1 Graphite and Graphene

1.1 Graphite

1.1.1 What is graphite?

Graphite is a naturally occurring mineral form of carbon. It differs from other naturally occurring forms of carbon (e.g. diamond), due to its two-dimensional, honeycomb molecular structure. This structure gives graphite useful properties such as being:

- soft and malleable
- excellent conductor of electricity and heat
- self-lubricating
- chemically resistant

1.1.2 What is graphite used for?

Traditionally graphite was used in the steel industry as a liner for crucibles and to increase the carbon content of steel. Due to its high electrical conductivity it is also used in batteries and electrodes. Its layered chemical structure means it can be used as a lubricant in situations where wet lubricants are not appropriate.

Graphite is a critical component in the production of lithium ion batteries and with the development of battery technology, demand for ultra-pure graphite is expected to grow.

1.2 Graphene

1.2.1 What is graphene and how does it differ from graphite?

Graphene is the individual layers of carbon lattice which make up graphite. Graphene has several useful properties including strength, efficient heat and electricity conduction and strong magnetism. Once successfully commercialised, graphene could be extremely valuable, being used for advanced electronics, energy storage, ultra-filtration and biological engineering.

1.2.2 What is graphene used for?

Due to its high conductivity graphene is used in electrodes and batteries. It is also used as a composite material to increase strength and electrical or thermal conductivity (Segal, 2009).

2 General Operations

2.1 What are the key parameters of the Campoona project?

Total Ore Movement:	140,000 tpa
Concentrate Production:	10,000 tpa
Product Grade:	>98.5% total graphitic carbon
Indicative Revenue:	$430M over 16 year mine life

2.2 Key Mining Questions

2.2.1 How often will mining occur and for how long?

Due to the small scale of this facility mining will occur in batches (or campaigns).

During small-scale start-up (years 0-3) there will be one short campaign for less than one month using an excavator and truck.

During full scale operation (years 4- 16) campaigns will run for 3-4 months during spring and/or autumn. Mining will only occur during daylight hours.

2.2.2 Will blasting be required and what will be the surrounding impacts?

This is a small scale mine that will require modest blasting. Blasting is not expected to be required until 60 m below the ground surface meaning pit walls will act as a buffer for any fly rock. Due to the small volumes involved, the distances to nearest receptors and communities and the depth when blasting is predicted to occur, no significant impacts are predicted from vibration, noise, or fly-rock.

2.2.3 Will dust be a problem?

Mining is not expected to occur during summer and winter so the project will not affect local air quality for half of the year. Due to the small scale of the mining operations, the distances to nearest receptors and communities and the mitigation and monitoring actions committed to, even worst case scenario modelling has suggested that no significant impacts are predicted during the short periods when mining occurs (see 2.2.1 above).

2.2.4 Where will the waste rock go?

Waste rock will be stored in two Waste Rock Storage Facilities (WRSF) to the east and west of the open pit mine at Campoona Shaft. The WRSF have been designed to allow progressive rehabilitation.

2.2.5 Will the pit be filled in with waste rock or will it fill with water after mining is complete?

The mine pit will not be backfilled due to environmental and cost reasons and may accumulate some water following rainfall events and this is expected to evaporate during warm/dry periods.

2.2.6 What will the rest of the area look like when the mine is finished?

The proposed mining lease will be relinquished back to the State Government once the closure criteria have been demonstrated as achieved. The mine closure plan is a dynamic document which will be adjusted throughout the life of the mine in accordance with statutory requirements, stakeholder expectations and success of progressive rehabilitation. The community will have input into the mine closure plan.

As a minimum, the objectives of the closure plan are:

- Ensure vegetation is resilient and aligned with final land use objectives
- Make the site physically safe post-mining
- Ensure site does not pose a geochemical risk to humans or the environment over a long-term

2.3 Key Processing Questions

2.3.1 How big is the processing plant?

The Sugarloaf processing and tailings lease will encompass 499ha. The processing plant will take up a small proportion of this area.

2.3.2 What processing has to occur to make a saleable product?

After crushing and milling, the ore will go through a series of steps to produce a high grade form of graphite. The steps are as follows:

Flotation	Roughing flotation units recover the majority of the graphite Scavenger flotation recovers further graphite from the rougher tailings Concentrate goes through another multi stage cleaning flotation process to further remove gangue.
Thickening	Concentrate and tailings are thickened so that recovered water can be recycled
Leaching	Concentrate is treated with weak HF to further remove gangue and increase recovery of graphite
Drying	Concentrate is washed in a centrifuge before a dryer to remove remaining water content
Bagging	Graphite is stored in silos for bagging and transport

2.3.3 What do the other graphite producers do to process their ores?

Kookaburra Gully (SA) and McIntosh Flake Graphite Project (QLD) are proposing to use flotation to separate graphite from the ore.

Several companies in Canada (e.g. Focus Graphite at Lac Knife) use hydroelectric power to power thermal treatment processes to produce high grade graphite. Obviously this is not an option for us.

2.3.4 Focus Graphite are proposing a thermal process to upgrade their product from the Lac Knife project. Why doesn't Pirie Resources use the same process?

Thermal processes require large amounts of energy and power. It has been determined that thermal processing is considerably more expensive than the chemical process to obtain natural graphite and is not considered feasible at Sugarloaf.

2.3.5 What are the tailings made up of?

Tailings solids are made up of mainly quartz and clay (composition breakdown can be seen in table 1). Tailings will be pumped as a slurry with a liquid concentration of around 50%.

There will be a very small amount of hydrocarbons in the tailings (13.4ppm), but at these low concentrations and due to their lack of solubility, no impacts are predicted.

Table 1: Tailings Mineral Composition Appendix M, P11

Mineral identified	*Concentration (% by mass)*
Clay mineral	< 1
Kandite group	20
Mica	9
Serpentine	8
K feldspar	4
Alpha quartz	52
Dolomite – ankerite	< 1
Alunite group	< 1
Goethite	1
Graphite	4

2.3.6 How toxic are the tailings?

Appropriate treatment of tailings will ensure that they are non-toxic. Treatment of possible contaminants is outlined below:

Hydrocarbons: Small quantities of kerosene and diesel are added during processing but are below detection levels in tailings solids.

Flotation reagents: Are absorbed by the graphite and carried through to the concentrate.

Hydrofluoric Acid: HF is neutralised with limestone or lime resulting in a non-toxic, insoluable material called Fluorspar in the TSF. Fluorospar is a common naturally occurring geological mineral on Eyre Peninsula.

2.3.7 Will the tailings contaminate the groundwater?

It is unlikely that any tailings seepage will reach or have detrimental effects to the groundwater due to the following reasons:

- Tailings have low permeability (from 5 × 10-8 to 4 × 10-9 ms-1) providing a barrier from seepage into the underlying natural soils

- The composition of natural soils indicate that once compacted, they will also have low permeability
- Little groundwater has been encountered at Sugarloaf and groundwater salinity is naturally high
- As outlined in question 2.3.6, any excess water in the tailings is not toxic and will have no detrimental effects on groundwater quality.

2.3.8 What airborne emissions are there from the processing plant?

Atmospheric emissions are treated via industry standard filters and scrubbers and all emissions will meet the air quality policy legislated concentrations. Monitoring will be installed and reported upon to confirm this is the case.

2.4 Key Infrastructure Questions

2.4.1 How many trucks will there be on the road?

During the small-scale start-up operation, a 1,000 tonne process stockpile will be developed at Sugarloaf. The process stockpile will be topped up one day per week requiring approximately 4 trips on that one day.

As production ramps to full scale the number of truck trips between the proposed ML and MPL (Sugarloaf) could range as follows (assuming 40 tonnes per truck):

- Approximately 5 per day (B-double) for 70,000 tpa capacity.
- Average 10 per day (B-double) for 140,000 tpa capacity.

2.4.2 Who will maintain the road between the mine at Campoona and processing plant at Sugarloaf?

Pirie Resources will cover their fair share of the mine related maintenance costs of this road.

Ongoing maintenance requirements of the road network will be under agreement with the DC Cleve.

2.4.3 The Campoona Road runs right next to the edge of the pit; will the road be closed when blasting occurs?

For safety reasons it is expected that there will be temporary road closures during blasting activity and up to 20 minutes before and after. However, blasting is not expected to be required until the latter stages of the project when mining occurs below 60m in depth.

2.5 Key External/Community Questions

2.5.1 Why are the mine and process plants in different locations?

There are several graphite deposits in the region, all of which are quite small so it makes sense to locate one processing plant that can service these mines into the future.

2.5.2 What happens if Pirie Resources goes bankrupt and doesn't have enough money to manage mine closure?

This is a situation at every mine, and most governments have a contingency plan. In South Australia, the Mining Act requires a bond to be made available by the mine owner for the appropriate closure of the site.

2.5.3 Why doesn't Pirie Resources ship the ore to China for processing?

It is more profitable to upgrade the graphite by a small percentage at the mine site and sell a refined product at an elevated price than allow another company to do this. In addition, Pirie Resources wants to value add in Australia to employ local people and provide maximum benefits to Australia.

2.5.4 Will Pirie Resources compensate me if the value of my property is impacted?

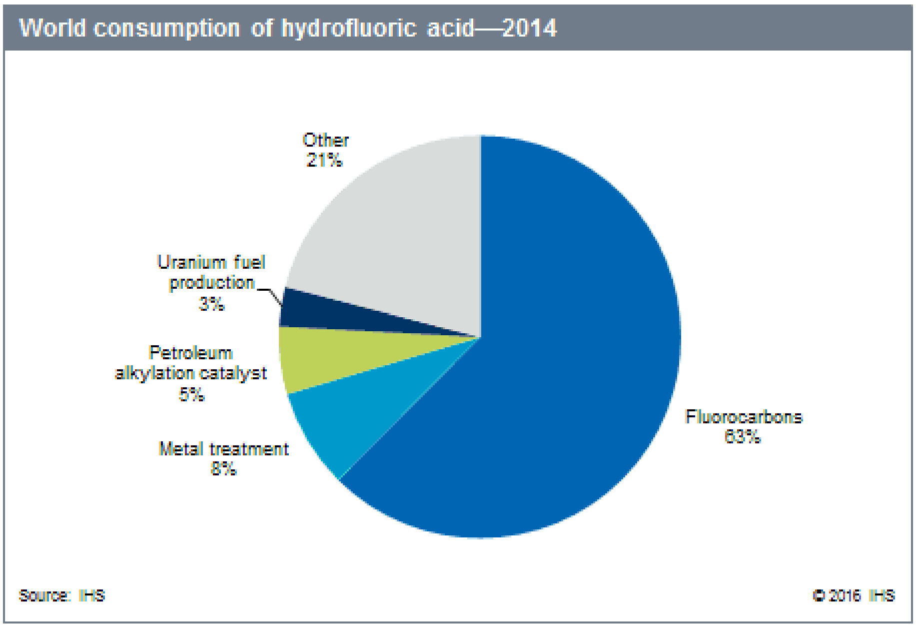
There is no evidence that the operation of Campoona will do anything other than increase the local economy and indirectly improve local land values. Should any landowner believe their property value would be decreased by Campoona then they should contact Pirie Resources to discuss the matter.

3 Hydrofluoric Acid (HF)

3.1 What is Hydrofluoric Acid?

Hydrofluoric Acid (HF) is a solution of hydrogen fluoride and water. Solution concentrations can range from 1% up to 70% and can be used for aluminium smelting, metal refining, polishing of glass, treatment of metals and fertiliser production (National Occupational Health and Safety Commission, 1989).

Pirie Resources plans to transport HF at 49% and use a solution of 8% for purification of graphite.



3.2 HF for Processing

3.2.1 Why do you need to use HF in processing graphite?

HF is used to separate graphite from impurities, in particular silica. In the process known as leaching, the concentrate is immersed in acid causing it to dissolve and separate from impurities. Other acids such as hydrochloric or sulphuric acids are also used in leaching processes but in this case are not appropriate as they are unable to dissolve silica effectively.

3.2.2 What alternative are there for processing graphite?

Pirie Resources has investigated alternatives to using HF for graphite purification. For example:

- Thermal purification uses high heat to separate the HF from impurities. High energy requirements are the main constraint for this process.
- Using Sodium Hydroxide is a similar process to using HF but has been found to be much less efficient.

3.2.3 What are the by-products of HF neutralisation?

HF is readily neutralised with limestone or lime before being sent and stored in the tailings storage facility. The neutralisation reaction produces calcium fluoride which is an insoluble and nonhazardous salt called Fluorspar (Honeywell, 2014).

3.3 Safety

3.3.1 What protections will there be to ensure workers and others at the plant will be safe from the effects of HF?

Good processing plant design, training, personal protective equipment and monitoring will ensure the safety of workers. This is a requirement of the Work Health and Safety Act.

In accordance with the Work Health and Safety Act, Pirie Resources will ensure the safety of its staff, contractors and visitors of the Campoona Graphite Project through safety inductions, personal protective equipment and safe work procedures etc..

3.3.2 Will HF emissions from the processing plant affect my crops and stock?

Emission modelling has demonstrated that emission concentrations will be below safety limits and legislative requirements, thus crops and stock will not be affected.

3.4 Transport

3.4.1 Why is HF transported at 49%?

Transporting HF at lower concentrations is more stable. Concentrations above 70% must be stored in pressure vessels, as it has a low boiling point, which is very costly. The industry has adopted a standard 49% for transport and there is extensive legislation around this.

3.4.2 Where will Pirie Resources be getting the HF from?

Pirie Resources, like any other user, will go to the market to purchase HF when required. Major suppliers include Honeywell and DuPont.

3.4.2.1 How many trucks of HF will there be each week?

69 tonnes of HF will be required per week; therefore, 3 to 4 trucks of HF will be required each week.

3.4.3 What protections are there to ensure HF will be transported safely?

As with many hazardous materials that are moved around Australia and the world every day, the transport is heavily regulated. In Australia, HF is controlled under the Australian Dangerous Goods Code for transport by road or rail. This code covers the packaging, storage and general handling procedures that must be complied with. All transport would be coordinated and communicated with the appropriate transport and emergency response authorities.

3.4.4 What will happen if there is an accident or a spill during HF transport?

We have all seen emergency response unit in action on TV following an accident or a spill of a potentially hazardous material. The same would apply for HF. A spill will be neutralised with appropriate source of alkali. Limestone is recommended since reaction rate is limited and the resulting salt is contained as insoluble and non-toxic calcium fluoride.