6. Outcomes and actions

6.1 Key outcomes

GHD's overall responsibility in regard to Safety in Design is to ensure, so far as reasonably practicable, that the design of the project does not create a risk to the health and safety of persons involved in the construction or use of the product.

GHD is required to consider the reasonably foreseeable risks pertinent to the investigation, construction, operation and maintenance of the project. The potential risks have been designed out (eliminated), however where this has not been possible, risks need to be controlled to a level, as low as reasonably practicable.

Hydro Aluminium Kurri Kurri Pty Ltd has a responsibility to communicate this report, including the Safety in Design rating matrix and the Safety in Design Register, to key stakeholders, contractors and owners of control measures.

Refer to Safety in Design Register in Appendix A for more details.

6.2 Specific actions and outstanding issues

While all risks listed in the Safety in Design Register need to be looked at and acted upon as required, risks listed as Significant" or "Extreme" require particular consideration due to the potential consequences if not acted upon suitably.

- Vehicle accident due to over steepened batters on perimeter of the Works Area
- Vehicle / person falling from access road

Refer to Safety in Design Register in Appendix A for more details.

6.3 Process for review or revision

It is assumed that the Contractor will review and update/incorporate any new risks in the risk register as required.

Issues relating to the ongoing operation and maintenance of the site can be viewed in the Safety in Design Register in Appendix A.

Appendices

Appendix A – Safety in Design Register

HSE040 Safety in Design Risk Assessment

Notes: *Designs with significant quantities of dangerous goods may require detailed risk assessments under Dangerous Goods or Major Hazard legislation
* Most industrial processes will require an industry specific assessment, e.g. HAZOP and/or Quantitative Risk Assessment for facilities that have chemical or high-pressure processes under Dangerous Goods or Major Hazard legislation.

Design Life Cycle:	Investigation and Design	Setup, Construction and Commissioning	Operation	Maintenance	Disposal		**Date:**	11/07/2018	**Revision No:** A
Job Name:	HAKK Demolition and Remediation Project		**Job No:**	22-18015	**Client**	Hydro Aluminium Kurri Kurri Pty Ltd.	**Design:**	Containment Cell Detailed Design	
People involved in Risk Assessment:		David Morrison, David Barrett							

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards (What could cause injury or ill health, damage to property or damage to the environment)	Risk (What could go wrong and what might happen as a result)	Existing Control Measures	Initial Risk Rating C	Initial Risk Rating L	Initial Risk Rating RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	Residual Risk Rating L	Residual Risk Rating RR	Comments
	Setup, Construction and Commissioning	Risks to off-site receptors associated with exhuming landfilled waste	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the waste. Disamenity (visual and/or odour) due to exposure to excessive dus and odour from exposed waste		C- Severe	3 - Possible	Moderate	- Minimise exhumation of landfilled waste during earthworks design based on inferred waste levels - Include provisions in the construction documentation for Contractor to prepare work method statements for waste exhumation and relocation	Contractor	Prior to and during construction works	Open	C- Severe	1 - Very Unlikely	Low	
	Setup, Construction and Commissioning	On-site workers being exposed to waste materials, including possible hazardous materials, during waste exhumation and relocation including airborne dust and fibres, chemical vapours and fumes	- Physical injury and illness due from inhaling or coming into contact with hazardous waste - Inhalation of hazardous waste fibres can lead to the development of respiratory diseases in humans - Inhalation or contact with chemical vapours or fumes can result in injury or illness		D - Critical	3 - Possible	Significant	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to possiblegeneral waste and possible hazardous waste exposure, exhumation and relocation	Contractor	Prior to and during construction works	Open	D - Critical	1 - Very Unlikely	Moderate	
	Investigation and Design	Oversteepened landform slopes become unstable resulting in slumping and/or landslides, causing injury on to-site workers	Physical injury to on-site workers due to slippage		D - Critical	3 - Possible	Significant	- Reduce Works Area to provide sufficient safe working distance from edge of oversteepened batters - Design regraded landform to reduce grades in steep areas at key in area (1(V):4(H) max)	Designer	During design phase	Closed	D - Critical	1 - Very Unlikely	Moderate	
	Investigation and Design	Oversteepened landform slopes become unstable resulting in slumping and/or landslides, causing injury on to-site workers	Physical injury to on-site workers due to slippage		D - Critical	3 - Possible	Significant	- Include provisions in the construction documentation for Contractor to prepare safety plans and traffic management plans with regards to working and trafficking in proximity to the oversteepened batters	Designer	During design phase	Closed.	D - Critical	1 - Very Unlikely	Moderate	
	Investigation and Design	On-site workers coming into contact with leachate resulting in injury/illness	Physical injury and illness in humans due to contact with or swallowing of uncontrolled leachate		C- Severe	3 - Possible	Moderate	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to the potential leachate exposure	Principal	Prior to construction works		C- Severe	2 - Unlikely	Low	
	Investigation and Design	Uncontrolled release of site contaminants during the Works (including leachate, landfill gas, sediment laden water, odour, dust)	- Contamination to local water sources resulting in injury, illness or death of wildlife or damage to environment - Odour and dust causing disamenity and discomfort to off-site residents and fauna		B - Major	3 - Possible	Low	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to the mitigating release of site contaminants, including monitoring requirements	Principal	Prior to construction works		B - Major	2 - Unlikely	Unlikely	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	Initial Risk Rating L	Initial Risk Rating RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	Residual Risk Rating L	Residual Risk Rating RR	Comments
	Investigation and Design	Vehicle accident due to oversteepened batters on perimeter of the Works Area	Physical injury to on-site workers due to vehicle crash and/or overturn		E- Catastrophic	3 - Possible	Extreme	- Reduce Works Area to provide sufficient safe working distance from edge of oversteepened batters	Designer	During design phase	Closed	E- Catastrophic	2 - Unlikely	Significant	
	Investigation and Design	Vehicle accident due to oversteepened batters on perimeter of the Works Area	Physical injury to on-site workers due to vehicle crash and/or overturn		E- Catastrophic	3 - Possible	Extreme	- Include provisions in the construction documentation for Contractor to prepare safety plans and traffic management plans with regards to working and trafficking in proximity to the oversteepened batters	Principal	Prior to construction works	Closed	D - Critical	1 - Very Unlikely	Moderate	
	Investigation and Design	Trenches and/or anchoring system	Trip hazard - fall over edge into cell		C- Severe	4 - Likely	Moderate	- Design anchor trenches to maintain offset from crest of batter.	Designer	Finalisation of design documentation	Considered in design	C- Severe	2 - Unlikely	Low	
	Investigation and Design	Trenches and/or anchoring system	Trip hazard - fall over edge into cell		C- Severe	4 - Likely	Moderate	- Include provisions in the construction documentation for Contractor to prepare safety plans - Install fencing system around possible trip hazards	Principal	Prior to construction works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	Landfill capping system - geosynthetics	Manual handling of geosynthetic rolls		C- Severe	4 - Likely	Moderate	- Contractor to develop WMS and supply and use suitable plant for moving material	Contractor	Throughout works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	Landfill capping system - geosynthetics	Wind uplift causing injury		C- Severe	4 - Likely	Moderate	Contractor to develop safe work method and cease work	Contractor	Throughout works		C- Severe	3 - Possible	Moderate	
	Setup, Construction and Commissioning	Fauna enter site and damage liner	Liner damaged. Trapped animal within cell. Unable to escape	Fauna fence included v	C- Severe	3 - Possible	Moderate	Contractor to monitor fencelines and ensure no breaks	Contractor	Throughout works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	Vehicle accident due to passing on-site traffic/earthmoving equipment	Injury/death from collision		E- Catastrophic	3 - Possible	Extreme	- Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing earthworks/traffic movements during the construction works	Contractor	Prior to and during construction works		D - Critical	1 - Very Unlikely	Moderate	
	Setup, Construction and Commissioning	Vehicle accident due to oversteepened batters on perimeter of the Works Area, and in proximity of western water body	Physical injury from trips and falls, vehicle overturn		E- Catastrophic	3 - Possible	Extreme	- Develop and implement appropriate work health and safety plan and traffic management plan to address safety measures for working and trafficking in proximity to the oversteepened batters - Install temporary safety measures as required (including fencing and temporary bunds)	Contractor	Prior to and during construction works		D - Critical	2 - Unlikely	Moderate	
	Setup, Construction and Commissioning	Earthworks - stockpiles	Injury from falling stockpiles		D - Critical	3 - Possible	Significant	- Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing stockpile sizes and placements on site	Contractor	Prior to and during construction works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	Oversteepened landform slopes become unstable resulting in slumping and/or landslides	Physical injury to on-site workers due to being struck or buried by soil		D - Critical	3 - Possible	Significant	- Develop and implement appropriate work health and safety plan and traffic management plan to address safety measures for working and trafficking in proximity to the oversteepened batters (adjacent to the Works Area)	Contractor	Prior to and during construction works		D - Critical	1 - Very Unlikely	Moderate	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating			Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating			Comments
					C	L	RR					C	L	RR	
	Setup, Construction and Commissioning	Trenches and/or anchoring system	Physical injury to on-site workers due to being struck or buried by soil		C- Severe	4 - Likely	Moderate	- Include provisions in the construction documentation for Contractor to prepare safety plans - Install fencing system around possible trip hazards	Contractor	Prior to and during construction works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	Landfill capping system - geosynthetics	Manual handling of geosynthetic rolls	None	C- Severe	4 - Likely	Moderate	- Contractor to develop SWMS and supply and use suitable plant for moving material	Contractor	Throughout works		B - Major	2 - Unlikely	Negligible	
	Setup, Construction and Commissioning	Landfill capping system - geosynthetics	Wind uplift causing injury	None	C- Severe	5 - Almost Certain	Significant	Contractor to develop safe work method and cease work	Contractor	Throughout works		C- Severe	3 - Possible	Moderate	
	Setup, Construction and Commissioning	Uncontrolled release of site contaminants during the Works (including leachate, landfill gas, sediment laden water, odour, dust)	- Contamination to local water sources resulting in injury, illness or death of wildlife or damage to environment - Odour and dust causing disamenity and discomfort to off-site residents and fauna		D - Critical	3 - Possible	Significant	- Provision of previous environmental monitoring results to Contractor	Principal	Prior to and during construction works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	On-site workers coming into contact with leachate resulting in injury/illness	Physical injury and illness in humans due to contact with or swallowing of uncontrolled leachate		C- Severe	3 - Possible	Moderate	- Develop and implement appropriate work health and safety plan and environmental management plan to address safety measures for managing potential leachate exposure - Environmental monitoring during the construction works as required	Contractor	Prior to and during construction works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	On-site workers coming into contact with leachate resulting in injury/illness	Physical injury and illness in humans due to contact with or swallowing of uncontrolled leachate		C- Severe	3 - Possible	Moderate	- Provision of previous environmental monitoring results to Contractor - No leachate irrigation to be undertaken in the Works Area following initiation of construction works	Principal	Prior to and during construction works		C- Severe	2 - Unlikely	Low	
	Setup, Construction and Commissioning	Electricals	Risk of electric shock from electricity. Overhead lines above road		E- Catastrophic	3 - Possible	Extreme	- Include isolation measures - Develop SWMS - Maintain plan of location of electrical infrastructure - Maintain signage - Utilise a service locator	Operator	Ongoing		D - Critical	2 - Very Unlikely	Moderate	
	Setup, Construction and Commissioning	Working near water	Trip or fall into existing or new pond resulting in drowning		E- Catastrophic	3 - Possible	Extreme	- Contractor to develop safe work method for working around ponds - Include barriers/fencing, signage, ladders for getting out of ponds, life saving equipment	Contractor	Throughout works		D - Critical	2 - Unlikely	Moderate	
	Setup, Construction and Commissioning	Extreme weather - rain	Inundation of void		D - Critical	2 - Unlikely	Moderate	- Contractor to develop safe work method and evacuation procedures for forecast bad weather	Contractor	Throughout works		C- Severe	1 - Very Unlikely	Low	
	Setup, Construction and Commissioning	Culverts	Potential for suction into pipe in rain events		D - Critical	3 - Possible	Significant	- Contractor to develop appropriate headwalls / grate structures - contractor to develop SWMS for entry into stormwater channels and perform regular maintenance on culverts	Contractor	Throughout works		D - Critical	2 - Unlikely	Moderate	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating			Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating			Comments
					C	L	RR					C	L	RR	
	Setup, Construction and Commissioning	Bushfire while workers are on-site	Physical injury/death to on-site workers due to smoke inhalation or burns		E- Catastrophic	2 - Unlikely	Significant	- Develop and implement appropriate work health and safety plan and bushfire management plan to address safety measures for managing bushfire	Principal	Throughout works		E- Catastrophic	1 - Very Unlikely	Moderate	
	Setup, Construction and Commissioning	Unauthorised access to site and monitoring infrastructure	Physical injury, discomfort, illness, or potential asphyxiation (and death)		D - Critical	3 - Possible	Significant	- Install suitable security measures to prevent unauthorised access to the site and the monitoring infrastructure	Operator	Ongoing		D - Critical	1 - Very Unlikely	Moderate	
	Operation	Current and future on-site workers being exposed to waste materials and leachate during landfill stages and cells reprofiling works including airborne dust and fibres, chemical vapours and fumes	- Physical injury and illness due from inhaling or coming into contact with hazardous waste - Inhalation of hazardous waste fibres can lead to the development of respiratory diseases in humans - Inhalation or contact with chemical vapours or fumes can result in injury or illness		D - Critical	4 - Likely	Significant	- Minimise exposure of waste during earthworks design based on inferred waste levels - Include provisions in the construction documentation for Contractor to prepare plans to manage waste exposure/exhumation/ relocation	Contractor	Prior to initiation of construction works		D - Critical	2 - Unlikely	Moderate	
	Operation	Current and future on-site workers being exposed to hazardous waste materials during reprofiling works including airborne dust and fibres, chemical vapours and fumes	- Physical injury and illness due from inhaling or coming into contact with hazardous waste - Inhalation of hazardous waste fibres can lead to the development of respiratory diseases in humans - Inhalation or contact with chemical vapours or fumes can result in injury or illness		D - Critical	3 - Possible	Significant	- Minimise exposure of waste during earthworks design based on inferred waste levels - Include provisions in the construction documentation for Contractor to prepare plans to manage waste exposure/exhumation/ relocation	Contractor	Finalisation of design documentation		D - Critical	2 - Unlikely	Moderate	
	Operation	Risks to off-site receptors associated with existing general solid waste and asbestos waste currently uncontained	Pollution of nearby waterways and wetlands		C- Severe	4 - Likely	Moderate	- Capture stormwater and test before release to surface waters to confirm not contaminated by waste material -Cap exposed waste with engineered capping system as soon as possible to reduce pollution of nearby waterways	Contractor	Prior to initiation of construction works		C- Severe	2 - Unlikely	Low	
	Operation	On-site workers coming into contact with leachate resulting in injury/illness	Physical injury and illness in humans due to contact with or swallowing of uncontrolled leachate during cell connection works		C- Severe	3 - Possible	Moderate	- Contractor to prepare and implement appropriate work health and safety plan and work method statements to address safety measures for managing potential leachate exposure - Provision of previous environmental monitoring results to Contractor	Contractor	Prior to initiation of construction works		C- Severe	2 - Unlikely	Low	
	Operation	On-site workers coming into contact with landfill gas resulting in injury/illness	Illness or death relating to asphixiation or explostion/fire by LFG during cell connection works		D - Critical	3 - Possible	Significant	- Contractor to prepare and implement appropriate work health and safety plan and work method statements to address safety measures for managing potential gas exposure - Provision of previous environmental monitoring results to Contractor (where available)	Principal and Contractor	Prior to initiation of construction works		C- Severe	2 - Unlikely	Low	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating			Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating			Comments
					C	L	RR					C	L	RR	
	Operation	Off site receptors (local residents, flora and fauna) coming into contact with leachate resulting in injury/illness	Physical injury and illness due to contact with or swallowing of uncontrolled leachate		C- Severe	3 - Possible	Moderate	- Contractor to prepare and implement appropriate work health and safety plan and work method statements to address safety measures for managing potential gas exposure - Provision of previous environmental monitoring results to Contractor (where available)	Principal and Contractor	Prior to initiation of construction works		C- Severe	2 - Unlikely	Low	
	Operation	Access road	Vehicle / person falling from access road		E-Catastrophic	3 - Possible	Extreme	- Vehicle speed limit to be set and restricted by the Principal. - Signage warning of height to be located at the entrances to the sidewall batter access road	Contractor	Until waste reaches road level		E-Catastrophic	2 - Unlikely	Significant	
	Operation	Access road	Vehicle / person falling from access road		E-Catastrophic	3 - Possible	Extreme	- Access roads to be included in design and width to consider anchor trenches and drains	Designer	Finalisation of design documentation	closed	C- Severe	2 - Unlikely	Low	
	Operation	Excavations and ponds	Falling in, injury, drowning		E-Catastrophic	3 - Possible	Extreme	- Site should be fenced and secured after hours - Fence should be regularly inspected. Contractor to develop inspection plan.	Contractor	Throughout works		D - Critical	2 - Unlikely	Moderate	
	Operation	Working near water	Trip or fall into pond resulting in drowning		E-Catastrophic	4 - Possible	Extreme	- Contractor to develop safe work method for working around ponds - Include barriers/fencing, signage, ladders for getting out of ponds, life saving equipment	Contractor	Throughout works		C- Severe	4 - Possible	Moderate	
	Operation	Vehicle accident due to passing on-site traffic/earthmoving equipment	Injury/death from collision		E-Catastrophic	3 - Possible	Extreme	- Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing earthworks/traffic movements during the construction works - Include access roads	Contractor	Throughout works		E-Catastrophic	1 - Very Unlikely	Moderate	
	Operation	Extreme weather - rain	Inundation of void		D - Critical	3 - Possible	Significant	- Contractor to develop safe work method and evacuation procedures for forecast bad weather	Contractor	Throughout works		C- Severe	2 - Unlikely	Low	
	Operation	Bushfire while workers are on-site	Physical injury/death to on-site workers due to smoke inhalation or burns		E-Catastrophic	2 - Unlikely	Significant	- Develop and implement appropriate EMP and work health and safety plan / safe work method statements to address safety measures for managing bushfire risks	Contractor	Prior to initiation of construction works		D - Critical	2 - Unlikely	Moderate	
	Operation	Unauthorised access to site and monitoring infrastructure	Physical injury, discomfort, illness, or potential asphyxiation		D - Critical	3 - Possible	Significant	- Install suitable security measures to prevent unauthorised access to the site and the monitoring infrastructure	Principal	Ongoing		D - Critical	2 - Unlikely	Moderate	
	Maintenance	Oversteepened landform slopes (adjacent to capped area) become unstable resulting in slumping and/or landslides	Physical injury to on-site workers due to being struck or buried by soil		E-Catastrophic	3 - Possible	Extreme	- Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing traffic movements after capping works are completed - Maintain appropriate identification (signage) and safety measures (including fencing oand temporary bunds) near edge of the oversteepened batters	Contractor	After construction works as required		D - Critical	1 - Very Unlikely	Moderate	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating			Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating			Comments
					C	L	RR					C	L	RR	
	Maintenance	Vehicle accident due to oversteepened batters on perimeter of the Works Area	Physical injury from trips and falls, vehicle overturn		E-Catastrophic	2 - Unlikely	Significant	- Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing traffic movements after capping works are completed - Maintain appropriate identification (signage) and safety measures (including fencing oand temporary bunds) near edge of the oversteepened batters	Principal	After construction works as required		D - Critical	1 - Very Unlikely	Moderate	
	Maintenance	Uncontrolled collapse of large vegetation during vegetation clearance/slashing	Physical injury to future on-site workers due to being struck by trees or branches		C- Severe	3 - Possible	Moderate	- Maintain site vegetation in accordance with the site landscape management plan - Develop and implement appropriate work health and safety plan and work method statements to address safety measures for managing vegetation clearance/slashing works	Principal	After construction works as required		C- Severe	1 - Very Unlikely	Low	
	Maintenance	Significant erosion of placed capping materials, resulting in exposure of future site workers to existing landfilled waste during construction works	Physical injury and illness due to uncontrolled exposure (including inhaling or coming into contact with the waste)		D - Critical	2 - Unlikely	Moderate	- Maintain site vegetation in accordance with the site landscape management plan - Regularly inspect and repair any damage caused by erosion to the capping layer	Principal	After construction works as required		C- Severe	1 - Very Unlikely	Low	
	Maintenance	Excavations and ponds	Falling in, injury, drowning		E-Catastrophic	3 - Possible	Extreme	- Site should be fenced and secured after hours. - Fence should be regularly inspected. Contractor to develop inspection plan.	Operator	Throughout works		D - Critical	2 - Unlikely	Moderate	
	Maintenance	Working near water	Trip or fall into existing or new pond resulting in drowning		E-Catastrophic	3 - Possible	Extreme	- Contractor to develop safe work method for working around ponds - Include barriers/fencing, signage, ladders for getting out of ponds, life saving equipment	Operator	Throughout works		C- Severe	3 - Possible	Moderate	
	Maintenance	Culverts	Potential for suction into pipe in rain events		D - Critical	3 - Possible	Significant	- contractor to develop SWMS for entry into stormwater channels and perform regular maintenance on culverts	Operator	Ongoing		D - Critical	2 - Unlikely	Moderate	
	Maintenance	Bushfire while workers are on-site	Physical injury/death to on-site workers due to smoke inhalation or burns		E-Catastrophic	2 - Unlikely	Significant	- Develop and implement appropriate EMP and work health and safety plan / safe work method statements to address safety measures for managing bushfire risks	Operator	Prior to initiation of construction works		D - Critical	2 - Unlikely	Moderate	
	Maintenance	Extreme weather - rain	Inundation of void		D - Critical	3 - Possible	Significant	- Contractor to develop safe work method and evacuation procedures for forecast bad weather	Operator	Throughout works		C- Severe	2 - Unlikely	Low	
	Maintenance	Unauthorised access to site and monitoring infrastructure	Physical injury, discomfort, illness, or potential asphyxiation (and death)		D - Critical	3 - Possible	Significant	- Install suitable security measures to prevent unauthorised access to the site and the monitoring infrastructure	Operator	Ongoing		D - Critical	2 - Unlikely	Moderate	

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	L	RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	L	RR	Comments
	Maintenance	Landfill gas and waste hazards from operating landfill nearby	Physical injury and illness due to uncontrolled exposure, including inhaling or coming into contact with the waste and landfill gas		C- Severe	3 - Possible	Moderate	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to waste exposure, exhumation and relocation	Operator	Ongoing		C- Severe	2 - Unlikely	Low	
	Maintenance	Landfill gas inhalation/combustion impacting upon local receptors	Fire/explosion/asphyxiation, physical illness due to inhalation		D - Critical	3 - Possible	Significant	- Maintain ongoing operation of existing landfill gas management system - Alert Principal if system is offline and develop response plan to address this potential issue	Landfill Gas Operator	After construction works as required		D - Critical	2 - Very Unlikely	Moderate	
	Maintenance	Landfill gas inhalation/combustion impacting upon on-site workers and local receptors	Fire/explosion/asphyxiation, physical illness due to inhalation		D - Critical	3 - Possible	Significant	- Include provisions in the construction documentation for Contractor to prepare safety plans and environmental management plans with regards to the presence of landfill gas, including monitoring requirements -Installation of gas collection system to be undertaken by others	Principal	After construction works as required		D - Critical	2 - Unlikely	Moderate	

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	David Morrison	David Barrett		David Barrett		11/07/18

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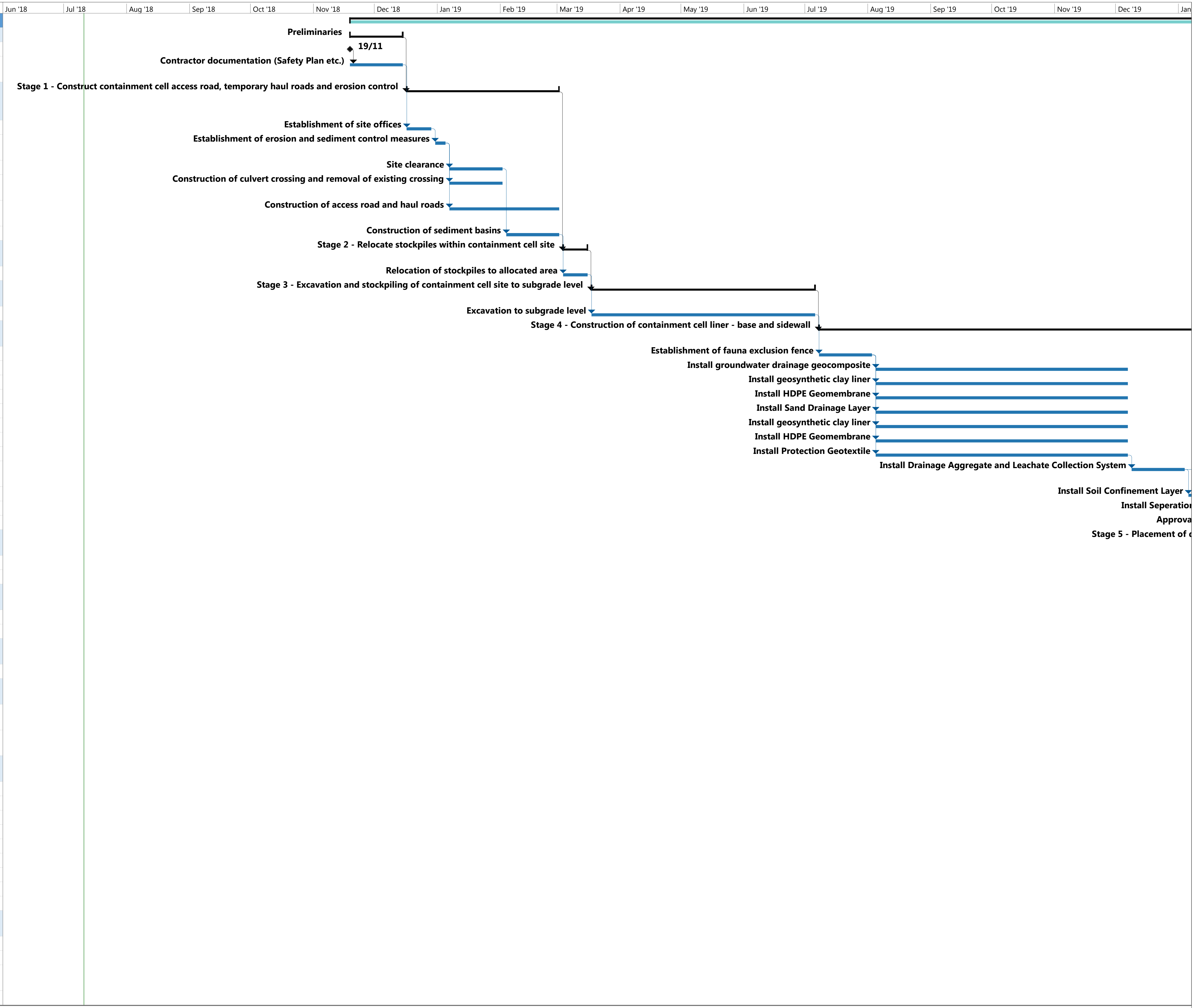
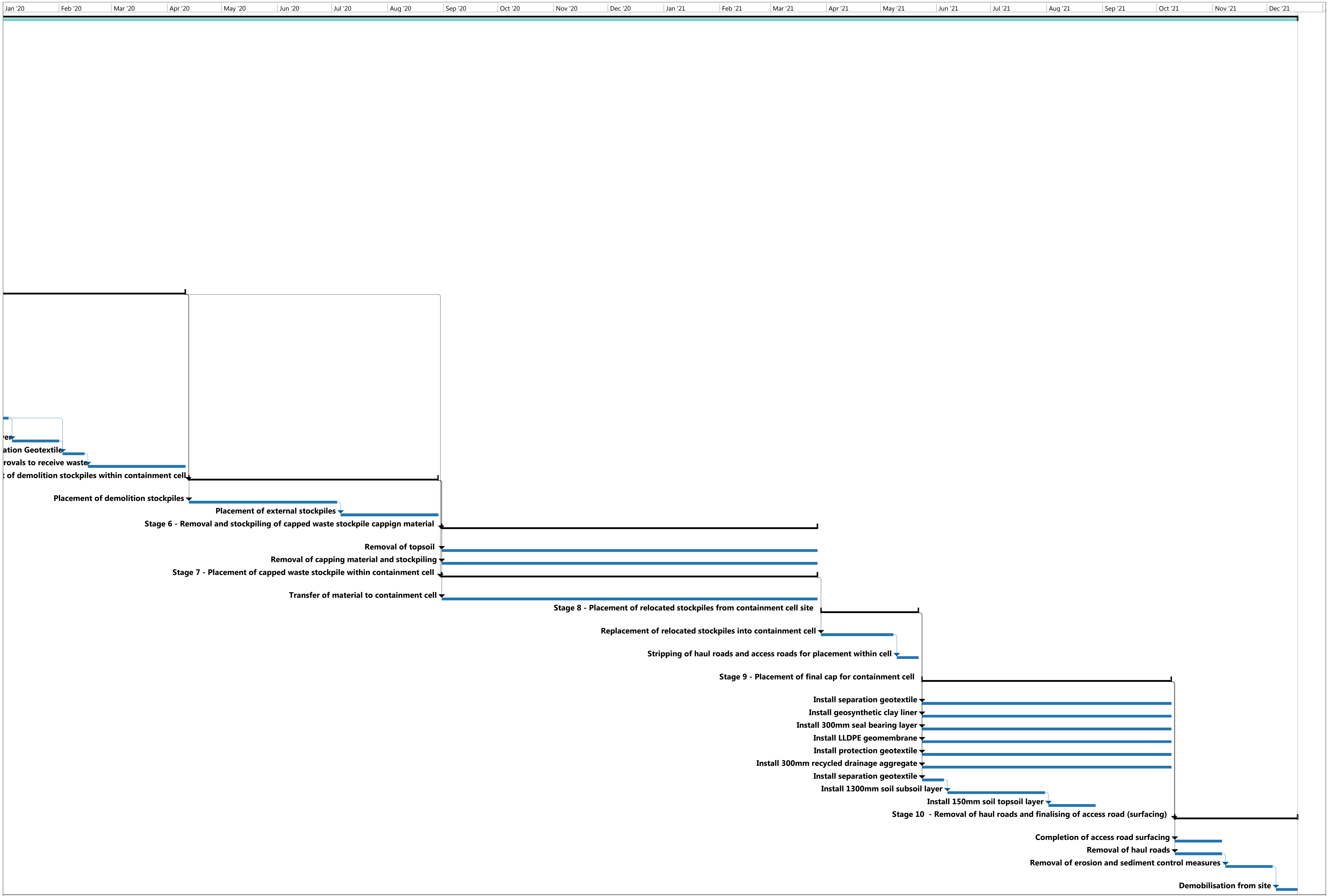
Appendix N Preliminary Construction schedule

ID	Task Name	Duration
1	**Containment Cell Detailed Design**	**805 days**
2	**Preliminaries**	**20 days**
3	Contract Award	0 days
4	Contractor documentation (Safety Plan etc.)	4 wks
5	**Stage 1 - Construct containment cell access road, temporary haul roads and erosion control**	**55 days**
6	Establishment of site offices	2 wks
7	Establishment of erosion and sediment control measures	1 wk
8	Site clearance	4 wks
9	Construction of culvert crossing and removal of existing crossing	4 wks
10	Construction of access road and haul roads	8 wks
11	Construction of sediment basins	4 wks
12	**Stage 2 - Relocate stockpiles within containment cell site**	**10 days**
13	Relocation of stockpiles to allocated area	2 wks
14	**Stage 3 - Excavation and stockpiling of containment cell site to subgrade level**	**80 days**
15	Excavation to subgrade level	16 wks
16	**Stage 4 - Construction of containment cell liner - base and sidewall**	**200 days**
17	Establishment of fauna exclusion fence	4 wks
18	Install groundwater drainage geocomposite	18 wks
19	Install geosynthetic clay liner	18 wks
20	Install HDPE Geomembrane	18 wks
21	Install Sand Drainage Layer	18 wks
22	Install geosynthetic clay liner	18 wks
23	Install HDPE Geomembrane	18 wks
24	Install Protection Geotextile	18 wks
25	Install Drainage Aggregate and Leachate Collection System	4 wks
26	Install Soil Confinement Layer	4 wks
27	Install Seperation Geotextile	2 wks
28	Approvals to receive waste	8 wks
29	**Stage 5 - Placement of demolition stockpiles within containment cell**	**100 days**
30	Placement of demolition stockpiles	12 wks
31	Placement of external stockpiles	8 wks
32	**Stage 6 - Removal and stockpiling of capped waste stockpile cappign material**	**150 days**
33	Removal of topsoil	30 wks
34	Removal of capping material and stockpiling	30 wks
35	**Stage 7 - Placement of capped waste stockpile within containment cell**	**150 days**
36	Transfer of material to containment cell	30 wks
37	**Stage 8 - Placement of relocated stockpiles from containment cell site**	**40 days**
38	Replacement of relocated stockpiles into containment cell	6 wks
39	Stripping of haul roads and access roads for placement within cell	2 wks
40	**Stage 9 - Placement of final cap for containment cell**	**100 days**
41	Install separation geotextile	20 wks
42	Install geosynthetic clay liner	20 wks
43	Install 300mm seal bearing layer	20 wks
44	Install LLDPE geomembrane	20 wks
45	Install protection geotextile	20 wks
46	Install 300mm recycled drainage aggregate	20 wks
47	Install separation geotextile	2 wks
48	Install 1300mm soil subsoil layer	8 wks
49	Install 150mm soil topsoil layer	4 wks
50	**Stage 10 - Removal of haul roads and finalising of access road (surfacing)**	**50 days**
51	Completion of access road surfacing	4 wks
52	Removal of haul roads	4 wks
53	Removal of erosion and sediment control measures	4 wks
54	Demobilisation from site	2 wks

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ation Geotextile
rovals to receive waste
of demolition stockpiles within containment cell
Placement of demolition stockpiles
Placement of external stockpiles
Stage 6 - Removal and stockpiling of capped waste stockpile cappign material
Removal of topsoil
Removal of capping material and stockpiling
Stage 7 - Placement of capped waste stockpile within containment cell
Transfer of material to containment cell
Stage 8 - Placement of relocated stockpiles from containment cell site
Replacement of relocated stockpiles into containment cell
Stripping of haul roads and access roads for placement within cell
Stage 9 - Placement of final cap for containment cell
Install separation geotextile
Install geosynthetic clay liner
Install 300mm seal bearing layer
Install LLDPE geomembrane
Install protection geotextile
Install 300mm recycled drainage aggregate
Install separation geotextile
Install 1300mm soil subsoil layer
Install 150mm soil topsoil layer
Stage 10 - Removal of haul roads and finalising of access road (surfacing)
Completion of access road surfacing
Removal of haul roads
Removal of erosion and sediment control measures
Demobilisation from site

Appendix O Gypsum Addition

Memorandum

10 July 2018

To	Hydro Aluminium Kurri Kurri (HAKK)		
Copy to			
From	David Barrett	Tel	+61 2 4350 4123
Subject	Implications of gypsum addition	Job no.	2218015

1 Introduction

Hydro Aluminium Kurri Kurri (HAKK) engaged GHD to design a containment cell as part of the remediation works at the former Hydro Aluminium Smelter. The system was designed for the storage of the following onsite waste sources:

- Capped Waste Stockpile
- Process Waste
- Smelter Contaminated Soils
- Buffer Zone Contaminated Soils
- Non-recyclable Demolition and Smelter Wastes (Non-leachable/Non-Hazardous and Leachable/Hazardous)

Subsequent to the completion of the design it has now been proposed to include 10% (by weight) of gypsum to the waste from both the capped waste stockpile (CWS) and process waste streams for the purpose of stabilizing and encapsulating extractable fluoride.

This purpose of this memorandum is to provide commentary on potential implications (if any) the addition of gypsum will have on the leachate containment and conveyance infrastructure of the cell.

2 Leachate source

The leachate system will manage the following water sources:

- Leachate from the Capped Waste Stockpile (CWS):
  - stormwater that falls on the CWS and becomes contaminated during excavation
  - residual leachate in the waste material and contaminated groundwater that enters the CWS excavation during the extraction of waste material and the underlying contaminated natural ground
- Leachate from the containment cell:
  - stormwater that falls within waste containing sub-cells in the containment cell and becomes contaminated during the placement of waste
  - residual leachate generated from the containment cell following capping of the sub-cells

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3 Key leachate containment and conveyance infrastructure

The cell design comprises the following key components, which would interact with the waste streams and/or leachate:

- Primary barrier system (refer to Figure 3-1)
  - HDPE geomembrane
  - Geosynthetic clay liner
- Leachate conveyance system (refer to Figure 3-2)
  - Separation geotextile
  - Drainage aggregate
  - Perforated leachate collection pipework
  - Protection geotextile
- Leachate extraction (refer to Figure 3-3)
  - Perforated leachate collection pipework
  - Collection sump with drainage aggregate
  - Pipe extraction riser

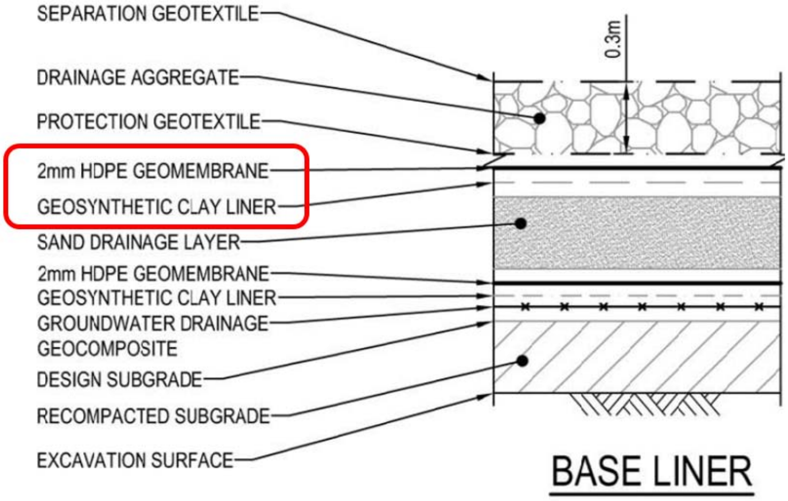

Figure 3-1 - Primary barrier system

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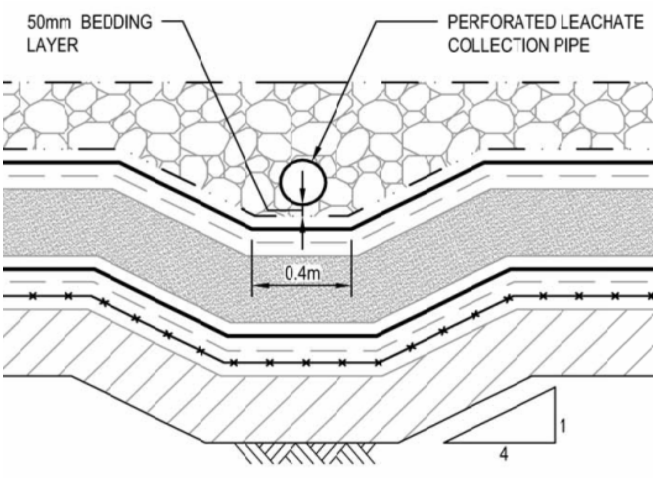

Figure 3-2 - Leachate conveyance system

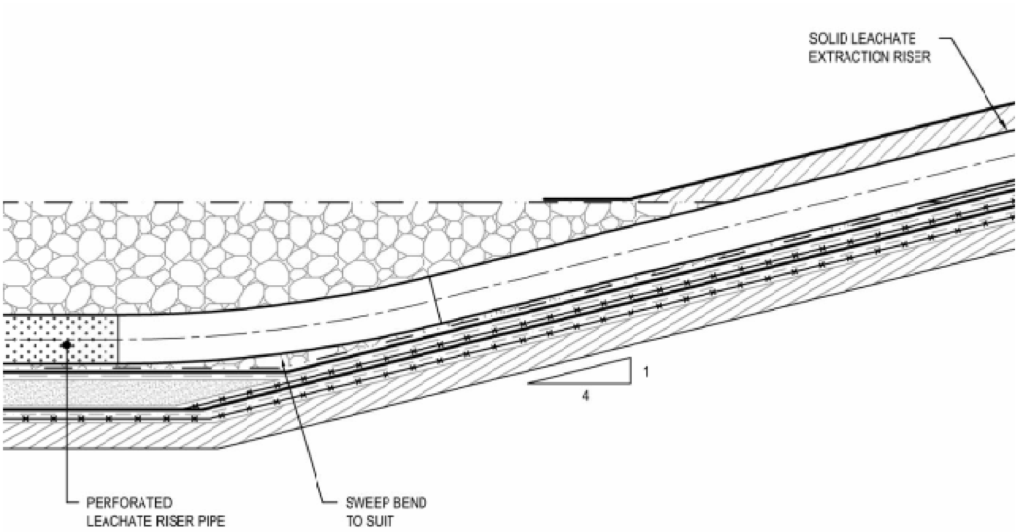

Figure 3-3 - Leachate riser

4 Design implications

4.1 Primary barrier system

Dr John Scheirs of ExcelPlas Independent Material Testing (ExcelPlas) was engaged to provide an opinion on the chemical resistance of the HDPE geomembrane to the leachate following the addition of gypsum to the waste stream (refer to attached letter).

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It is his expert opinion that the reduction in leachable fluoride and the lowering of pH achieved through the addition of gypsum **will not adversely affect** the HDPE liner materials or their stabilizer packages.

4.2 Leachate conveyance and extraction system

The key implication to be assessed with regard to both the conveyance and the extraction system is whether the addition of gypsum will result in clogging whereby leachate cannot be extracted with the same efficiency. Clogging (if it occurs) can be a major issue during the filling stages, as leachate generation is at its peak. Post final capping, as leachate generation is much lower, the reduction in available flow paths is not as critical.

Firstly, it must be recognised that leachate conveyance systems are prone to experiencing significant amounts of clogging due to microbial slimes, inorganic precipitates and suspended solids and that the amount of clogging is generally dependant on the composition of the leachate.

Secondly, all leachate collection systems will clog, and they are designed with an acceptance that clogging will occur, however the question is will they excessively clog. Typically, it takes several years of high leachate flows and/or saturation (i.e. in-cell storage is common practice) for excessive clogging to develop.

Biofilm growth, mineral precipitation, and suspended particulate matter deposition are the main mechanisms of LCS clogging [1].

In a batch synthetic and real leachate irrigating experiment, Fleming and Rowe determined that CO_3^{2-} from the microbial degradation of volatile fatty acids in leachate binds to Ca^{2+} in leachate to form calcium carbonate as the primary driver of LCS clogging [2].

Meanwhile, by column experiment, Rowe et al. pointed out that the column irrigated with real landfill leachate reduced the porosity of the drainage layer by 24% more than that with the synthetic leachate without suspended particulate matter [3]. This result indicated the high contribution of particulate matter to LCS clogging.

Other things being equal, McIsaac & Rowe (2007) found that there was substantially greater clogging in a fully saturated mesocosm (300 mm saturated thickness) than in a partly saturated mesocosm (100 mm saturated thickness). Saturation of the gravel:

- increased the retention time of leachate in the drainage layer, and
- created a more conducive environment for the microbial growth on the surface of gravel.

This resulted in the formation of a much greater clog mass in the 300 mm of gravel when fully saturated than when only 100 mm was saturated and 200 mm was unsaturated. McIsaac & Rowe (2007) suggested that the LCSs should be designed and operated with a minimum saturated drainage height by regularly pumping leachate out of the landfill and avoiding accumulation of leachate within the LCSs. [4]

Taking the above into account the following must be recognised regarding the design intent behind the Hydro Containment Cell:

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- The filling stages will be complete within a short period (<2 years)
- Leachate conveyance pipework has perforations well in excess of what is required
- A secondary leachate extraction riser pipe (redundancy)
- Operational intent is to maintain low leachate levels by extracting to the onsite leachate pond
- Capping works will be complete within 6 months of final waste placement

Through the implementation of good operational practices regarding leachate extraction, the short-term operational phase of the cell and the increased number of perforations, it is anticipated that **excessive clogging would not occur**.

5 Additional mitigating strategies

5.1 Design phase

The following mitigation strategies have also been proposed to reduce clogging:

- A large surface area exists in the sumps to allow for some clogging
- Design utilises rounded to sub-rounded aggregate with large porosity in the sump and leachate trenches
- Geotextiles wraps which provide increased surface area for clogging around pipes are not employed
- Leachate collection pipes are placed on a bedding layer as the lower portion of the aggregate layer is the primary clogging area.
- Pipe perforations have been designed as large as possible

5.2 Operations phase

- In-cell storage only to occur during major weather events or due to breakdowns/maintenance of the disposal system
- Waste is to be well compacted and placement of gypsum to be as homogenous as is practical
- Ensure the separation geotextile is appropriately installed to reduce particulate matter build-up into the leachate blanket and sumps
- Ensure the drainage aggregate has minimal fines, consider washing out fines prior to placement
- Monitor leachate head build-up within the cells as a proxy to leachate clogging. If the leachate drainage blanket is functioning then a leachate mound should not occur
- Leachate riser pipe can be regularly inspected and cleaned by flushing (if required)

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6 Conclusion

The addition of 10% gypsum (by weight) to the containment cell waste stream for the purposes of stabilizing, sequestering and fixing the extractable fluoride results in:

- Clear reduction in the amount of leachable fluoride;
- reduction in pH to ca. 7-7.5; and
- increased fines content to waste stream.

The following is noted with regard to the proposed design:

- HDPE liner materials and their stabilizer packages **would not be compromised** as pH levels would need to be reduced to approximately 3-3.5; and
- while some clogging will occur, **excessive clogging is not anticipated** as numerous contingencies are incorporated into both the design and the proposed operations.

Regards

David Barrett
Manager, Central Coast

Attachment:

ExcelPlas - Opinion on the chemical resistance of HDPE geomembrane

References:

1. Cooke, A.J.; Rowe, R.K.; Rittmann, B.E. Modelling species fate and porous media effects for landfill leachate flow. Can. Geotech. J. 2005, 42, 1116–1132.
2. Fleming, I.R.; Rowe, R.K. Laboratory studies of clogging of landfill leachate collection and drainage systems. Can. Geotech. J. 2004, 41, 134–153.
3. Rowe, R.K.; Vangulck, J.F.; Millward, S.C. Biologically induced clogging of a granular medium permeated with synthetic leachate. J. Environ. Eng. Sci. 2002, 1, 135–156.
4. McIsaac, R., and Rowe, R.K. (2007) Clogging of Gravel Drainage Layers Permeated with Landfill Leachate. Journal of Geotechnical and Geoenvironmental Engineering, 133(8): 1026-1039.

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OPINION ON THE CHEMICAL RESISTANCE OF HDPE GEOMEMBRANE

Prepared for: GHD

Prepared by: Dr. John Scheirs (ExcelPlas)
P.O. Box 147, Moorabbin, VIC 3189
www.excelplas.com

5th April, 2018

COMMERCIAL-IN-CONFIDENCE

Dr. John Scheirs, ExcelPlas Polymer Testing Services, NATA Certified Laboratory,
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Postal Address: PO Box 147, Moorabbin, Vic 3189,
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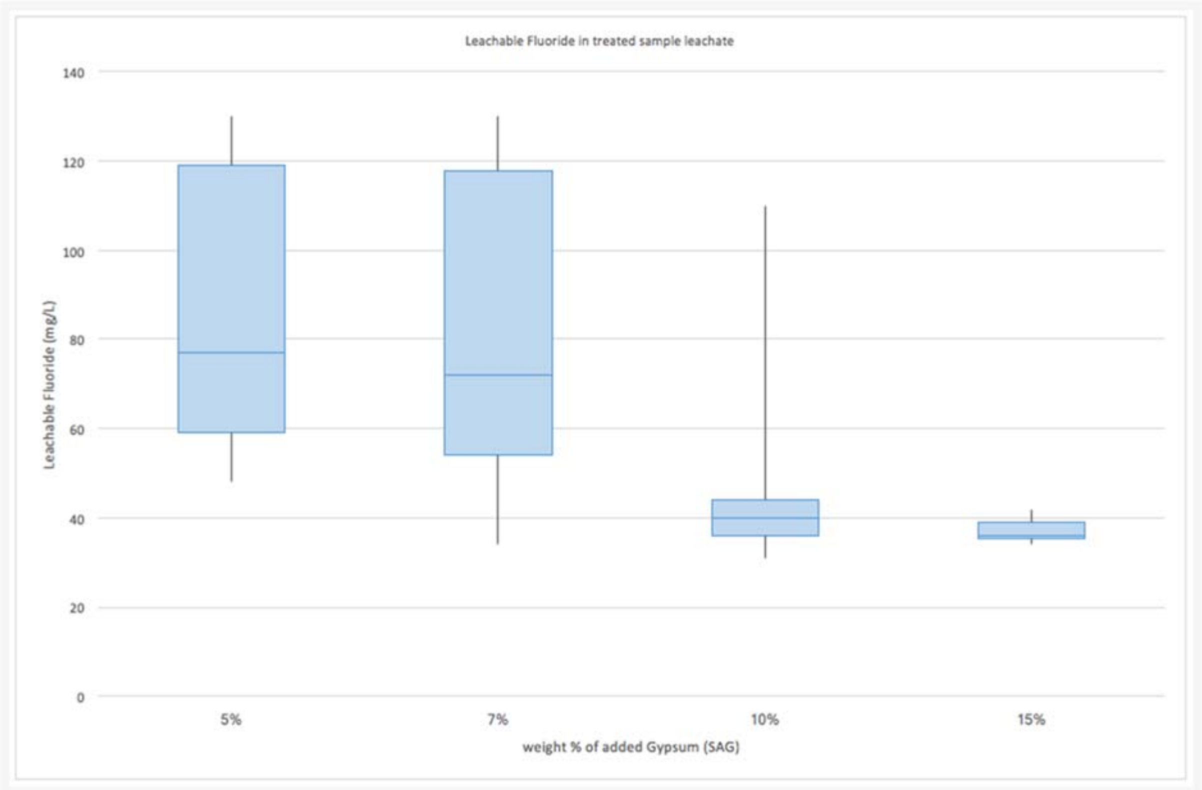
Opinion

I have been asked to provide an expert opinion on the chemical resistance of HDPE geomembrane exposed to gypsum-treated mixed smelter waste (containing approx. 20% spent pot lining, SPL).

It has been proposed that 10% (by weight) of gypsum added to the waste from the capped waste stockpile (CWS) for the purpose of stabilizing, sequestering and fixing the extractable fluoride from SPL.

The plot below shows the effect of gypsum addition on the leachable and extractable fluoride content.



There is a clear reduction in the amount of leachable fluoride from the CWS with the addition of 10 wt.% of gypsum.

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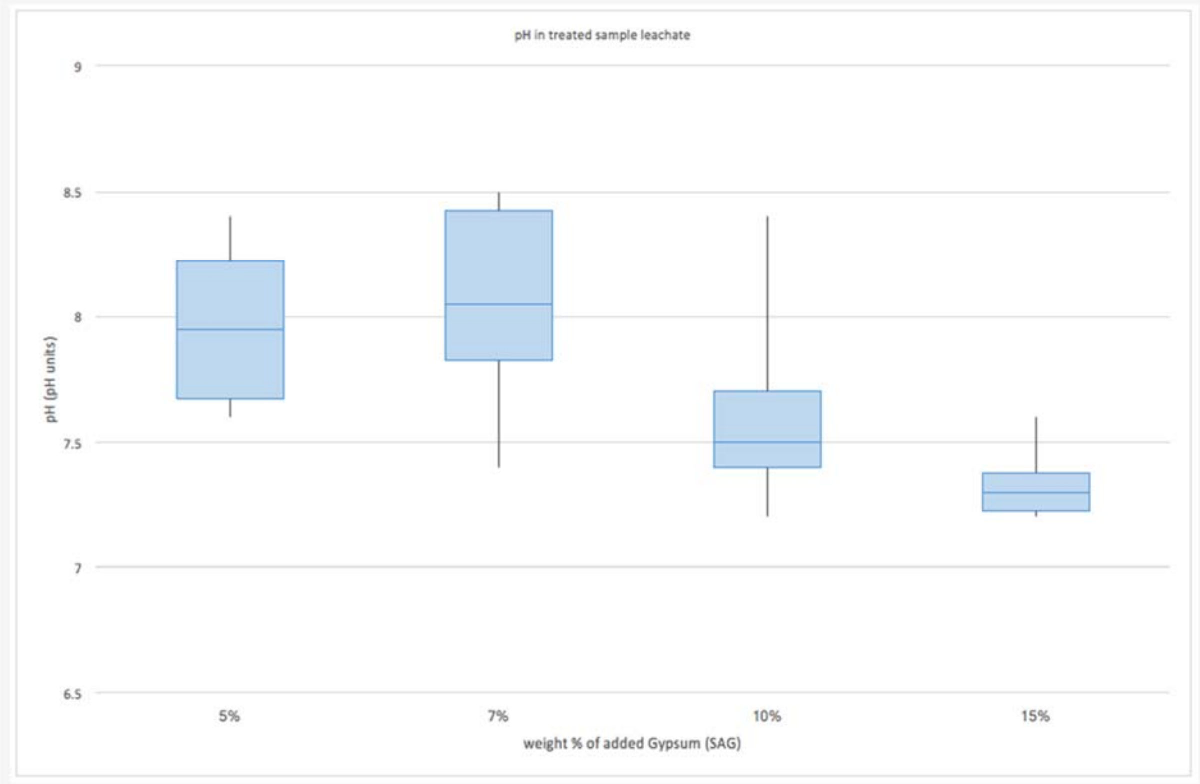
The addition of gypsum however also serves to lower the pH of the CSW.

The plot below shows the effect of gypsum addition on the pH of the CSW.



I can confirm the measured pH levels above will not adversely affect the HDPE liner materials nor their stabilizer packages.

Signature

Dr. John Scheirs
Director
ExcelPlas Geomembrane Testing,
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DOC18/468606

Hydro Aluminium Kurri Kurri Pty Ltd
ACN 093 266 221 ABN 55 093 266 221
Via e-mail at: richard.brown@hydro.com

Attention: Ms Kerry McNaughton

09 June 2018

Dear Mr Brown

Environment Protection Licence 1548
CWS Waste Management Option 4 Remediation Design and Proposed Validation of Treatment
EPA comment on Ramboll response dated 08 June 2018

I refer to the e-mail from Mr Shaun Taylor of Ramboll Australia Pty Ltd (Ramboll) and attached letter dated 08 June 2018 on behalf of Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) in response to our meeting held on 27 April 2018 and follow-up e-mail that day whereby I provided Mr Taylor with the Environment Protection Authority's (EPA) Hazardous Materials Unit's detailed comments on the revised CWS Waste Management Option 4 Remediation Design and Proposed Validation of Treatment Report.

The EPA has now reviewed the additional information provided in respect of the revised CWS Waste Management Option 4 Remediation Design and Proposed Validation of Treatment Report and advises:

1. That the EPA is satisfied that the proposed treatment strategy using gypsum is generally sound and should ensure that leachable levels of fluoride and cyanide are below the levels referred to in the Aluminium Smelter Waste Chemical Control Order; and
2. That the EPA is satisfied that the validation of the treatment process where undertaken as proposed should be sufficient to identify the effectiveness of the proposed treatment strategy.

This letter will be provided to the Department of Planning and Environment (DPE) and Ramboll so that they are also aware of the EPA's position.

Please note that the EPA will now look to work with DPE to investigate potential ways to ensure the long-term monitoring and management of any containment cell is adequately addressed and financed.

If you have any questions about this matter, please contact me on (02) 4908 6830.

Yours sincerely

MATTHEW CORRADIN
A/Unit Head Hunter South
Environment Protection Authority
CC: DPE, Ramboll

ENVIRONMENT
& HEALTH

Environment Protection Authority
PO Box 468G
Newcastle NSW 2300
Attention: Mark Hartwell

HYDRO ALUMINIUM KURRI KURRI CAPPED WASTE STOCKPILE TREATMENT: RESPONSE TO EPA FEEDBACK

Date 08/06/2018

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Ref AS130525
AS130525 Letter Response to EPA Feedback 2018_06_08

Please find attached the response from Ramboll Australia Pty Ltd (Ramboll) on behalf of Hydro Aluminium Kurri Kurri Pty Ltd (Hydro) to the letter dated 20 April 2018 and, in particular, the review prepared by the EPA Hazardous Materials Unit which was subsequently provided on 27 April 2018.

The response specifically addresses each of the issues listed in the Hazardous Materials Unit review document.

Hydro and Ramboll request that the EPA provide their feedback to this response by Wednesday 20 June 2018. We are available for a meeting if the EPA wishes to discuss our response while you are preparing your feedback.

We would also request that a meeting between the EPA, Hydro and Ramboll be held soon after the noted date to discuss the EPA feedback and the way forward. We suggest Friday 22 June 2018 at 11am at the EPA offices in Sydney.

We trust that this response now satisfies the outstanding concerns raised by the EPA to allow the Department of Planning and Environment to progress the determination of the Project.

Yours sincerely

Shaun Taylor
Senior Environmental Scientist

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Ramboll Australia Pty Ltd.
ACN 095 437 442
ABN 49 095 437 442

Attachment A – Response to EPA comments issued on 27 April 2018

EPA Information Requirement	Hydro Comment
Containment cell design	The containment cell is designed for dry entombment, meaning the waste will be of low moisture content and the ultimate long term leachate generation prediction is very low. Modelling of leachate generation has been completed by GHD in the Containment Cell detailed design and predicts that the long term steady state leachate generation is <400 L p.a. using a 90% AEP rainfall[1]. Initial leachate generation higher than the long term average is predicted to occur due to moisture that is trapped within the waste during the cell filling process. This leachate is predicted to make its way to the sump over a short time period of less than 5 years. Reactions with gypsum may occur during this timeframe. However, over the longer term, the reactions described in the following and the treatment of waste with gypsum is precautionary, and required to meet the CCO, as the waste and gypsum will essentially remain dry. The long term management plan includes monitoring of leachate volume generation in the sump as a key indicator of performance. Where leachate volume generation varies outside of normal performance expectations (as determined by modelling and then model calibration monitoring) this may indicate a breach in the containment cell cap. Should this occur, contingencies to investigate and remedy the cause of the leak are proposed. The intention is to minimise leachate generation by minimising the flow of water through the waste and maintaining dry entombment. This process provides a further mechanism by which dry entombment is maintained and further confidence that gypsum and waste are likely to remain unreacted.
ACTION (1a): Hydro be requested to provide the following information.	
1. An analysis and discussion of the chemistry explaining SAG reaction with cyanide and why there appears to be a reaction despite statement that calcium chloride or gypsum has no chemical effect on cyanide. This explanation should also detail expected impacts on cyanide leaching.	Table 8-1 of the report[2] presents total Cyanide concentrations in leachate with increasing additions of gypsum from 5% to 15%. The table shows a reduction of 0.5mg/L in total Cyanide from 3.4 mg/L to 2.9 mg/L, or 17%. The mass of gypsum added between the 5% trial and the 15% trial is 8.3% of the total weight, which is due to the manner of adding 10% gypsum to the mass, as opposed to adding an amount of gypsum to make up 10% of the

[1] 'Hydro Aluminium Kurri Kurri Pty Ltd, Containment Cell Design Report', GHD, October 2017, Appendix C

[2] 'Hydro Aluminium Kurri Kurri, CWS Waste – Gypsum Treatability Study', Ramboll, April 2018

EPA Information Requirement	Hydro Comment
2. An analysis and discussion of the results from Treatment Study 1 and other cyanide leaching data. This should include: a. an explanation of why a dilution effect was not observed in Treatment study 1; b. the likelihood for leachable cyanide concentrations to exceed 10 mg/L; and c. why Stage 1, 2 and 3 testing showed relatively low average concentrations for cyanide compared to historic samples. 3. An analysis and discussion of the cyanide results from the testing performed for Stages 1-3.	total final mass. For example, if the sample weighs 100g and 5g of gypsum is added, this represents 5g in 105g, or 4.79% of the total mass. So reasonably, it could be considered that an 8.3% reduction in Total Cyanide would occur from dilution alone. The remaining change is considered an artefact of averaging the data set. When reviewing Figure 8-5, the box and whisker plot, the range of variability in the data set can be seen, though noting that the data set is small. The standard deviation for the 5% gypsum and the 15% gypsum tests is 0.6 mg/L and 0.36 mg/L respectively and represents up to 20% of the average concentration. Comparison of the 10% added gypsum results shows a lower standard deviation, average and 95% UCL, than 15 % added gypsum result If gypsum was reducing Total Cyanide in the data set this would not be the case. This observation provides further evidence that variability in the data set accounts for some of the variability in results observed. All data relation to leachable Total Cyanide is shown in Table 2-1, and a visual representation is presented in response to question 1(f) below. The data shows that testing of waste using the ASLP analysis found a maximum concentration of 10 mg/L. The results for cyanide reported are for Total Cyanide in leachate, as Total Cyanide is the specified compound in the Chemical Control Order. However, analysis of results was also completed for free cyanide and weak acid dissociable (WAD) cyanide, refer to Appendix 2 of the report. Free cyanide represents un-complexed CN compounds in water. WAD represents cyanides that are weakly complexed and may become Free CN when pH decreases, typically to less than 6 pH units. It is well known that hydrogen cyanide can form when free CN is present and pH drops to around 8 pH units. With further pH declines below 6 pH units WAD CN can become free CN, leading to further HCN production. For HCN to form at the pH observed, free CN is required. Laboratory analysis of leachate following treatment (pH between 7 and 8) has identified very low concentrations of both Free CN and WAD CN, with concentrations below detection levels of <0.1 mg/L and <0.004mg/L when lower detection limits were employed.

	Free CN	WAD Cyanide
No of samples	74	74
Detections	3	6
Max	0.13 mg/L	0.21 mg/L
Min	<0.004 mg/L	<0.004 mg/L

EPA Information Requirement	Hydro Comment

Furthermore, a suite of testing completed on leachate collected from four monitoring wells installed in the Capped Waste Stockpile is presented in the GHD report[3] and is tabulated below.

	Free CN	WAD Cyanide
No of samples	4	2
Detections	0	1
Max	<0.04 mg/L	<0.4 mg/L
Min	<0.004 mg/L	0.047 mg/L

Lower results for Total Cyanide were documented in the treatability trials due to the method of sample preparation. Characterisation of the waste using ASLP analysis was undertaken as required by the waste classification guidelines is presented in Table 2-1 of the report. In this instance a sample for ASLP analysis was collected from the bulk sample. The sample was selected randomly and included a range of material sizes. Where the material selected for analysis was large it was crushed and then subsampled for analysis. As the waste includes large pieces of spent pot lining that were cored during the sampling process, it is expected that spent pot lining was sampled as part of the ASLP analysis, subsequently crushed and analysed. These samples result in the high leachable values and can be seen as outliers in the data set. The analysis undertaken by this method indicates that Total Cyanide concentrations of untreated waste when tested by ASLP were found to range between 0.198 mg/L and 10 mg/L. This variation reflects the expected variation in the waste materials whereby a sample was sub-sampled and crushed prior to the leachate analysis.

When waste was mixed with gypsum and tested in accordance with the requirements of the CCO, a more consistent leachable concentration was observed. This would be expected considering that the sample was mixed with gypsum, crushed to <9.5mm and then sub-sampled for leachate analysis, as required by the test method. This process is expected to result in a more homogenous sample for ASLP analysis and be more representative of the mixed waste following entombment.

[3] 'Hydro Aluminium Kurri Kurri Pty Ltd, Containment Cell Design Report', GHD, October 2017, Appendix C

EPA Information Requirement	Hydro Comment
ACTION (1b): Hydro be requested to provide the following information.	
1. An analysis and discussion of the composition of SAG and relevant chemistry, explaining the apparent influence SAG has on leachate pH; and	The proposed SAG comprises: 90-96% Calcium Sulphate Dihydrate ($CaSO_4.2H_2O$); <2% paper liner (organic); <2% Calcium carbonate ($CaCO_3$) and trace sodium chloride (NaCl) and Crystalline Silica. SAG gypsum is produced for reuse as a soil conditioner in agriculture and mine rehabilitation applications. When in contact with waste containing fluoride and water is added to cause soluble ions, the following reaction occurs $2NaF + CaSO_4.2H_2O = CaF_2 + Na_2SO_4 + 2H_2O$ The products in the above equation are neutral and can move pH towards neutral conditions. Sulphate as Na_2SO_4 is soluble in water. In the presence of certain conditions the sodium and sulphate may disassociate and other metallic sulphates form, such as manganese sulphate, with little effect on pH or toxicity. The potential for generation of sulphuric acid was considered and found unlikely to occur. As the sulphate present is oxidised sulphur as sulphate, sulphuric acid can only occur in the presence free hydrogen ions, through the addition of an acid such as hydrochloric acid. As there is no additional acid in the waste and none to be added, sulphuric acid will not occur. Consideration was also given as to whether thiocyanate might form in the presence of sulphate and free cyanide. As shown above, concentrations of free cyanide are very low and therefore thiocyanate production is unlikely. In any case, thiocyanate is a lower toxicity compound than free CN. Ammonia sulphate is another product that could result from the presence of both ammonia and sulphate. Again, this is a precipitate that would solubilise in the presence of water and potentially result in the release of a nitrogen ion and a corresponding small decrease in pH which is unlikely to have any effect in the presence of the waste buffering capacity.
2. An analysis and discussion on the potential for non-gypsum constituents in SAG to modify the chemistry within the containment cell, and any possible long-term impacts this may have.	As described above the non-gypsum constituents are predominantly organic paper and calcium carbonate. These materials are compatible with the waste materials and in the case of calcium carbonate can add to the performance of the gypsum.
ACTION (1c): Hydro be requested to provide the following information	
An analysis and discussion on the long term fate of gypsum in the containment cell, to demonstrate this is well understood and can be reliably predicted. This should address potential changes due to material decomposition and changing chemistry, microbiology and other conditions.	It is expected that gypsum will remain in the solid form as a dry to slightly moist constituent of the overall waste mass. Should water enter the containment cell dissolution of sulphate and calcium through the above reaction can occur as described above.

EPA Information Requirement	Hydro Comment
ACTION (1d): Hydro be requested to provide the following information.	
1. An analysis and discussion on the use of gypsum at the Tomago Aluminium Wallaroo Landfill, in particular data and detailed information on all relevant aspects such as the composition and amount of leachate generated, the treatment method, and the design and performance of the landfill cell.	Data available to Hydro has been presented to the EPA. As this project was approved by the EPA, further information is likely held with the regulator.
ACTION (1e): Hydro be requested to provide the following information.	
1. References that support and justify the use of gypsum to treat aluminium smelting waste, in particular over project relevant timescales, and a discussion of relevant aspects to the proposed method for remediation of the CWS waste material.	As described above at the Tomago facility which has been in place for approximately 30 years. This example is a local and relevant example of the use of gypsum in this context. The treatment completed by Tomago Aluminium was approved by the EPA and was demonstrated to be effective in treatment and is continuing to meet performance criteria [4].
ACTION (1f): Hydro be requested to provide the following information.	
1. An analysis and discussion of the chemistry explaining SAG reaction with fluoride. The analysis should demonstrate the mechanism/s involved are well understood and that the chosen gypsum application rate is appropriate for use.	Refer to Question 1(b). The chosen gypsum application rate was adopted based on a series of testing using a range of application rates. Whilst all application rates trialled passed the CCO requirements, an application of an added 10% by weight was adopted as this gave a factor of safety of around three. That is, the leachable concentration of F when tested in accordance with the EPA prescribed method was 48mg/L[5], or less than one third of the target concentration of 150mg/L. As a further check on validity of the application rate, a stoichiometric calculation of the moles of soluble F in the mass compared to the moles of Ca added in gypsum was undertaken. The calculation was completed two ways based on the estimated mass of F in the waste. The mass can be estimated a number of ways as follows: 1. As before, the mass of spent pot lining is estimated as 35000T of the total mass. The MSDS reports that 7 to 22% of first cut spent pot lining can comprise total F. On this basis there is 7700T of F in the waste. It is further estimated that only 17% of this total F mass comprises soluble F as approximately 80% is cryolite (Na_3AlF_6) and 3% is Calcium Fluoride, both of which are insoluble in water. Therefore, there is an approximate 1330T of soluble F presented in the waste, when adopting the 22% upper limit of total F.

[4] Monitoring results available at: http://www.tomago.com.au/health-safety/monitoring-results

[5] Calculated as a 95% Upper confidence limit of the mean from 36 samples

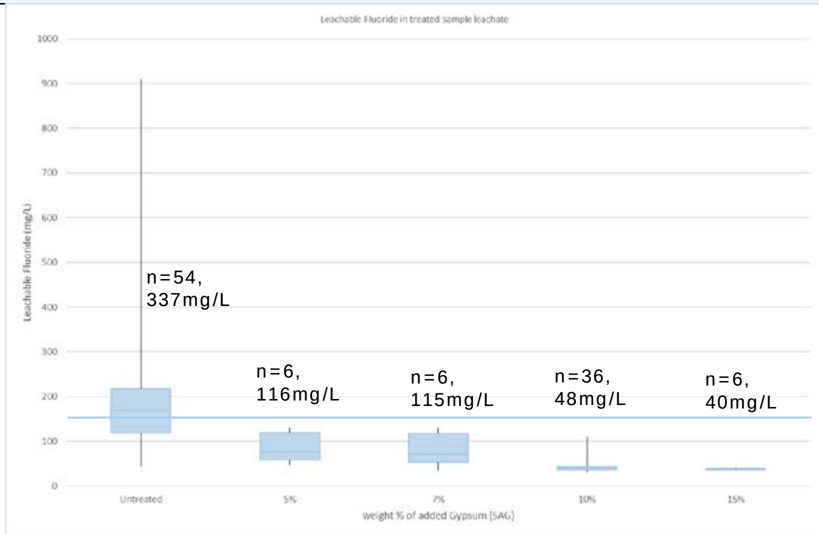
EPA Information Requirement	Hydro Comment
	2. An alternate method to calculate the total mass of F, is to adopt the 95% UCL mean of the untreated waste data set (Table 2-1 of the report). Using the 95% UCL and applying this to the full 240000T of waste, and assuming the same proportion (17%) of this mass is soluble, equates to 1260 T of soluble F. 3. Using the 95% UCL average of soluble F of 337 mg/L determined by TCLP testing, and calculating the total mass of soluble F within the waste. This method uses the leachable value to calculate a total soluble F concentration in the mass. Interestingly the soluble concentration calculated by this method was 22% of the 95%UCL total concentration determined for the waste. This is reasonably consistent with the estimated 17% of total F that is soluble. This calculation resulted in an estimate 1620 T of soluble F and was used in the following calculation. The mass of gypsum proposed to be added to the waste is 24000T[6], of which 22800T is actual gypsum assuming 10% of impurities as per the SDS. This equates to 5018T (or 1.25e8 mol) of Ca available for reaction with 1620T of soluble F (or 8.51e7 mol). As the formation of CaF_2 consumes two molecules of F to one molecule of Ca, there is an excess of Ca remaining (8.99e7 mol) or 3600T of calcium, which equates to 16280T of gypsum. This calculation demonstrates that there is sufficient calcium available in the addition of gypsum to stabilise the soluble F ions present in the waste.

[6] Based on 10% added to 240000T of waste, however actual amount will be 10% of final waste mass measured.

EPA Information Requirement

2. Test results for non-treated samples, and a discussion and analysis of these results. The analysis may assist to explain observed variability in the results and to demonstrate the effectiveness of the use of gypsum.

Hydro Comment



The figure above shows the trial results (Figure 8-4 of the report) with untreated data from previous samples (data presented in Table 2-1 of the report) included. Table 2-1 of the report shows untreated samples subject to a TCLP leachate test reporting a 95% UCL average of 337 mg/L. The figure above shows the box and whisker representation of this data set and indicates that three quartiles of the untreated data are below 217mg/L, however a whisker extending to 909 mg/L is observed. The distribution observed in the data is not unexpected as the waste includes fragments of spent pot lining which are expected to produce high leachable fluoride levels when subject to the analysis. As presented the estimated mass of spent pot lining within the overall waste mass is 35000T of first cut spent pot lining in approximately 240000T of waste, less than 15% of the overall waste mass.

The method of testing untreated samples was to select the sample for analysis and then crush and test. As the sample size was variable, this method sometimes results in a cobble sized ‘piece’ being selected and crushed for analysis. Where this was spent pot lining, a high leachable F^- concentration resulted. Whereas, for the treatability trials the whole sample was crushed, mixed and then sampled for TCLP analysis. Therefore increased homogeneity is expected from the treatability trials, and this is also expected to best replicate any leachate derived from the waste following mixing with gypsum and relocation to the new cell.

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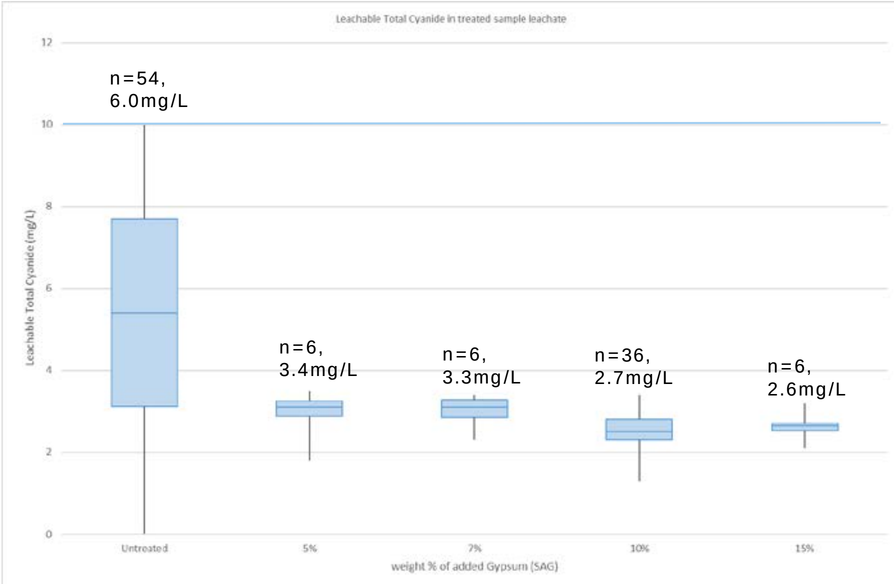
EPA Information Requirement	Hydro Comment
	The same effect is observed to Total Cyanide, noting the data presented is for Total Cyanide as required under the CCO, not WAD or Free Cyanide. 
ACTION (2a): Hydro be requested to provide the following information.	
1. An analysis and discussion of the pH and buffering capacity of the leachate, and why the formation of acidic leachates will be prevented by using gypsum to treat the waste material.	Refer to the response to 1(b)

EPA Information Requirement	Hydro Comment
ACTION (2b): Hydro be requested to provide the following information.	
1. An analysis and discussion of potential long term changes within the containment cell.	As the containment cell is designed as dry entombment, changes in the containment cell as a consequence of introducing gypsum are expected to be negligible. In the event that water enters the cell, the mixing of gypsum with waste will allow solubilisation of ions and the formation of fluorite as described in the report. Fluorite is a precipitate and may form crystals within the waste. It is possible that precipitation may occur within the leachate collection system. Should this occur, the containment cell is designed to facilitate backflushing with water or acidic solutions to dissolve precipitates and remove these from the system. All leachate extracted following cell closure, is taken off site for treatment by a waste contractor.
ACTION (2c): Hydro be requested to provide the following information.	
1. An analysis and discussion of the fate of sulfate ions generated by the reaction of gypsum with fluoride, including over project relevant timeframes.	As the containment cell is designed for dry entombment, sulphate ions are expected to stay in the solid gypsum form. As described in the response at 1(b), where water is present sulphate ions are expected to form sodium sulphate (Na_2SO_4) which is neutral.
ACTION (3a): Hydro be requested to provide the following information.	
1. An analysis and discussion of the results obtained and used to determine the application rate of gypsum. The discussion should demonstrate the sample sizes are appropriate to evaluate the observed variability with each test, and to ensure fluoride capture will be predictable, efficient and sufficient at the selected application rate.	Statistical analysis is commonly used in characterising stockpiles. Characterisation of the Capped Waste Stockpile was completed by sampling at six locations to the full depth of waste (approximately 12 m). Approximately 10 samples from each core were selected from varying materials and analysed. Statistics were then used as described in Procedure B of the NSW EPA *Sampling Design Guidelines*, to determine if the number of samples meets a sufficient number to characterise a stockpile based on the mean and standard deviation of the data set. Table 2-1 of the report documents the data and demonstrates that sufficient samples have been collected to characterise the stockpile. Based on the collection of data from the full depth of the waste and the results of the analysis, it is concluded that the waste characteristics have been adequately determined. Testing was undertaken in accordance with the test method requirements outlined in the Chemical Control Order. Substantial information on the types of waste placed in the Capped Waste Stockpile is available in site records. The primary waste contributing to leachable F concentration is known to be the first cut spent potlining, which is estimated to comprise 35000T of the 240000T stockpile. For further information refer to response 1(f).

EPA Information Requirement	Hydro Comment
ACTION (3b): Hydro be requested to provide the following information.	
1. An analysis and discussion of the selection of the gypsum application rate, in particular to demonstrate the chosen rate is the most appropriate for the project.	As described in the report, an initial application rate of 10% was applied for the purpose of testing performance of gypsum in reducing leachable F^-. This application rate performed well and a range of application rates were then tested to assess performance under different applications and identify the optimum application. The chosen application rate incorporated a safety factor of three fold to allow for variability in the wastes. The application rate chosen of 10% added weight was also an easily calculated mass to apply during the project. It was also noted that increasing the amount of gypsum did not realise proportionally any difference to the 10% application rate. Additionally, whilst arguments could be made in support of 5 and 7%, as they both met the CCO requirement and had less associated environmental and financial cost, 10% was adopted to reflect advice from the EPA to adopt a treatment rate with a suitable factor of safety.
ACTION (3c): Hydro be requested to provide the following information.	
1. An analysis and discussion of the methods and strategies that will be required to ensure the method of treatment is suitable for all potential materials to go into the containment cell. The analysis should also consider materials that are significantly different to those used in the treatment verification testing (current) reports, and how these would be identified and managed eg. how an appropriate gypsum application rate would be determined (if appropriate).	The proposed application of gypsum as described in the report is for materials within the Capped Waste Stockpile only. As outlined in the EIS, any other materials proposed for disposal in the containment cell will be tested for leachable F and leachable CN. Where these do not meet the CCO requirements or the waste classification criteria for solid waste, a separate application for these materials will be made to the EPA. A register of wastes and contaminated soils is being kept for the site. At present there are no wastes proposed to be included in the cell other than soils from remediation areas, demolition materials that are unable to be recycled or reused, and the Capped Waste Stockpile. All soils from remediation areas are separately classified in accordance with the NSWEPA Guidelines for classifying wastes. This approach allows for each waste proposed for disposal to the cell to be independently evaluated. Hydro has maximised the reuse of wastes by seeking expressions of interest from the market and reusing wastes wherever opportunity in the market exists both domestically and internationally. Of the total waste expected to be generated at the site following demolition and remediation, approximately 40% by volume will be recycled. This includes smelter by-products and inert demolition products such as ferrous and non-ferrous scrap metal and concrete and brick.
ACTION (4a): Hydro be requested to clarify why the sample amount has been halved to 0.5kg for treatment testing purposes.	The volume was adjusted to accommodate the vessel size used by the laboratory in the analysis. This modification to the testing procedure described is not considered to affect the results and this is confirmed by the relative uniformity in the data set.

EPA Information Requirement	Hydro Comment
ACTION (5a): Hydro be advised of the following.	
1. A detailed contingency plan will be required to manage any unexpected finds associated with the project. The contingency plan should be included as a part of the Project Environmental Management Plan.	Agreed. Hydro has committed to the preparation of such plans in the EIS and the RAP.
ACTION (6): Hydro be advised of the following.	
1. Detailed environmental management plans, such as an asbestos management plan, and air quality management plan (or similar), will be required to be developed and implemented to ensure that during the remediation project asbestos emissions are prevented or minimised to the maximum extent practicable.	Agreed. Hydro has committed to the preparation of such plans in the EIS.
ACTION (7a): Hydro be advised of the following.	
1. Project environmental management strategies and plans will be required to address any potential for material incompatibility during placement or within the containment cell.	Agreed. Hydro has committed to the preparation of such plans in the EIS.
ACTION (7b): Hydro be advised of the following.	
1. Project environmental management strategies and plans will be required address any potential risks associated with the generation of flammable gas, and the appropriate placement of waste.	Agreed. Hydro has committed to the preparation of such plans in the EIS.
ACTION (7b): Hydro be requested to provide the following information.	
An analysis and discussion of how other aluminium smelter waste will be identified, assessed and managed.	Hydro maintains a comprehensive waste register for all materials at the site. The waste register and the ultimate fate of all wastes at the site forms part of the auditable documentation that will be reviewed by the Site Auditor.

EPA Information Requirement	Hydro Comment
ACTION (8a): Hydro be advised of the following.	
Hydro will be required to prepare detailed design specifications and a validation plan for the construction of the containment cell.	EPA has been provided a copy of the Detailed Design. The design is currently being revised to accommodate gypsum application and will be provided in the Response to Submissions Report and separately to the EPA. The Validation Plan is the Construction Quality Assurance, Appendix I of the Detailed Design Report.
ACTION (8b): Hydro be requested to provide the following information.	
Further detailed information on the suitability of the HDPE membrane, including its chemical resistance - including to unlikely but potential scenarios, and expected design life.	Details on the HDPE liner design life and chemical resistance has previously been provided to the EPA as part of the Containment Cell Detailed Design Report. Extensive testing of the HDPE liner including leachate immersion has been completed and is reported in the GHD Detailed Cell Design Report. An update of this report is currently being prepared and will be submitted with the Response to Submissions shortly and separately to the EPA

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A Roberts	David Barrett		David Barrett		19/10/2017
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