1 RISK MATRIX ASSOCIATED WITH THE BESS TECHNOLOGY ALTERNATIVES

The BESS battery alternative technologies considered for the proposed BESS **were** as follows:

1. Li-ion (lithium ion) Battery Technology
2. Vanadium Redox Flow Battery Technology
3. Zinc-hybrid (Zinc-Bromine (ZNBR)) Flow Battery Technology

Although Li-ion technology is currently the most widely used and assessed battery storage technology available, all three battery technologies **were** assessed so as not to limit the developer in the future should the technology of certain battery types advance.

Each battery technology has potential risks associated with the battery technology type. The Table below outlines the technology associated with each battery as well as the capability to mitigate the risk, based on practical and applicable technology solutions.

TABLE 1: Risks and Design Mitigation Measures associated with each Battery Technology.

Risk	Mitigation
Li-ion battery technology	
Temperature fluctuations Temperature fluctuations in the Kimberley area (minimum temperatures of below 0°C and maximum temperatures of over 25°C) mean that the batteries may be at risk of being damaged due to instability of temperatures. Resultant impacts could include fire, or permanent structural damage to the batteries.	The design of the Li-ion system includes: ▪ Insulated containers ▪ High powered HVAC (Heating, Ventilation and Air-Conditioning) System, monitored centrally ▪ Multiple temperature sensors for both the cells and air temperature ▪ Automated shut down mechanism if temperatures get too high ▪ Containers sealed and douse in case of fire to prevent the spread ▪ Battery management system to prevent overuse and maintain good battery condition
Fire and dangerous chemicals The volatility of the battery system, prior to any mitigation, could result in significant fire danger. In addition to this, there is a risk associated with the chemicals contained within the actual battery storage system itself.	The design of the Li-ion system includes: ▪ Fire detection and suppressant systems ▪ Gas level monitoring for several different gases (related to degradation of the batteries that increases risk of fire) ▪ Heat sensors ▪ Battery condition monitoring ▪ Dousing mechanism for emergency cooling and fire suppression ▪ Density limits in the containers ▪ Spacing limits between containers
Vanadium redox flow battery technology	
Dangerous chemicals and gases Due to the use of aqueous electrolytes, the fire risk of VRFB systems is much lower than with other technologies. Overcharging the battery does not lead to fire but to a reduction in battery performance and aging of the stacks. Thermal runaway as with lithium-ion batteries is excluded.	The design of the VRFBs includes: ▪ Battery condition monitoring ▪ Fire detection and suppressant systems ▪ Leak detection and monitoring system ▪ A secondary containment to prevent the escape of vanadium solution into the environment during operation (storage and refilling when required). The VRFBs

In addition to its corrosive character, the vanadium electrolyte solution is classified as toxic and hazardous to groundwater. The electrolyte is used in a closed system and vanadium can escape solely through electrolyte leaks. In spite of the measures described above, there will always be a small amount of hydrogen produced during charging at high states of charge, which is a safety risk due to the possible explosive reaction with atmospheric oxygen. The amount is extremely small, but must be taken into account when installing the battery.	will be placed within a 2.5 m high berm wall. ▪ Hydrogen gas is discharged from the negative tank into the environment through a simple pipe and the battery room or container is well ventilated and flushed with fresh air to prevent any build-up of hydrogen gas. ▪ A Major Hazards Risk Assessment must be undertaken prior to construction (should VRFBs be used), and the recommendations of the assessment implemented.
Zinc-hybrid (zinc-bromine) flow battery technology	
Bromine is a highly toxic material through inhalation and absorption. Maintaining a stable amine complex with the bromine is key to system safety. In addition, repeated plating of metals in general is difficult due to the formation of “rough” surfaces (dendrite formation) that can puncture the separator.	The design of the ZNBRs includes: ▪ Active cooling systems are provided by system manufacturers to maintain stability of the bromine-amine complex when ambient temperatures may exceed 95°F. ▪ Special cell design and operating modes (pulsed discharge during charge) are required to achieve uniform plating and reliable operation.

Based on the appropriate design mitigation measures outlined above, the risks associated with each Battery technology can be adequately mitigated