6.32E-04	3.56E-07	8.34E-05	1.35E-04		1.19E-03	3.32E-06
Dibenz(a,h)anthracene	3.17E-06	2.55E-05		2.38E-04	8.65E-08	2.96E-05	4.80E-05		4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04
Chrysene	1.39E-05	1.12E-04				1.30E-04	2.10E-04			
Benzo(g,h,i)perylene	9.56E-06	7.68E-05				8.92E-05	1.44E-04			
Arsenic	1.23E-05	1.03E-05				1.15E-04	1.94E-05			
TRH Aliphatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aromatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aliphatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			
TRH Aromatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.08E-05	2.79E-06		7.32E-04	1.37E-03	1.94E-04	5.24E-06		1.38E-03	1.28E-02
Benzo(a)pyrene	2.56E-07	2.06E-06		1.21E-05	6.98E-09	2.39E-06	3.88E-06		2.28E-05	6.51E-08
Benz(a)anthracene	2.36E-07	1.90E-06		7.71E-06	6.69E-09	2.20E-06	3.57E-06		1.45E-05	6.24E-08
Benzo(b)fluoranthene	4.32E-07	3.47E-06		9.09E-06	8.94E-09	4.03E-06	6.53E-06		1.71E-05	8.34E-08
Benzo(k)fluoranthene	4.44E-07	3.57E-06		4.77E-06	2.83E-09	4.14E-06	6.71E-06		8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene	1.28E-07	1.03E-06		9.03E-06	5.09E-09	1.19E-06	1.93E-06		1.70E-05	4.75E-08
Dibenz(a,h)anthracene	4.54E-08	3.65E-07		3.39E-06	1.24E-09	4.23E-07	6.86E-07		6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06
Chrysene	1.99E-07	1.60E-06				1.85E-06	3.00E-06			
Benzo(g,h,i)perylene	1.37E-07	1.10E-06				1.27E-06	2.06E-06			
Arsenic	1.76E-07	1.48E-07				1.64E-06	2.78E-07			
TRH Aliphatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aromatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aliphatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			
TRH Aromatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 4 Additional Exposure Scenario (Opt4_AEE12): Major Containment Cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.64E-02	4.88E-03	-	1.28E+00	2.39E+00	3.40E-01	9.17E-03	-	2.41E+00	2.23E+01
Benzo(a)pyrene	5.98E-02	4.81E-01	-	2.83E+00	1.63E-03	5.58E-01	9.05E-01	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.23E-02	1.03E-02	-	-	-	1.15E-01	1.94E-02	-	-	-
TRH Aliphatic >C10-C16	1.35E-04	3.63E-03	-	-	-	1.26E-03	6.82E-03	-	-	-
TRH Aromatic >C10-C16	3.38E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aliphatic >C16-C34	3.39E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aromatic >C16-C34	2.26E-02	6.05E-01	-	-	-	2.11E-01	1.14E+00	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.65E-06	5.94E-06	-	3.49E-05	7.21E-08
Benz(a)anthracene	2.44E-07	5.46E-07	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	4.46E-07	1.00E-06	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	4.58E-07	1.03E-06	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	1.32E-07	2.96E-07	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	4.69E-07	1.05E-06	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.05E-08	4.60E-08	-	-	-
Benzo(g,h,i)perylene	1.41E-08	3.16E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE1): Heavy rainfall event causes erosion and sediment lost offsite at receiving facility. Assumes exposure to soil and leachate by adult workers at the Kemps Creek facility; and management measures take 2 weeks to complete.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	10	assumes management measures take 2 weeks to complete	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	10	assumes management measures take 2 weeks to complete	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25mL/hr for >15hrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	2	Assumes direct contact with surface water for 2hrs each	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	1.38E-05	4.87E-06		2.13E-03	3.68E-03					
Benzo(a)pyrene	1.71E-07	3.60E-06		2.50E-05	1.88E-08					
Benz(a)anthracene	1.57E-07	3.31E-06		1.59E-05	1.80E-08					
Benzo(b)fluoranthene	2.87E-07	6.07E-06		1.87E-05	2.41E-08					
Benzo(k)fluoranthene	2.95E-07	6.23E-06		9.83E-06	7.63E-09					
Indeno(1,2,3-c,d)pyrene	8.49E-08	1.79E-06		1.86E-05	1.37E-08					
Dibenz(a,h)anthracene	3.02E-08	6.37E-07		6.99E-06	3.33E-09					
Naphthalene				4.56E-06	1.14E-07					
TRH Aliphatic >C6-C10				1.03E-04	6.46E-07					
TRH Aromatic >C6-C10				7.70E-06	6.46E-07					
Chrysene	1.32E-07	2.79E-06								
Benzo(g,h,i)perylene	9.08E-08	1.92E-06								
Arsenic	1.17E-07	2.58E-07								
TRH Aliphatic >C10-C16	1.16E-07	8.15E-06								
TRH Aromatic >C10-C16	1.16E-07	8.15E-06								
TRH Aliphatic >C16-C34	5.79E-06	4.08E-04								
TRH Aromatic >C16-C34	5.79E-06	4.08E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water
Fluoride (soluble)	2.00E-06	6.96E-08		3.05E-05	5.26E-05					
Benzo(a)pyrene	2.47E-08	5.15E-08		3.57E-07	2.68E-10					
Benz(a)anthracene	2.27E-08	4.73E-08		2.27E-07	2.57E-10					
Benzo(b)fluoranthene	4.15E-08	8.67E-08		2.67E-07	3.44E-10					
Benzo(k)fluoranthene	4.26E-08	8.90E-08		1.40E-07	1.09E-10					
Indeno(1,2,3-c,d)pyrene	1.23E-08	2.56E-08		2.66E-07	1.96E-10					
Dibenz(a,h)anthracene	4.36E-09	9.11E-09		9.99E-08	4.75E-11					
Naphthalene				6.51E-08	1.62E-09					
TRH Aliphatic >C6-C10				1.47E-06	9.23E-09					
TRH Aromatic >C6-C10				1.10E-07	9.23E-09					
Chrysene	1.91E-08	3.99E-08								
Benzo(g,h,i)perylene	1.31E-08	2.74E-08								
Arsenic	1.69E-08	3.68E-09								
TRH Aliphatic >C10-C16	1.67E-08	1.16E-07								
TRH Aromatic >C10-C16	1.67E-08	1.16E-07								
TRH Aliphatic >C16-C34	8.37E-07	5.83E-06								
TRH Aromatic >C16-C34	8.37E-07	5.83E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE1): Heavy rainfall event causes erosion and sediment lost offsite at receiving facility. Assumes exposure to soil and
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.46E-04	1.22E-04	-	5.33E-02	9.20E-02	-	-	-	-	-
Benzo(a)pyrene	5.68E-04	1.20E-02	-	8.33E-02	6.26E-05	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	2.28E-04	5.68E-06	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	2.28E-05	1.44E-07	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	2.14E-04	1.79E-05	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.17E-04	2.58E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	1.29E-06	9.06E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	3.21E-06	2.26E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	3.22E-06	2.27E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	2.14E-04	1.51E-02	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.47E-08	5.15E-08	-	3.57E-07	2.68E-10
Benz(a)anthracene	2.27E-09	4.73E-09	-	2.27E-08	2.57E-11
Benzo(b)fluoranthene	4.15E-09	8.67E-09	-	2.67E-08	3.44E-11
Benzo(k)fluoranthene	4.26E-09	8.90E-09	-	1.40E-08	1.09E-11
Indeno(1,2,3-c,d)pyrene	1.23E-09	2.56E-09	-	2.66E-08	1.96E-11
Dibenz(a,h)anthracene	4.36E-09	9.11E-09	-	9.99E-08	4.75E-11
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	1.91E-10	3.99E-10	-	-	-
Benzo(g,h,i)perylene	1.31E-10	2.74E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE2): Leachate reacts with other waste leachate within the large cell. Assumes mixed leachate discharges offsite and remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water. The reported hazard index represents the total calculated hazard index increased by 50% to account for any additive toxicity effects caused by interaction with unknown chemicals in the co-disposed waste. Similarily, the ILCR is increased by an order of magnitude to account for any additive toxicity effects.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE2): Leachate reacts with other waste leachate within the large cell. Assumes mixed leachate discharges offsite and remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water. The reported hazard index represents the total calculated hazard index increased by 50% to account for any additive toxicity effects caused by interaction with unknown chemicals in the co-disposed waste. Similarily, the ILCR is increased by an order of magnitude to account for any additive toxicity effects.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE3): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	5	Assumes repairs take one week	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	5	Assumes repairs take one week	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.91E-06	2.44E-06								
Benzo(a)pyrene	8.53E-08	1.80E-06								
Benz(a)anthracene	7.84E-08	1.66E-06								
Benzo(b)fluoranthene	1.44E-07	3.03E-06								
Benzo(k)fluoranthene	1.47E-07	3.12E-06								
Indeno(1,2,3-c,d)pyrene	4.24E-08	8.97E-07								
Dibenz(a,h)anthracene	1.51E-08	3.19E-07								
Chrysene	6.60E-08	1.40E-06								
Benzo(g,h,i)perylene	4.54E-08	9.59E-07								
Arsenic	5.86E-08	1.29E-07								
TRH Aliphatic >C10-C16	5.78E-08	4.08E-06								
TRH Aromatic >C10-C16	5.78E-08	4.08E-06								
TRH Aliphatic >C16-C34	2.89E-06	2.04E-04								
TRH Aromatic >C16-C34	2.89E-06	2.04E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.00E-06	3.48E-08								
Benzo(a)pyrene	1.23E-08	2.57E-08								
Benz(a)anthracene	1.13E-08	2.37E-08								
Benzo(b)fluoranthene	2.08E-08	4.33E-08								
Benzo(k)fluoranthene	2.13E-08	4.45E-08								
Indeno(1,2,3-c,d)pyrene	6.14E-09	1.28E-08								
Dibenz(a,h)anthracene	2.18E-09	4.55E-09								
Chrysene	9.55E-09	1.99E-08								
Benzo(g,h,i)perylene	6.56E-09	1.37E-08								
Arsenic	8.47E-09	1.84E-09								
TRH Aliphatic >C10-C16	8.37E-09	5.82E-08								
TRH Aromatic >C10-C16	8.37E-09	5.82E-08								
TRH Aliphatic >C16-C34	4.19E-07	2.91E-06								
TRH Aromatic >C16-C34	4.19E-07	2.91E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE3): Minor repairs to Cap (<2% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	1.73E-04	6.09E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	2.84E-04	6.01E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	5.86E-05	1.29E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	6.43E-07	4.53E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	1.61E-06	1.13E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	1.07E-04	7.55E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	1.23E-08	2.57E-08	-	-	-
Benz(a)anthracene	1.13E-09	2.37E-09	-	-	-
Benzo(b)fluoranthene	2.08E-09	4.33E-09	-	-	-
Benzo(k)fluoranthene	2.13E-09	4.45E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	6.14E-10	1.28E-09	-	-	-
Dibenz(a,h)anthracene	2.18E-09	4.55E-09	-	-	-
Chrysene	9.55E-11	1.99E-10	-	-	-
Benzo(g,h,i)perylene	6.56E-11	1.37E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE5): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE5): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE6): Community access offsite containment cell location and exposed to gas. EPC represents the average ammonia and H2S concentration in the CWS with an attenuation factor of 0.00005 adopted to represent outdoor air concentration (in accordance with indoor air hydrocarbon attenuation CRC CARE (2011) approaches, with an additional two orders of magnitude applied to account for attenuation in outdoor air).
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	27-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	29	NEPM (2013) recreational	-	-
Exposure frequency to site (days/year)	EF	12	assume once per month	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	1	Assume 1hr exposed to gas from containment cell air	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia					1.51E-05
Hydrogen sulfide (H2S)					1.37E-05

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	-	2.17E-04
Hydrogen sulfide (H2S)	-	-	-	-	4.91E-04

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE12): Leachate activates lime which crystallises and clogs leachate capture system resulting in increased gas emissions due to water content. EPC represents the average ammonia and H2S concentration measured in vapour wells and gas vents installed through the CWS with an attenuation factor of 0.005 adopted to represent indoor air building concentration (in accordance with CRC CARE (2011) approaches). An additional two orders of magnitude was applied to the attenuation factor due too additional outdoor air attenuation.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	30	NEPM (2013) commercial	-	-
Exposure frequency to site (days/year)	EF	4	Quarterly monitoring	-	-
Vapour Inhalation					
Expsoure time spent outdoors (hrs)	timeout	8	Conservative assumption	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia					4.02E-05
Hydrogen sulfide (H2S)					3.65E-05

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	-	5.78E-04
Hydrogen sulfide (H2S)	-	-	-	-	1.31E-03

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt4_AEE13): Moderate repairs to Cap (2-<10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	20	Assumes repairs take one month	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	20	Assumes repairs take one month	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	-	-	-	-
Surface water ingestion rate (L/day)	IRsw	-	-	-	-
Exposure time (surface water) (hrs/event)	ETsw	-	-	-	-
Skin surface area exposed (cm^2)	SA	-	-	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.77E-05	9.74E-06								
Benzo(a)pyrene	3.41E-07	7.21E-06								
Benz(a)anthracene	3.14E-07	6.63E-06								
Benzo(b)fluoranthene	5.74E-07	1.21E-05								
Benzo(k)fluoranthene	5.90E-07	1.25E-05								
Indeno(1,2,3-c,d)pyrene	1.70E-07	3.59E-06								
Dibenz(a,h)anthracene	6.03E-08	1.27E-06								
Chrysene	2.64E-07	5.58E-06								
Benzo(g,h,i)perylene	1.82E-07	3.84E-06								
Arsenic	2.34E-07	5.16E-07								
TRH Aliphatic >C10-C16	2.31E-07	1.63E-05								
TRH Aromatic >C10-C16	2.31E-07	1.63E-05								
TRH Aliphatic >C16-C34	1.16E-05	8.16E-04								
TRH Aromatic >C16-C34	1.16E-05	8.16E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.00E-06	1.39E-07								
Benzo(a)pyrene	4.93E-08	1.03E-07								
Benz(a)anthracene	4.53E-08	9.47E-08								
Benzo(b)fluoranthene	8.30E-08	1.73E-07								
Benzo(k)fluoranthene	8.53E-08	1.78E-07								
Indeno(1,2,3-c,d)pyrene	2.45E-08	5.13E-08								
Dibenz(a,h)anthracene	8.72E-09	1.82E-08								
Chrysene	3.82E-08	7.97E-08								
Benzo(g,h,i)perylene	2.63E-08	5.48E-08								
Arsenic	3.39E-08	7.37E-09								
TRH Aliphatic >C10-C16	3.35E-08	2.33E-07								
TRH Aromatic >C10-C16	3.35E-08	2.33E-07								
TRH Aliphatic >C16-C34	1.67E-06	1.17E-05								
TRH Aromatic >C16-C34	1.67E-06	1.17E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt4_AEE13): Moderate repairs to Cap (2-<10% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.91E-04	2.44E-04	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.14E-03	2.40E-02	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	2.34E-04	5.16E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	2.57E-06	1.81E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	6.43E-06	4.53E-04	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	4.29E-04	3.02E-02	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	4.93E-08	1.03E-07	-	-	-
Benz(a)anthracene	4.53E-09	9.47E-09	-	-	-
Benzo(b)fluoranthene	8.30E-09	1.73E-08	-	-	-
Benzo(k)fluoranthene	8.53E-09	1.78E-08	-	-	-
Indeno(1,2,3-c,d)pyrene	2.45E-09	5.13E-09	-	-	-
Dibenz(a,h)anthracene	8.72E-09	1.82E-08	-	-	-
Chrysene	3.82E-10	7.97E-10	-	-	-
Benzo(g,h,i)perylene	2.63E-10	5.48E-10	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE14): Truck spills contaminated load on public road. Assumes negligible exposure to public, and clean up by adult workers.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.00E-07	2.09E-08								
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE14): Truck spills contaminated load on public road. Assumes negligible exposure to public, and clean up by adult workers.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE15): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes cleanup takes 1 day	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidential ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	8	Assumes direct contact all day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)										
	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				8.54E-04	3.68E-04					
Benzo(a)pyrene				5.00E-06	1.88E-09					
Benz(a)anthracene				3.18E-06	1.80E-09					
Benzo(b)fluoranthene				3.74E-06	2.41E-09					
Benzo(k)fluoranthene				1.97E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				3.72E-06	1.37E-09					
Dibenz(a,h)anthracene				1.40E-06	3.33E-10					
Naphthalene				1.22E-06	1.14E-08					
TRH Aliphatic >C6-C10				2.25E-05	6.46E-08					
TRH Aromatic >C6-C10				2.35E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)										
	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				1.22E-05	5.26E-06					
Benzo(a)pyrene				7.14E-08	2.68E-11					
Benz(a)anthracene				4.54E-08	2.57E-11					
Benzo(b)fluoranthene				5.35E-08	3.44E-11					
Benzo(k)fluoranthene				2.81E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				5.32E-08	1.96E-11					
Dibenz(a,h)anthracene				2.00E-08	4.75E-12					
Naphthalene				1.74E-08	1.62E-10					
TRH Aliphatic >C6-C10				3.21E-07	9.23E-10					
TRH Aromatic >C6-C10				3.36E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE15): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	2.13E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.67E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	6.11E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	5.00E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.53E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	7.14E-08	2.68E-11
Benz(a)anthracene	-	-	-	4.54E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	5.35E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	2.81E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	5.32E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	2.00E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE16): Containment cell leaks causing leachate migration to groundwater (assumes fluoride is removed via treatment prior to placement in containment cell). Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure scenario. Assumes leachate is present for 1yr prior to cleanup.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	07-Jul-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	Conservative assumption	1	Conservative assumption
Skin surface area exposed (cm^2)	SA	6700	Hands, feet, forearms, lower legs exposed - mean value from Table 3.2.3 (enHealth, 2012)	2700	Hands, feet, forearms, lower legs exposed - mean value 3-6yr old, from Table

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE16): Containment cell leaks causing leachate migration to groundwater (assumes fluoride is removed via treatment prior to placement in containment cell). Assumes groundwater not used for drinking purposes, and groundwater is exposed to surface in a recreational land use exposure
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	07-Jul-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE18): Major Containment Cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes cleanup takes 1 yr	1	assumes cleanup takes 1yr
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) recreational	50	NEPM (2013) recreational
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.3	2700	feet, hands, forearms & lower legs (enHealth, 2012) Table 3.2.5 for
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.46E-03	1.95E-04		5.13E-02	9.57E-02	1.36E-02	3.67E-04		9.64E-02	8.93E-01
Benzo(a)pyrene	1.80E-05	1.44E-04		8.49E-04	4.88E-07	1.68E-04	2.71E-04		1.60E-03	4.56E-06
Benz(a)anthracene	1.65E-05	1.33E-04		5.39E-04	4.68E-07	1.54E-04	2.50E-04		1.01E-03	4.37E-06
Benzo(b)fluoranthene	3.02E-05	2.43E-04		6.36E-04	6.26E-07	2.82E-04	4.57E-04		1.20E-03	5.84E-06
Benzo(k)fluoranthene	3.10E-05	2.50E-04		3.34E-04	1.98E-07	2.90E-04	4.69E-04		6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene	8.93E-06	7.18E-05		6.32E-04	3.56E-07	8.34E-05	1.35E-04		1.19E-03	3.32E-06
Dibenz(a,h)anthracene	3.17E-06	2.55E-05		2.38E-04	8.65E-08	2.96E-05	4.80E-05		4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04
Chrysene	1.39E-05	1.12E-04				1.30E-04	2.10E-04			
Benzo(g,h,i)perylene	9.56E-06	7.68E-05				8.92E-05	1.44E-04			
Arsenic	1.23E-05	1.03E-05				1.15E-04	1.94E-05			
TRH Aliphatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aromatic >C10-C16	1.22E-05	3.26E-04				1.14E-04	6.14E-04			
TRH Aliphatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			
TRH Aromatic >C16-C34	6.09E-04	1.63E-02				5.69E-03	3.07E-02			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.08E-05	2.79E-06		7.32E-04	1.37E-03	1.94E-04	5.24E-06		1.38E-03	1.28E-02
Benzo(a)pyrene	2.56E-07	2.06E-06		1.21E-05	6.98E-09	2.39E-06	3.88E-06		2.28E-05	6.51E-08
Benz(a)anthracene	2.36E-07	1.90E-06		7.71E-06	6.69E-09	2.20E-06	3.57E-06		1.45E-05	6.24E-08
Benzo(b)fluoranthene	4.32E-07	3.47E-06		9.09E-06	8.94E-09	4.03E-06	6.53E-06		1.71E-05	8.34E-08
Benzo(k)fluoranthene	4.44E-07	3.57E-06		4.77E-06	2.83E-09	4.14E-06	6.71E-06		8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene	1.28E-07	1.03E-06		9.03E-06	5.09E-09	1.19E-06	1.93E-06		1.70E-05	4.75E-08
Dibenz(a,h)anthracene	4.54E-08	3.65E-07		3.39E-06	1.24E-09	4.23E-07	6.86E-07		6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06
Chrysene	1.99E-07	1.60E-06				1.85E-06	3.00E-06			
Benzo(g,h,i)perylene	1.37E-07	1.10E-06				1.27E-06	2.06E-06			
Arsenic	1.76E-07	1.48E-07				1.64E-06	2.78E-07			
TRH Aliphatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aromatic >C10-C16	1.74E-07	4.66E-06				1.62E-06	8.77E-06			
TRH Aliphatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			
TRH Aromatic >C16-C34	8.70E-06	2.33E-04				8.12E-05	4.39E-04			

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE18): Major Containment Cell failure as a result of seismic event/major climate event. Assumes onsite soil and groundwater CWS concentrations migrate offsite to recreational user.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.64E-02	4.88E-03	-	1.28E+00	2.39E+00	3.40E-01	9.17E-03	-	2.41E+00	2.23E+01
Benzo(a)pyrene	5.98E-02	4.81E-01	-	2.83E+00	1.63E-03	5.58E-01	9.05E-01	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.23E-02	1.03E-02	-	-	-	1.15E-01	1.94E-02	-	-	-
TRH Aliphatic >C10-C16	1.35E-04	3.63E-03	-	-	-	1.26E-03	6.82E-03	-	-	-
TRH Aromatic >C10-C16	3.38E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aliphatic >C16-C34	3.39E-04	9.07E-03	-	-	-	3.16E-03	1.71E-02	-	-	-
TRH Aromatic >C16-C34	2.26E-02	6.05E-01	-	-	-	2.11E-01	1.14E+00	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.65E-06	5.94E-06	-	3.49E-05	7.21E-08
Benz(a)anthracene	2.44E-07	5.46E-07	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	4.46E-07	1.00E-06	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	4.58E-07	1.03E-06	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	1.32E-07	2.96E-07	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	4.69E-07	1.05E-06	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	2.05E-08	4.60E-08	-	-	-
Benzo(g,h,i)perylene	1.41E-08	3.16E-08	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE19): Major repairs to Cap (10-<20% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	27-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	120	Assumes repairs takes 6 months	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	120	Assumes repairs takes 6 months	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.66E-04	5.84E-05								
Benzo(a)pyrene	2.05E-06	4.32E-05								
Benz(a)anthracene	1.88E-06	3.98E-05								
Benzo(b)fluoranthene	3.44E-06	7.28E-05								
Benzo(k)fluoranthene	3.54E-06	7.48E-05								
Indeno(1,2,3-c,d)pyrene	1.02E-06	2.15E-05								
Dibenz(a,h)anthracene	3.62E-07	7.65E-06								
Chrysene	1.58E-06	3.35E-05								
Benzo(g,h,i)perylene	1.09E-06	2.30E-05								
Arsenic	1.41E-06	3.10E-06								
TRH Aliphatic >C10-C16	1.39E-06	9.78E-05								
TRH Aromatic >C10-C16	1.39E-06	9.78E-05								
TRH Aliphatic >C16-C34	6.95E-05	4.89E-03								
TRH Aromatic >C16-C34	6.95E-05	4.89E-03								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.40E-05	8.35E-07								
Benzo(a)pyrene	2.96E-07	6.18E-07								
Benz(a)anthracene	2.72E-07	5.68E-07								
Benzo(b)fluoranthene	4.98E-07	1.04E-06								
Benzo(k)fluoranthene	5.12E-07	1.07E-06								
Indeno(1,2,3-c,d)pyrene	1.47E-07	3.08E-07								
Dibenz(a,h)anthracene	5.23E-08	1.09E-07								
Chrysene	2.29E-07	4.78E-07								
Benzo(g,h,i)perylene	1.58E-07	3.29E-07								
Arsenic	2.03E-07	4.42E-08								
TRH Aliphatic >C10-C16	2.01E-07	1.40E-06								
TRH Aromatic >C10-C16	2.01E-07	1.40E-06								
TRH Aliphatic >C16-C34	1.00E-05	6.99E-05								
TRH Aromatic >C16-C34	1.00E-05	6.99E-05								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE19): Major repairs to Cap (10-<20% cap surface)
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	27-Jun-17

Hazard Index (HI)

	ADULT					**CHILD**				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	4.15E-03	1.46E-03	-	-	-	-	-	-	-	-
Benzo(a)pyrene	6.82E-03	1.44E-01	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.41E-03	3.10E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	1.54E-05	1.09E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	3.86E-05	2.72E-03	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	2.57E-03	1.81E-01	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.96E-07	6.18E-07	-	-	-
Benz(a)anthracene	2.72E-08	5.68E-08	-	-	-
Benzo(b)fluoranthene	4.98E-08	1.04E-07	-	-	-
Benzo(k)fluoranthene	5.12E-08	1.07E-07	-	-	-
Indeno(1,2,3-c,d)pyrene	1.47E-08	3.08E-08	-	-	-
Dibenz(a,h)anthracene	5.23E-08	1.09E-07	-	-	-
Chrysene	2.29E-09	4.78E-09	-	-	-
Benzo(g,h,i)perylene	1.58E-09	3.29E-09	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE20): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.00E-07	2.09E-08								
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 5 Additional Exposure Scenario (Opt5_AEE20): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE1): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE1): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE3): Gas build up in salt cavity of flammable/toxic gasses (cavity not vented). EPCs represent the odour threshold for hydrogen sulfide (0.0007 mg/m3), ammonia (34.83 mg/m3) and hydrogen fluoride (0.0327 mg/m3), on the assumption that workers smell the gas leak into work place cavities and it takes two weeks to stop the leak.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	single isolated event	-	-
Exposure frequency to site (days/year)	EF	14	assumes it take 2 weeks to stop the leak	-	-
Vapour Inhalation					
Expsoure time spent in salt cavity (hrs)	timeout	8	Conservative assumption	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia				4.45E-01	
Hydrogen sulfide (H2S)				8.95E-06	
Hydrogen Fluoride				4.18E-04	

Hazard Index (HI)

Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Indoor Vapour Inhalation	Outdoor Vapour Inhalation
Ammonia	-	-	-	6.41E+00	-
Hydrogen sulfide (H2S)	-	-	-	3.21E-04	-
Hydrogen Fluoride	-	-	-	2.55E-02	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt5_AEE7): Truck spills contaminated load on public road. Assumes negligible exposure to public, and clean up by adult workers.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.00E-07	2.09E-08								
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt5_AEE7): Truck spills contaminated load on public road. Assumes negligible exposure to public, and clean up by adult workers.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE8): Train derailment causing spillage. Assumes derailment occurs in residential backyard, with exposure to child and adult residents. Assumes cleanup will take 5 days.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes one event	1	assumes one event
Exposure frequency to site (days/year)	EF	5	Assumes cleanup takes 5 days	5	Assumes cleanup takes 5 days
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	50	NEPM (2013) residential	100	NEPM (2013) residential
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6300	NEPM (2013) residential	2702	NEPM (2013) residential
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	5	Assumes cleanup takes 5 days	5	Assumes cleanup takes 5 days

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.40E-04	8.82E-06				1.31E-03	1.76E-05			
Benzo(a)pyrene	1.73E-06	6.52E-06				1.61E-05	1.31E-05			
Benz(a)anthracene	1.59E-06	6.00E-06				1.48E-05	1.20E-05			
Benzo(b)fluoranthene	2.91E-06	1.10E-05				2.71E-05	2.20E-05			
Benzo(k)fluoranthene	2.99E-06	1.13E-05				2.79E-05	2.26E-05			
Indeno(1,2,3-c,d)pyrene	8.59E-07	3.25E-06				8.02E-06	6.50E-06			
Dibenz(a,h)anthracene	3.05E-07	1.15E-06				2.85E-06	2.31E-06			
Naphthalene										
TRH Aliphatic >C6-C10										
TRH Aromatic >C6-C10										
Chrysene	1.34E-06	5.05E-06				1.25E-05	1.01E-05			
Benzo(g,h,i)perylene	9.19E-07	3.47E-06				8.58E-06	6.95E-06			
Arsenic	1.19E-06	4.67E-07				1.11E-05	9.35E-07			
TRH Aliphatic >C10-C16	1.17E-06	1.48E-05				1.09E-05	2.95E-05			
TRH Aromatic >C10-C16	1.17E-06	1.48E-05				1.09E-05	2.95E-05			
TRH Aliphatic >C16-C34	5.86E-05	7.38E-04				5.47E-04	1.48E-03			
TRH Aromatic >C16-C34	5.86E-05	7.38E-04				5.47E-04	1.48E-03			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.00E-06	1.26E-07				1.87E-05	2.52E-07			
Benzo(a)pyrene	2.47E-08	9.32E-08				2.30E-07	1.87E-07			
Benz(a)anthracene	2.27E-08	8.57E-08				2.12E-07	1.72E-07			
Benzo(b)fluoranthene	4.15E-08	1.57E-07				3.87E-07	3.14E-07			
Benzo(k)fluoranthene	4.26E-08	1.61E-07				3.98E-07	3.23E-07			
Indeno(1,2,3-c,d)pyrene	1.23E-08	4.64E-08				1.15E-07	9.29E-08			
Dibenz(a,h)anthracene	4.36E-09	1.65E-08				4.07E-08	3.30E-08			
Naphthalene										
TRH Aliphatic >C6-C10										
TRH Aromatic >C6-C10										
Chrysene	1.91E-08	7.22E-08				1.78E-07	1.44E-07			
Benzo(g,h,i)perylene	1.31E-08	4.96E-08				1.23E-07	9.93E-08			
Arsenic	1.69E-08	6.67E-09				1.58E-07	1.34E-08			
TRH Aliphatic >C10-C16	1.67E-08	2.11E-07				1.56E-07	4.22E-07			
TRH Aromatic >C10-C16	1.67E-08	2.11E-07				1.56E-07	4.22E-07			
TRH Aliphatic >C16-C34	8.37E-07	1.05E-05				7.81E-06	2.11E-05			
TRH Aromatic >C16-C34	8.37E-07	1.05E-05				7.81E-06	2.11E-05			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE8): Train derailment causing spillage. Assumes derailment occurs in residential backyard, with exposure to child and adult residents. Assumes cleanup will take 5 days.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.50E-03	2.20E-04	-	-	-	3.27E-02	4.41E-04	-	-	-
Benzo(a)pyrene	5.75E-03	2.17E-02	-	-	-	5.37E-02	4.35E-02	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.19E-03	4.67E-04	-	-	-	1.11E-02	9.35E-04	-	-	-
TRH Aliphatic >C10-C16	1.30E-05	1.64E-04	-	-	-	1.21E-04	3.28E-04	-	-	-
TRH Aromatic >C10-C16	3.25E-05	4.10E-04	-	-	-	3.04E-04	8.20E-04	-	-	-
TRH Aliphatic >C16-C34	3.26E-05	4.10E-04	-	-	-	3.04E-04	8.21E-04	-	-	-
TRH Aromatic >C16-C34	2.17E-03	2.73E-02	-	-	-	2.03E-02	5.47E-02	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.55E-07	2.80E-07	-	-	-
Benz(a)anthracene	2.34E-08	2.57E-08	-	-	-
Benzo(b)fluoranthene	4.29E-08	4.71E-08	-	-	-
Benzo(k)fluoranthene	4.41E-08	4.84E-08	-	-	-
Indeno(1,2,3-c,d)pyrene	1.27E-08	1.39E-08	-	-	-
Dibenz(a,h)anthracene	4.51E-08	4.95E-08	-	-	-
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	1.97E-09	2.17E-09	-	-	-
Benzo(g,h,i)perylene	1.36E-09	1.49E-09	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE9): Groundwater seeps into the waste cell in the salt cavity. Assumes groundwater not used for drinking purposes (onsite treatment would occur), and groundwater is exposed to workers of the salt mine. Groundwater is approximately 140m below groundsurface, and therefore migration to surface water is unlikely.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	30-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	25	Estimated duration of salt mine	-	-
Exposure frequency to site (days/year)	EF	240	Assumes 4 weeks holiday per year	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	240	Assumes 4 weeks holiday per year	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidental ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	1	Conservative assumption	-	-
Skin surface area exposed (cm^2)	SA	1450	Hands and 25% of head value from Table 3.2.3 (enHealth, 2012)	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				2.56E-02	8.83E-02					
Benzo(a)pyrene				4.24E-04	4.51E-07					
Benz(a)anthracene				2.69E-04	4.32E-07					
Benzo(b)fluoranthene				3.18E-04	5.78E-07					
Benzo(k)fluoranthene				1.67E-04	1.83E-07					
Indeno(1,2,3-c,d)pyrene				3.16E-04	3.29E-07					
Dibenz(a,h)anthracene				1.19E-04	7.98E-08					
Naphthalene				7.53E-05	2.72E-06					
TRH Aliphatic >C6-C10				1.75E-03	1.55E-05					
TRH Aromatic >C6-C10				1.22E-04	1.55E-05					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				9.15E-03	3.15E-02					
Benzo(a)pyrene				1.51E-04	1.61E-07					
Benz(a)anthracene				9.62E-05	1.54E-07					
Benzo(b)fluoranthene				1.13E-04	2.06E-07					
Benzo(k)fluoranthene				5.96E-05	6.54E-08					
Indeno(1,2,3-c,d)pyrene				1.13E-04	1.17E-07					
Dibenz(a,h)anthracene				4.24E-05	2.85E-08					
Naphthalene				2.69E-05	9.73E-07					
TRH Aliphatic >C6-C10				6.26E-04	5.54E-06					
TRH Aromatic >C6-C10				4.34E-05	5.54E-06					

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE9): Groundwater seeps into the waste cell in the salt cavity. Assumes groundwater not used for drinking purposes (onsite treatment would occur), and groundwater is exposed to workers of the salt mine. Groundwater is approximately 140m below groundsurface, and therefore migration to surface water is unlikely.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	30-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	6.40E-01	2.21E+00	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.41E+00	1.50E-03	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	3.76E-03	1.36E-04	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	3.90E-04	3.44E-06	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	3.38E-03	4.31E-04	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.51E-04	1.61E-07
Benz(a)anthracene	-	-	-	9.62E-06	1.54E-08
Benzo(b)fluoranthene	-	-	-	1.13E-05	2.06E-08
Benzo(k)fluoranthene	-	-	-	5.96E-06	6.54E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	1.13E-05	1.17E-08
Dibenz(a,h)anthracene	-	-	-	4.24E-05	2.85E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE10): Extreme weather event occurs during transport or transitory storage causing damage to containers and bags with uncontrolled release in air and water. Assumes bags/containers are damaged in residential/recreational area during transport, and groundwater in the vicinity is not used for potable purposes. EPCs represent the soil and groundwater concentrations within the CWS. Exposure to child and adult residents. Assumes cleanup will take 5 days.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes one event	1	assumes one event
Exposure frequency to site (days/year)	EF	5	Assumes cleanup takes 5 days	5	Assumes cleanup takes 5 days
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	50	NEPM (2013) residential	100	NEPM (2013) residential
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	6300	NEPM (2013) residential	2702	NEPM (2013) residential
Soil skin adherence (mg/cm^2)	SL	0.5	NEPM (2013) recreational	0.5	NEPM (2013) recreational
Exposure frequency to surface soil (days/year)	EFsoil	5	Assumes cleanup takes 5 days	5	Assumes cleanup takes 5 days
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	5	Assumes cleanup takes 5 days	5	Assumes cleanup takes 5 days
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs exposed

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	1.40E-04	8.82E-06		2.46E-03	4.60E-03	1.31E-03	1.76E-05		4.64E-03	4.29E-02
Benzo(a)pyrene	1.73E-06	6.52E-06		4.08E-05	2.35E-08	1.61E-05	1.31E-05		7.67E-05	2.19E-07
Benz(a)anthracene	1.59E-06	6.00E-06		2.59E-05	2.25E-08	1.48E-05	1.20E-05		4.88E-05	2.10E-07
Benzo(b)fluoranthene	2.91E-06	1.10E-05		3.06E-05	3.01E-08	2.71E-05	2.20E-05		5.75E-05	2.81E-07
Benzo(k)fluoranthene	2.99E-06	1.13E-05		1.61E-05	9.54E-09	2.79E-05	2.26E-05		3.02E-05	8.90E-08
Indeno(1,2,3-c,d)pyrene	8.59E-07	3.25E-06		3.04E-05	1.71E-08	8.02E-06	6.50E-06		5.72E-05	1.60E-07
Dibenz(a,h)anthracene	3.05E-07	1.15E-06		1.14E-05	4.16E-09	2.85E-06	2.31E-06		2.15E-05	3.88E-08
Naphthalene				7.24E-06	1.42E-07				1.36E-05	1.32E-06
TRH Aliphatic >C6-C10				1.69E-04	8.07E-07				3.18E-04	7.53E-06
TRH Aromatic >C6-C10				1.17E-05	8.07E-07				2.20E-05	7.53E-06
Chrysene	1.34E-06	5.05E-06				1.25E-05	1.01E-05			
Benzo(g,h,i)perylene	9.19E-07	3.47E-06				8.58E-06	6.95E-06			
Arsenic	1.19E-06	4.67E-07				1.11E-05	9.35E-07			
TRH Aliphatic >C10-C16	1.17E-06	1.48E-05				1.09E-05	2.95E-05			
TRH Aromatic >C10-C16	1.17E-06	1.48E-05				1.09E-05	2.95E-05			
TRH Aliphatic >C16-C34	5.86E-05	7.38E-04				5.47E-04	1.48E-03			
TRH Aromatic >C16-C34	5.86E-05	7.38E-04				5.47E-04	1.48E-03			

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	2.00E-06	1.26E-07		3.52E-05	6.57E-05	1.87E-05	2.52E-07		6.62E-05	6.13E-04
Benzo(a)pyrene	2.47E-08	9.32E-08		5.83E-07	3.35E-10	2.30E-07	1.87E-07		1.10E-06	3.13E-09
Benz(a)anthracene	2.27E-08	8.57E-08		3.71E-07	3.21E-10	2.12E-07	1.72E-07		6.97E-07	3.00E-09
Benzo(b)fluoranthene	4.15E-08	1.57E-07		4.37E-07	4.30E-10	3.87E-07	3.14E-07		8.22E-07	4.01E-09
Benzo(k)fluoranthene	4.26E-08	1.61E-07		2.30E-07	1.36E-10	3.98E-07	3.23E-07		4.32E-07	1.27E-09
Indeno(1,2,3-c,d)pyrene	1.23E-08	4.64E-08		4.34E-07	2.45E-10	1.15E-07	9.29E-08		8.17E-07	2.28E-09
Dibenz(a,h)anthracene	4.36E-09	1.65E-08		1.63E-07	5.94E-11	4.07E-08	3.30E-08		3.07E-07	5.54E-10
Naphthalene				1.03E-07	2.03E-09				1.95E-07	1.89E-08
TRH Aliphatic >C6-C10				2.41E-06	1.15E-08				4.54E-06	1.08E-07
TRH Aromatic >C6-C10				1.67E-07	1.15E-08				3.15E-07	1.08E-07
Chrysene	1.91E-08	7.22E-08				1.78E-07	1.44E-07			
Benzo(g,h,i)perylene	1.31E-08	4.96E-08				1.23E-07	9.93E-08			
Arsenic	1.69E-08	6.67E-09				1.58E-07	1.34E-08			
TRH Aliphatic >C10-C16	1.67E-08	2.11E-07				1.56E-07	4.22E-07			
TRH Aromatic >C10-C16	1.67E-08	2.11E-07				1.56E-07	4.22E-07			
TRH Aliphatic >C16-C34	8.37E-07	1.05E-05				7.81E-06	2.11E-05			
TRH Aromatic >C16-C34	8.37E-07	1.05E-05				7.81E-06	2.11E-05			

Project Number	AS130515
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE10): Extreme weather event occurs during transport or transitory storage causing damage to containers and bags with uncontrolled release in air and water. Assumes bags/containers are damaged in residential/recreational area during transport, and groundwater in the vicinity is not used for potable purposes. EPCs represent the soil and groundwater concentrations within the CWS. Exposure to child and adult residents. Assumes cleanup will take 5 days.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	3.50E-03	2.20E-04	-	6.16E-02	1.15E-01	3.27E-02	4.41E-04	-	1.16E-01	1.07E+00
Benzo(a)pyrene	5.75E-03	2.17E-02	-	1.36E-01	7.83E-05	5.37E-02	4.35E-02	-	2.56E-01	7.31E-04
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	3.62E-04	7.09E-06	-	-	-	6.81E-04	6.62E-05
TRH Aliphatic >C6-C10	-	-	-	3.75E-05	1.79E-07	-	-	-	7.06E-05	1.67E-06
TRH Aromatic >C6-C10	-	-	-	3.25E-04	2.24E-05	-	-	-	6.12E-04	2.09E-04
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	1.19E-03	4.67E-04	-	-	-	1.11E-02	9.35E-04	-	-	-
TRH Aliphatic >C10-C16	1.30E-05	1.64E-04	-	-	-	1.21E-04	3.28E-04	-	-	-
TRH Aromatic >C10-C16	3.25E-05	4.10E-04	-	-	-	3.04E-04	8.20E-04	-	-	-
TRH Aliphatic >C16-C34	3.26E-05	4.10E-04	-	-	-	3.04E-04	8.21E-04	-	-	-
TRH Aromatic >C16-C34	2.17E-03	2.73E-02	-	-	-	2.03E-02	5.47E-02	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	2.55E-07	2.80E-07	-	1.68E-06	3.47E-09
Benz(a)anthracene	2.34E-08	2.57E-08	-	1.07E-07	3.32E-10
Benzo(b)fluoranthene	4.29E-08	4.71E-08	-	1.26E-07	4.44E-10
Benzo(k)fluoranthene	4.41E-08	4.84E-08	-	6.61E-08	1.41E-10
Indeno(1,2,3-c,d)pyrene	1.27E-08	1.39E-08	-	1.25E-07	2.53E-10
Dibenz(a,h)anthracene	4.51E-08	4.95E-08	-	4.70E-07	6.14E-10
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-
Chrysene	1.97E-09	2.17E-09	-	-	-
Benzo(g,h,i)perylene	1.36E-09	1.49E-09	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE12): Leachate tanker spills/over tops onsite. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	16-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes cleanup takes 1 day	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidential ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	8	Assumes direct contact all day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				8.54E-04	3.68E-04					
Benzo(a)pyrene				5.00E-06	1.88E-09					
Benz(a)anthracene				3.18E-06	1.80E-09					
Benzo(b)fluoranthene				3.74E-06	2.41E-09					
Benzo(k)fluoranthene				1.97E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				3.72E-06	1.37E-09					
Dibenz(a,h)anthracene				1.40E-06	3.33E-10					
Naphthalene				1.22E-06	1.14E-08					
TRH Aliphatic >C6-C10				2.25E-05	6.46E-08					
TRH Aromatic >C6-C10				2.35E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				1.22E-05	5.26E-06					
Benzo(a)pyrene				7.14E-08	2.68E-11					
Benz(a)anthracene				4.54E-08	2.57E-11					
Benzo(b)fluoranthene				5.35E-08	3.44E-11					
Benzo(k)fluoranthene				2.81E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				5.32E-08	1.96E-11					
Dibenz(a,h)anthracene				2.00E-08	4.75E-12					
Naphthalene				1.74E-08	1.62E-10					
TRH Aliphatic >C6-C10				3.21E-07	9.23E-10					
TRH Aromatic >C6-C10				3.36E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE12): Leachate tanker spills/over tops onsite. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	16-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	2.13E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.67E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	6.11E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	5.00E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.53E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	7.14E-08	2.68E-11
Benz(a)anthracene	-	-	-	4.54E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	5.35E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	2.81E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	5.32E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	2.00E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE13): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	27-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet soil)	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)	6.00E-07	2.09E-08								
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE13): Truck turnover spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	27-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE14): Material interacts with co-disposed waste. Assumes mixed leachate discharges offsite and remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water. The reported hazard index represents the total calculated hazard index which is increased by 50% to account for any additive toxicity effects due to unknown chemicals in the co-disposed waste.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 6 Additional Exposure Scenario (Opt6_AEE14): Material interacts with co-disposed waste. Assumes mixed leachate discharges offsite and remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water. The reported hazard index represents the total calculated hazard index which is increased by 50% to account for any additive toxicity effects due to unknown chemicals in the co-disposed waste.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7 Additional Exposure Scenario (Opt7_AEE1): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	15	NEPM (2013)
Lifetime (days/lifetime)	L	25550	US EPA (1989)	25550	US EPA (1989)
Exposure duration (years/lifetime)	ED	1	assumes leachate remains for 1yr prior to cleanup	1	assumes leachate remains for 1yr prior to cleanup
Exposure frequency to site (days/year)	EF	104	Every weekend	104	Every weekend
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	104	Every weekend	104	Every weekend
Surface water ingestion rate (L/day)	IRsw	0.0125	50% of the enHealth (2012) swimming ingestion rate for >15yrs (adult wading)	0.025	50% of enHealth (2012) swimming ingestion rate for <15 yrs (child wading)
Exposure time (surface water) (hrs/event)	ETsw	1	conservative assumption	1	conservative assumption
Skin surface area exposed (cm^2)	SA	6700	hands, feet, forearms, lower legs exposed	2700	hands, feet, forearms, lower legs

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				5.13E-02	9.57E-02				9.64E-02	8.93E-01
Benzo(a)pyrene				8.49E-04	4.88E-07				1.60E-03	4.56E-06
Benz(a)anthracene				5.39E-04	4.68E-07				1.01E-03	4.37E-06
Benzo(b)fluoranthene				6.36E-04	6.26E-07				1.20E-03	5.84E-06
Benzo(k)fluoranthene				3.34E-04	1.98E-07				6.28E-04	1.85E-06
Indeno(1,2,3-c,d)pyrene				6.32E-04	3.56E-07				1.19E-03	3.32E-06
Dibenz(a,h)anthracene				2.38E-04	8.65E-08				4.47E-04	8.07E-07
Naphthalene				1.51E-04	2.95E-06				2.83E-04	2.75E-05
TRH Aliphatic >C6-C10				3.51E-03	1.68E-05				6.60E-03	1.57E-04
TRH Aromatic >C6-C10				2.44E-04	1.68E-05				4.58E-04	1.57E-04

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidental Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				7.32E-04	1.37E-03				1.38E-03	1.28E-02
Benzo(a)pyrene				1.21E-05	6.98E-09				2.28E-05	6.51E-08
Benz(a)anthracene				7.71E-06	6.69E-09				1.45E-05	6.24E-08
Benzo(b)fluoranthene				9.09E-06	8.94E-09				1.71E-05	8.34E-08
Benzo(k)fluoranthene				4.77E-06	2.83E-09				8.98E-06	2.65E-08
Indeno(1,2,3-c,d)pyrene				9.03E-06	5.09E-09				1.70E-05	4.75E-08
Dibenz(a,h)anthracene				3.39E-06	1.24E-09				6.38E-06	1.15E-08
Naphthalene				2.15E-06	4.22E-08				4.05E-06	3.93E-07
TRH Aliphatic >C6-C10				5.02E-05	2.40E-07				9.44E-05	2.24E-06
TRH Aromatic >C6-C10				3.48E-06	2.40E-07				6.54E-06	2.24E-06

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7 Additional Exposure Scenario (Opt7_AEE1): Heavy rainfall causes leachate discharge to offsite surface water. Assumes leachate remains for one year prior to cleanup, and a recreational landuse exposure scenario with direct contact to surface water.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	28-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	1.28E+00	2.39E+00	-	-	-	2.41E+00	2.23E+01
Benzo(a)pyrene	-	-	-	2.83E+00	1.63E-03	-	-	-	5.32E+00	1.52E-02
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	7.53E-03	1.48E-04	-	-	-	1.42E-02	1.38E-03
TRH Aliphatic >C6-C10	-	-	-	7.80E-04	3.73E-06	-	-	-	1.47E-03	3.48E-05
TRH Aromatic >C6-C10	-	-	-	6.77E-03	4.66E-04	-	-	-	1.27E-02	4.35E-03

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	3.49E-05	7.21E-08
Benz(a)anthracene	-	-	-	2.22E-06	6.91E-09
Benzo(b)fluoranthene	-	-	-	2.62E-06	9.24E-09
Benzo(k)fluoranthene	-	-	-	1.38E-06	2.93E-09
Indeno(1,2,3-c,d)pyrene	-	-	-	2.60E-06	5.26E-09
Dibenz(a,h)anthracene	-	-	-	9.78E-06	1.28E-08
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7 Additional Exposure Scenario (Opt7_AEE8): Truck turn over spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	3	Assumes cleanup takes 3 days	-	-
Soil Ingestion					
Soil ingestion rate (mg/day)	IRsoil	25	NEPM (2013) for commercial landuse. Conservative assumption considering PPE worn during remediation activities.	-	-
Soil Dermal Contact					
Skin surface area exposed (cm^2/day)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth (2012)	-	-
Soil skin adherence (mg/cm^2)	SL	0.6	enHealth (2012) 50th percentile for pipe layers (wet	-	-
Exposure frequency to surface soil (days/year)	EFsoil	3	Assumes cleanup takes 3 days	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	4.15E-06	1.46E-06								
Benzo(a)pyrene	5.12E-08	1.08E-06								
Benz(a)anthracene	4.70E-08	9.94E-07								
Benzo(b)fluoranthene	8.61E-08	1.82E-06								
Benzo(k)fluoranthene	8.85E-08	1.87E-06								
Indeno(1,2,3-c,d)pyrene	2.55E-08	5.38E-07								
Dibenz(a,h)anthracene	9.05E-09	1.91E-07								
Chrysene	3.96E-08	8.37E-07								
Benzo(g,h,i)perylene	2.72E-08	5.76E-07								
Arsenic	3.51E-08	7.74E-08								
TRH Aliphatic >C10-C16	3.47E-08	2.45E-06								
TRH Aromatic >C10-C16	3.47E-08	2.45E-06								
TRH Aliphatic >C16-C34	1.74E-06	1.22E-04								
TRH Aromatic >C16-C34	1.74E-06	1.22E-04								

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	6.00E-07	2.09E-08								
Benzo(a)pyrene	7.40E-09	1.54E-08								
Benz(a)anthracene	6.80E-09	1.42E-08								
Benzo(b)fluoranthene	1.25E-08	2.60E-08								
Benzo(k)fluoranthene	1.28E-08	2.67E-08								
Indeno(1,2,3-c,d)pyrene	3.68E-09	7.69E-09								
Dibenz(a,h)anthracene	1.31E-09	2.73E-09								
Chrysene	5.73E-09	1.20E-08								
Benzo(g,h,i)perylene	3.94E-09	8.22E-09								
Arsenic	5.08E-09	1.11E-09								
TRH Aliphatic >C10-C16	5.02E-09	3.49E-08								
TRH Aromatic >C10-C16	5.02E-09	3.49E-08								
TRH Aliphatic >C16-C34	2.51E-07	1.75E-06								
TRH Aromatic >C16-C34	2.51E-07	1.75E-06								

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7 Additional Exposure Scenario (Opt7_AEE8): Truck turn over spilling contaminated load onsite
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	23-May-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Fluoride (soluble)	1.04E-04	3.65E-05	-	-	-	-	-	-	-	-
Benzo(a)pyrene	1.71E-04	3.60E-03	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-
Arsenic	3.51E-05	7.74E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C10-C16	3.86E-07	2.72E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C10-C16	9.64E-07	6.79E-05	-	-	-	-	-	-	-	-
TRH Aliphatic >C16-C34	9.65E-07	6.80E-05	-	-	-	-	-	-	-	-
TRH Aromatic >C16-C34	6.43E-05	4.53E-03	-	-	-	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	7.40E-09	1.54E-08	-	-	-
Benz(a)anthracene	6.80E-10	1.42E-09	-	-	-
Benzo(b)fluoranthene	1.25E-09	2.60E-09	-	-	-
Benzo(k)fluoranthene	1.28E-09	2.67E-09	-	-	-
Indeno(1,2,3-c,d)pyrene	3.68E-10	7.69E-10	-	-	-
Dibenz(a,h)anthracene	1.31E-09	2.73E-09	-	-	-
Chrysene	5.73E-11	1.20E-10	-	-	-
Benzo(g,h,i)perylene	3.94E-11	8.22E-11	-	-	-
Arsenic	-	-	-	-	-
TRH Aliphatic >C10-C16	-	-	-	-	-
TRH Aromatic >C10-C16	-	-	-	-	-
TRH Aliphatic >C16-C34	-	-	-	-	-
TRH Aromatic >C16-C34	-	-	-	-	-

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7 Additional Exposure Scenario (Opt7_AEE11): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	16-Jun-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	assumes event takes place once	-	-
Exposure frequency to site (days/year)	EF	1	Assumes cleanup takes 1 day	-	-
Surface Water Contact					
Exposure frequency to surface water (days/yr)	EFsw	1	assumes event takes place once	-	-
Surface water ingestion rate (L/day)	IRsw	0.005	1/5th of the enHealth (2012) recommended incidential ingestion of 25mL/hr for >15yrs whilst swimming	-	-
Exposure time (surface water) (hrs/event)	ETsw	8	Assumes direct contact all day	-	-
Skin surface area exposed (cm^2)	SA	1450	hands and 25% of head value Table 3.2.3 enHealth	-	-
Event frequency for dermal exposure to water (events/day)	Evwater	1	assumes event takes place once	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				8.54E-04	3.68E-04					
Benzo(a)pyrene				5.00E-06	1.88E-09					
Benz(a)anthracene				3.18E-06	1.80E-09					
Benzo(b)fluoranthene				3.74E-06	2.41E-09					
Benzo(k)fluoranthene				1.97E-06	7.63E-10					
Indeno(1,2,3-c,d)pyrene				3.72E-06	1.37E-09					
Dibenz(a,h)anthracene				1.40E-06	3.33E-10					
Naphthalene				1.22E-06	1.14E-08					
TRH Aliphatic >C6-C10				2.25E-05	6.46E-08					
TRH Aromatic >C6-C10				2.35E-06	6.46E-08					

Chronic Daily Intakes (Non-Threshold Chemicals) (mg/kg/day)	ADULT					CHILD				
Chemical	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water	Incidental Soil ingestion	Dermal contact with soil	Inhalation of Particulates	Dermal Contact with Surface Water	Incidential Ingestion of Surface Water
Fluoride (soluble)				1.22E-05	5.26E-06					
Benzo(a)pyrene				7.14E-08	2.68E-11					
Benz(a)anthracene				4.54E-08	2.57E-11					
Benzo(b)fluoranthene				5.35E-08	3.44E-11					
Benzo(k)fluoranthene				2.81E-08	1.09E-11					
Indeno(1,2,3-c,d)pyrene				5.32E-08	1.96E-11					
Dibenz(a,h)anthracene				2.00E-08	4.75E-12					
Naphthalene				1.74E-08	1.62E-10					
TRH Aliphatic >C6-C10				3.21E-07	9.23E-10					
TRH Aromatic >C6-C10				3.36E-08	9.23E-10					

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7 Additional Exposure Scenario (Opt7_AEE11): Leachate tanker spills/over tops. Assumes cleanup takes one day.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	16-Jun-17

Hazard Index (HI)

	ADULT					CHILD				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidential Ingestion of Surface Water**
Fluoride (soluble)	-	-	-	2.13E-02	9.20E-03	-	-	-	-	-
Benzo(a)pyrene	-	-	-	1.67E-02	6.26E-06	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	6.11E-05	5.68E-07	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	5.00E-06	1.44E-08	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	6.53E-05	1.79E-06	-	-	-	-	-

Increased Lifetime Cancer Risk (ILCR)

Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Particulates**	**Dermal Contact with Surface Water**	**Incidental Ingestion from Surface Water**
Fluoride (soluble)	-	-	-	-	-
Benzo(a)pyrene	-	-	-	7.14E-08	2.68E-11
Benz(a)anthracene	-	-	-	4.54E-09	2.57E-12
Benzo(b)fluoranthene	-	-	-	5.35E-09	3.44E-12
Benzo(k)fluoranthene	-	-	-	2.81E-09	1.09E-12
Indeno(1,2,3-c,d)pyrene	-	-	-	5.32E-09	1.96E-12
Dibenz(a,h)anthracene	-	-	-	2.00E-08	4.75E-12
Naphthalene	-	-	-	-	-
TRH Aliphatic >C6-C10	-	-	-	-	-
TRH Aromatic >C6-C10	-	-	-	-	-

RAMBOLL ENVIRON

Project Number	AS130525
Project Name	Hydro Comparative Health Risk Assessment (Appendix C of The Options Study)
Client	Hydro Australia
Exposure Scenario	Option 7, Additional Exposure Scenario (Opt7_AEE9): plasma gasification plant gas leak occurs. Exposure scenario considers a leak of hydrogen fluoride with a EPC of 0.0327 mg/m3 which represents the odour threshold. This assumes a worker smells the leak, and it takes two weeks to stop the leak.
Risk Assessor	B.Goldsworthy, N Ahubelem
Date	24-May-17

	Notation	Adult	Reference	Child	Reference
General Exposure Parameters					
Body weight (kg)	BW	70	NEPM (2013)	-	-
Lifetime (days/lifetime)	L	25550	US EPA (1989)	-	-
Exposure duration (years/lifetime)	ED	1	Assumes the event takes place once	-	-
Exposure frequency to site (days/year)	EF	10	Assumes it takes two weeks to fix the leak	-	-
Exposure time spent indoors (hours/day)	time_in	8	NEPM (2013) commerical	-	-

Mean Daily Intakes (Threshold Chemicals) (mg/kg/day)

	ADULT				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Vapours Indoors**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Hydrogen Fluoride			2.99E-04		

Hazard Index (HI)

	ADULT				
Chemical	**Incidental Soil ingestion**	**Dermal contact with soil**	**Inhalation of Vapours Indoors**	**Dermal Contact with Surface Water**	**Incidental Ingestion of Surface Water**
Hydrogen Fluoride	-	-	1.82E-02	-	-