4 QUANTITATIVE RISK ASSESSMENT

4.1 Safety, health, environment and quality policy

Rand Carbide is committed to delivering quality products to all their customers, quality of health to their employees and an environment that is sustained through best practice.

Rand Carbide is furthermore committed to complying with all Health, Safety and Environmental legislation, as well as all other requirements as stipulated by the Villar Mir Group.

Rand Carbide strives to continuously improve their product quality, environmental aspects and the safety and health of all their employees. In order to achieve this, Rand Carbide is committed to:

- Setting a framework for establishing safety, health, environmental and quality objectives and targets;
- Endeavouring to not only prevent pollution, but also reduce, recycle and re-use waste;
- Briefing all employees on the SHEQ (Safety, Health, Environmental and Quality management) Policy Statement;
- Auditing all SHEQ management systems on a regular basis to determine compliance and implement corrective actions where necessary, which will ensure compliance to international standards, ISO (International Organisation for Standardisation) 9001, ISO 14001 and OHSAS (Occupational Health and Safety Advisory Services) 18001; and
- Mitigating, managing and (where practical) eliminating risks, hazards or related aspects which may impact negatively on employees, the community or the environment.

4.2 Objectives and strategies

4.2.1 General objectives

- **Compliance with the Department of Water Affairs' water management hierarchy for resource protection** as this forms the foundation of the authority's approach to water management. It is essential to be able to demonstrate that pollution prevention, water reuse / reclamation and water treatment principles have been considered and optimally applied.
- **Compliance with all legislation** including:
  - NEMA;
  - NEM:BA;
  - NEM:WA;
  - NEM:AQA;
  - NWA; and
  - OHSA.
- **Life-cycle approach** to ensure a holistic view is taken over the life cycle of a facility and that integrated water and waste management addresses all these phases.
- **Cradle-to-grave principle** to ensure the facility retains responsibility for all its waste streams and their consequential impacts, even when they have left the facility boundaries.
- **Precautionary principle** that uses appropriate and accepted techniques to anticipate all potential impacts.
- **Consideration of temporal variability of water quality and quantity.** Integrated water and waste management must make use of accepted techniques that are capable of qualitatively and quantitatively defining water quality and quantity variations and their impact on surface and groundwater systems, currently and in the future.

- **Risk-based approach** in which the facility applies appropriate risk assessment techniques to quantify the potential current and long-term risks associated with its practices or activities and then applies appropriate management actions to minimise or mitigate the potentially significant risks.
- **Reclamation of materials** that severely impacts the environment and/or a high reclamation value.
- **Protection of the environment,** specifically water resources and public health. Reduction of potential environmental and other liabilities due to impacts on the receiving water resources due to seepage/releases/discharges. Containment of water contaminated by its operations; lining of storage facilities to prevent seepage and adequate design capacity to contain storm events.
- **Water conservation** principles based on the scarcity of water as a valuable resource in South Africa. Water use should be effective, and this can be achieved through the minimisation of evaporative, seepage and overflow losses as well as evaluating alternative process technologies, which consume less water. The consumption of municipal water should be limited to processes requiring such good quality water and water requirements that cannot be supplied within the network; to reduce cost and maximise reuse of internal water sources.

4.2.2 Rand Carbide specific objectives and strategies

Objective 1: Prevent/minimise contamination of the groundwater resource by removing major surface contamination sources.

Strategy 1:
- Raw material storage is not considered a major pollution source impacting on groundwater.
- As the plant is extensively covered with cement and concrete foundations, it is not considered a major pollution source that can impact on groundwater quality.
- The major surface contamination source impacting on groundwater quality is identified as the historical waste dump.
- No waste is disposed of on the Rand Carbide site or onto the historic dump.
- All waste currently generated on the site is recycled or removed off site for disposal.
- The dump has been reprocessed since 2005 (reclamation).
- The reprocessing will continue for approximately another 10 years.
- Waste is sorted and separated where after it is recycled, reprocessed (EMB plant) or removed for off-site disposal.
- After the entire dump has been reprocessed, the footprint will be rehabilitated.

Objective 2: Prevent/minimise contamination of the surface water resources by containing potentially contaminated water on the site for reuse. Refer to storm water management plan (Etek, 2011)

Strategy 2:
- **Diversion & discharge of clean water:** Build diversion berms to prevent clean water from entering the Rand Carbide site and potentially becoming contaminated. Refer to storm water management plan (Etek, 2011). An additional berm is required on the southern boundary to prevent clean water from the area of the school finding its way onto the Rand Carbide site and potentially becoming contaminated, thereby increasing the volumes of water to be managed by Rand Carbide. The water will then be diverted around the Rand Carbide site's potential contamination sources (on the eastern side) with existing structures and will discharge to the municipal storm water infrastructure (located along the old Middelburg road), which will in turn replenish the surface water resources (Olifants River).

- **Containment of process spillages:** Rand Carbide does have bunds within their plant area to contain spillages in areas of high pollution potential. All bunded areas should be equipped with a sump-and-pump system to allow any spillages to be returned to its origin. Storage areas with pollution potential are also bunded.
- **Capture and contain contaminated storm water:** All areas containing Rand Carbide infrastructure, facilities and operations are considered dirty areas. Any rainfall on these areas and surface water runoff from these areas can therefore be potentially contaminated and may therefore not be fit for release and needs to be captured and contained. Existing infrastructure (drains, pipes etc) for capturing will be upgraded and maintained. Additional infrastructure will be established to divert the potentially contaminated storm water from the plant area to a containment facility (pollution control dam) which will be built. The storm water containment dam (pollution control dam) will be 19 986 m^3 to contain the 1:50 year daily flood event from the plant and stockpile area with a bottom width of 63m and a depth of 4m. A 0.8m freeboard should be maintained at all times to allow capacity for the 1:50 year storm event.

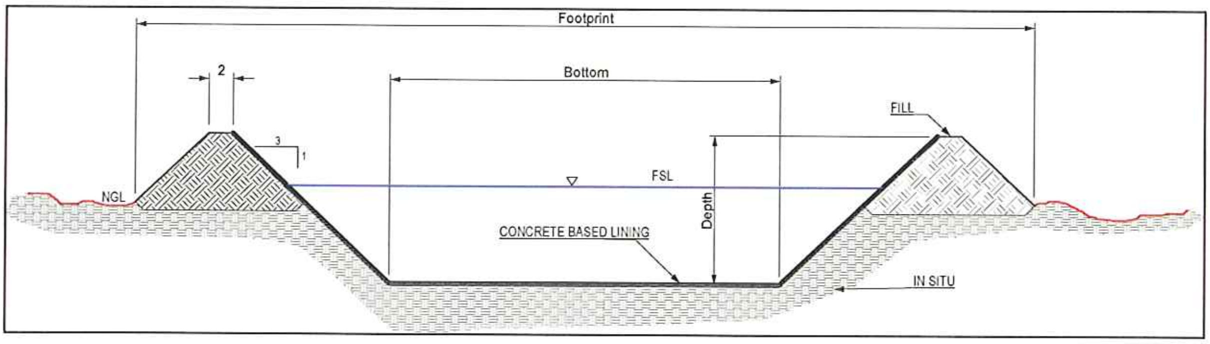

Figure 4-1: Storm water containment dam (Etek, 2011)

- **Reuse contained storm water:** Water contained in the storm water dam (pollution control dam) will be used for process purposes, specifically dust suppression, to reduce the amount of municipal water required on the site (water conservation). Provision for the transfer of at least 9m^3/hour (equivalent of maximum monthly inflow of 7 082m^3/month) from the storm water containment dam (pollution control dam) to the plant should be made to provide for peak demand periods.
- **Sediment traps:** The Rand Carbide site has a high amount of fine particles on the site. These particles will be carried with the storm water runoff to the containment dam. To ensure the containment dam remains free of silt that will reduce its holding capacity, sediment traps will be required. Two (2) sediment traps are proposed to provide for desilting (cleaning) of one trap while the other is used. The volume is the maximum of the average monthly flow converted to a daily volume. The overflow from the sediment traps will be conveyed to the storm water containment dam (pollution control dam). Sediment traps will be 9m wide and 1.5m deep with 1V:2H side slopes and a capacity of 229m^3. Access for cleaning purposes should be considered and addressed during detailed design.
- **Reuse spring water:** Some springs are evident on the Rand Carbide site. Due to the location of these springs in the plant area (underneath furnace buildings), these are contaminated and the water is therefore not fit for release into the environment. Rand Carbide should use the contaminated spring water for dust suppression rather than discharging it into the storm water management system and importing municipal water for dust suppression purposes (water reclamation).

Objective 3: Monitor effectiveness of management measures implemented (refer to Section 7).

Strategy 3:
- Monitor the eleven (11) boreholes on the Rand Carbide property six-monthly.
- Monitor the spring off-site as well as the three (3) springs on site.
- Monitor surface water and storm water on the property as well as any discharges.

4.3 Key performance areas and indicators

4.3.1 Monitor reclamation of materials from historic waste dump

Waste from the historic heterogeneous, hazardous, unlined waste dump located on the property is sorted, separated, reprocessed and disposed of off-site. Due to the mixed (heterogeneous) and possible hazardous nature of materials historically disposed on the site as well as the fact that the dump was never lined, the dump poses a risk for environmental pollution. No waste currently generated on the site is disposed at the facility and all waste generated is either reprocessed, reused/recycled or disposed of off-site. The throughput of material through the EMB plant should be monitored to ensure the material is reprocessed and removed from site at an acceptable rate in order to have the dump removed and area rehabilitated within the next 8 – 10 years. Rand Carbide should keep record of all materials removed from the historic waste dump, all materials removed off site for disposal (include destination) or recycling as well as material reprocessed and used.

4.3.2 Monitor water quantity

Water usage (volumes) should be monitored (through the installation of flow meters) so as to ensure efficient water use. All water taken from the municipal water supply line should be accounted for. Water used from the municipal water supply should be minimised to reduce cost and make this water available to other users (domestic users). Water already contaminated by Rand Carbide's operations, such as storm water and spring water, should be used in preference to municipal water. Rand Carbide should establish and maintain (update) a water balance for the site. Refer to Sections 6 & 7.

4.3.3 Monitor water quality

Water utilised for potable and process use as well as waste water that get discharged must be monitored to ensure compliance with both environmental legislation (NEMA, 1998) as well as applicable municipal by-laws and to prevent any human health risk. Groundwater quality should be monitored to refine and update the groundwater model. Groundwater quality should further be monitored to establish groundwater pollution levels and movement of the contamination plume to allow management actions to be taken in cases where pollution reach unacceptable levels or move beyond the site boundary. Refer to Section 7.

4.4 Methodology followed

The significance of the environmental impacts identified will be assessed in terms of their:

- duration
- extent
- probability
- severity

The above will be used to determine the significance of an impact without any mitigation, as well as with mitigation.

Table 4-1: Environmental risk and impact assessment criteria

DURATION		
Short term	6 months	1
Construction	36 months	2
Life of project	29 years	3
Post rehabilitation	Time for re-establishment of natural systems	4
Residual	Beyond the project life	5
EXTENT		
Site specific	Site of the proposed development	1
Local	Farms and surrounding farms	2
District	Nkangala district	3
Regional	Region	4
Provincial	Mpumalanga Province	5
National	Republic of South Africa	6
International	Beyond RSA borders	7
PROBABILITY		
Almost Certain	100% probability of occurrence – is expected to occur	5
Likely	99% - 60% probability of occurrence – will probably occur in most circumstances	4
Possible	59% - 16% chance of occurrence – might occur at some time	3
Unlikely	15% - 6% probability of occurrence – could occur at some time	2
Rare	<5% probability of occurrence – may occur in exceptional circumstances	1
SEVERITY		
Catastrophic (critical)	Total change in area of direct impact, relocation not an option, death, toxic release off-site with detrimental effects, huge financial loss	5
Major (High)	> 50% change in area of direct impact, relocation required and possible, extensive injuries, long term loss in capabilities, off-site release with no detrimental effects, major financial implications	4
Moderate (medium)	20 – 49% change, medium term loss in capabilities, rehabilitation / restoration / treatment required, on-site release with outside assistance, high financial impact	3
Minor	10 – 19% change, short term impact that can be absorbed, on-site release, immediate contained, medium financial implications	2
Insignificant (low)	< 10 % change in the area of impact, low financial implications, localised impact, a small percentage of population	1

RISK ESTIMATION (Nel 2002)					
	SEVERITY				
PROBABILITY	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)
Almost certain (5)	H	H	**E**	**E**	**E**
Likely (4)	M	H	H	**E**	**E**
Possible (3)	L	M	H	**E**	**E**
Unlikely (2)	L	L	M	H	**E**
Rare (1)	L	L	M	H	H

E	Extreme risk – immediate action required, detail considerations required in planning by specialists – alternatives to be considered	4
H	High risk – specific management plans required by specialists in planning process to determine if risk can be reduced by design and management and auditing plans in planning process, taking into consideration capacity, capabilities and desirability – if cannot, alternatives to be considered, senior management responsibility	3
M	Moderate risk – management and monitoring plans required with responsibilities outlined for implementation, middle management responsibility	2
L	Low risk – management as part of routine requirements	1

IMPACT SIGNIFICANCE	
Negligible	The impact is non-existent or insubstantial, is of no or little importance to any stakeholder and can be ignored.
Low	The impact is limited in extent, even if the intensity is major; whatever its probability of occurrence, the impact will not have a significant impact considered in relation to the bigger picture; no major material effect on decisions and is unlikely to require management intervention bearing significant costs.
Moderate	The impact is significant to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and management intervention will be required.
High	The impact could render development options controversial or the entire project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in project decision-making.
Very high	Usually applies to potential benefits arising from projects.

4.5 Potential impacts on the environment

4.5.1 Groundwater contamination potential from leaching of hazardous elements

Aquifer vulnerability: The primary aquifer type present at Rand Carbide is a laterally extensive weathered zone aquifer. This aquifer will display unconfined to semi-unconfined piezometric conditions and may as a result, potentially be highly susceptible to surface induced activities and impacts.

Although weathered zone aquifers are normally highly vulnerable to surface induced impacts, no severe impacts could be delineated within the weathered zone aquifers at Rand Carbide. The vulnerability of the aquifer with regards to contamination thereof resulting from a surface induced source indicates a low aquifer vulnerability (JMA, 2012).

A low level groundwater protection is required based on the GQM Index.

Surface sources with potential risk:

- The plant area is extensively covered with cement and concrete foundations and therefore not considered a major pollution source.
- The majority of the raw material stockpiles are located directly on the surface.
- The historic waste dump is not lined and has been disposed of directly on top of the land surface. The dump contains a mixture of materials (heterogeneous), some of which are considered hazardous.

Leaching: If materials stored on site and sediments within containment or evaporation ponds contain hazardous elements, these elements could leach from the materials and could lead to contamination of the underlying and surrounding soil and/or underlying groundwater aquifer.

Leachability of raw materials: A large number of raw materials are stored on site (refer to Figure 2-5) and can potentially contaminate soil and groundwater. Therefore, these materials were evaluated at potential sources of pollution. All these materials were sampled and analysed (distilled water leaching, XRD & XRF) by JMA Consulting (Pty) Ltd in 2011 to determine their pollution potential risk to the groundwater environment. Twenty (20) different raw material samples were collected (December 2011) and the mineralogy and elemental composition was determined through XRD (X-ray diffraction) and XRF (X-ray fluorescence) as well as distilled water leach extract analysis. *Raw materials were found to not generate leachate with adverse qualities as a result of precipitation coming into contact with the raw materials as they are stockpiled.*

Identified risk: The only source which poses a leaching risk is the historic waste dump which contains hazardous materials and was never lined. The dump is currently being processed.

4.5.2 Surface runoff contamination potential

Runoff from the Rand Carbide site can potentially become contaminated due to its contact with Rand Carbide infrastructure, facilities, operations, activities and pollution sources. Contaminated runoff from the site could impact the surrounding environment and should therefore be captured and contained. A storm water management plan has therefore been put in place (Etek, 2011) and will be implemented over the next 5 years.

4.6 Significance of potential impacts

4.6.1 Leaching from raw materials impacting on groundwater

Negligible significance because:

- Raw materials were found to not generate leachate with adverse qualities as a result of precipitation coming into contact with the raw materials as they are stockpiled.
- Current groundwater qualities show no impact from raw material stockpiling.
- Aquifer has low vulnerability and requires low level protection.

Duration:	Extent:	Probability:	Severity:	Significance:
Life of project (3)	Site specific (1)	Rare (1)	Insignificant (1)	Negligible

4.6.2 Leaching from historic waste dump impacting on groundwater

The historic waste dump poses a leaching risk because it contains hazardous materials and was never lined.

Significance without management: A significant residual impact, if nothing is done. The extent is site specific as boreholes on the Rand Carbide site show signs of contamination (RCG-B4) but the contamination has not moved beyond the site boundaries to a level where it poses a risk. The probability of an impact is certain as it has been proven through monitoring of boreholes. Due to the major severity of the impact, Rand Carbide had to put management measures in place.

Duration:	Extent:	Probability:	Severity:	Significance:
Residual (5)	Site specific (1)	Almost certain (5)	Major (4)	Moderate

Although no significant groundwater contamination plume could be delineated, it is suspected that the slightly elevated SO_4 (and probably Ca) concentrations observed in the groundwater is related to contamination from one or more of the delineated surface contamination sources. The major contamination source is identified as the historical waste dump.

Management:
- Groundwater monitoring programme (refer to Section 7).
- Update of groundwater model
- Reprocessing of dump

Significance with management: With management which entails reprocessing, the waste materials and dump will be removed and the significance will reduce to low or negligible if contaminated footprint is also removed and the area is properly rehabilitated.

Duration:	Extent:	Probability:	Severity:	Significance:
Life of project (3)	Site specific (1)	Almost certain (5)	Minor (2)	Low / negligible

After rehabilitation: After 100 years (effectively 2026), all the potential pollution sources are deemed to have been completely removed and rehabilitated and the simulated pollution plume will decrease significantly after 10 years and is almost absent after 20 years. Based on the simulated results, it is deemed that removal and rehabilitation of the historical waste dump along with good housekeeping practices may be viewed as an effective groundwater management measure at Rand Carbide and will need to be continually verified during future groundwater monitoring.

4.6.3 Surface water contamination due to Rand Carbide infrastructure, facilities, operations and activities

Significance without management: The activities, operations, facilities and infrastructure on the site of Rand Carbide can potentially cause any rainwater on the site as well as any municipal water intake to become contaminated due to the industrial nature of the activities and the hazardous nature of materials used and produced. This includes dust from the historical waste dump. If not captured and contained, this contaminated water can enter the municipal storm water system and end up in the surface water resources (Olifants River).

Duration:	Extent:	Probability:	Severity:	Significance:
Life of project (3)	District (3)	Almost certain (5)	Moderate (3)	Moderate

Significance with current management: Rand Carbide has existing infrastructure to capture contaminated storm water. Captured storm water is contained in Harry's dam, an unlined earth dam or discharged into the veldt on the property. No contaminated storm water is discharged from the site.

Duration:	Extent:	Probability:	Severity:	Significance:
Life of project (3)	Site specific (1)	Almost certain (5)	Minor (2)	Low

Significance with planned management (Etek storm water management plan, 2011): The upgrade of storm water management infrastructure and the containment of contaminated storm water in an appropriately designed and lined storm water dam as well as the reuse of the contained water in the process will, improve storm water management on the site significantly.

Duration:	Extent:	Probability:	Severity:	Significance:
Life of project (3)	Site specific (1)	Possible (3)	Unlikely (1)	Negligible

4.7 Risks

4.7.1 Risks to human health

Groundwater protection required: A low level groundwater protection is required based on the GQM Index. Only three (3) groundwater users were identified in a 500m radius of Rand Carbide since municipal water is supplied to the area.

Water supply sources: Municipal water is supplied to the area and only three (3) users were found to use groundwater (boreholes) on their property for domestic and garden purposes within a 500m radius of Rand Carbide. These boreholes were found acceptable for use.

Water used for dust suppression to minimise human health risk: Human health risk relates to the inhalation and ingestion of excess particulate matter that becomes air-borne during on-site operations if sufficient dust suppression with water is not carried out since Rand Carbide is situated in close proximity to the residential areas of Witbank/eMalahleni. Large quantities of water is therefore used on the Rand Carbide site for dust suppression

Safety and structural integrity risk: Damage may be caused to infrastructure if the water arising from the springs underneath the furnaces and B-conveyor sump is not being pumped away and used elsewhere on site (dust suppression). The spring water could weaken the structural stability and integrity of on-site infrastructure that could cause physical harm to employees. Spring water is therefore pumped out and will be used for dust suppression.

4.7.2 Risks to the environment

Current: Ineffective storm water containment and historic waste dump.

Storm water: Water originating from the site (storm water in contact with potential pollution sources and process water overflow) that is not contained but discharged into an unlined dam (Harry's dam) and veldt on the site after limited treatment (removal of oils and grease as well as settlement of solids) could cause harm to the environment.

Waste management: The historic waste dump is unlined and contains hazardous waste materials and can therefore cause harm to the environment as is evident by groundwater contamination in its vicinity (RCG-B4).

Future: Storm water management plan (Etek, 2011) and reprocessing of waste materials on historic dump should minimise any risks to the water environment from Rand Carbide operations.