7 MONITORING SYSTEMS

7.1 General

The following monitoring strategies and principles apply:

- Compile a sampling protocol for water monitoring, especially in terms of groundwater monitoring. Develop procedures (including criteria) for field measurements and sampling.
- Rainfall should be recorded on the site.
- Monitor outflows and discharges to identify water reuse options.
- Water use of different plant water users should be monitored and the data used in the water balance.
- Water reticulation diagram should indicate all water flow meters used for daily water quantity monitoring.
- Monitoring programme to include the following:
  - Meteorological data (rainfall).
  - Map with monitoring positions.
  - Monitoring frequency.
  - Monitoring parameters based on potential pollution sources, indicator contaminants and constituents of concern (depending on objectives).
  - Analyses according to approved methods (internationally accepted or SANS approved).
  - Baseline monitoring points.
  - Downstream monitoring points to determine impacts.
  - Storm water monitoring points.
  - Groundwater monitoring across the area to ensure representative monitoring and assessment of impact of all possible pollution sources.
  - Compliance monitoring points.
- Monitoring positions should be split into categories indicating the reason for their sampling, for example compliance monitoring, impact monitoring, environmental monitoring etc.
- Quantifiable objectives and performance indicators must be developed for each category above, based on applicable standards and on-site/downstream requirements. Monthly performance reviews of the monitoring results should be performed.
- Establish an operating and maintenance programme for the water monitoring system. Ensure that instrumentation such as water flow meters are maintained and regularly calibrated to ensure accurate measurements. Additional water flow meters are required. Introduce preventative maintenance and regular inspections to ensure effective operation of the monitoring system.
- Data management system (one database) for all water quantity and quality data, which should be made available to all relevant parties requiring access. This will also allow for quick action when errors do occur (re-analysing of samples, corrective action, investigations or management measures).
- Quality control and assurance measures should be implemented to verify results and ensure data reliability. Include duplicate sampling, standards, blanks, cation-anion balances etc.
- Develop non-compliance reporting structure and contingency measures.
- Review or audit and revise monitoring system annually and ensure compliance with any licence conditions, including any licences to be applied for and issued in future. This means reassessing objectives of monitoring, the location of monitoring points, the frequency of sampling, the parameters analysed, the procedures, quality control measures, data management and reporting.

7.2 Water monitoring

Water monitoring is a legal requirement and generates baseline and background data, identifies pollution sources, determines the extent of pollution, monitors water usage by different plant water users (cost control), can be used to calibrate and verify prediction and assessment models (to plan for closure and make financial provision), helps with identification of water reuse opportunities, can assist with identification of appropriate water treatment technology, helps with the control of unit processes (water-and-salt balances), determines and evaluates the success of implemented management measures, and assesses compliance (with standards and legislation) and the impact on the receiving water environment.

To ensure that the data collected through the water monitoring system is reliable and appropriate, the following is required:

- **Consultation** with interested and affected parties (I&APs) to address their concerns, specifically downstream users to assess the risk of water pollution and its associated impact.
- Clear definition of objectives of **management actions** that drive the monitoring programme.
- A detailed **design** of a water monitoring system, which specifies location of monitoring points (map), data to be collected (flow, variables, frequency), data collection procedure (sampling protocol), management (database, storage, assessment) and reporting.
- **Audit** to ensure implementation is according to detailed design and that the objectives are achieved.
- Data that represents the actual situation by covering the area in sufficient detail and using procedures that will provide **representative** data.
- An **operating and maintenance programme** to ensure the water monitoring system functions properly.
- A **data management system**, which is accessible to all relevant users and ensures that data is used optimally.
- **Quality control and assurance measures** to ensure reliable and verifiable data.

7.2.1 Groundwater monitoring

Monitoring points: Rand Carbide has eight (8) existing monitoring boreholes spread across the site (see Figure 7-1 & Table 7-1; BH1 – BH6; lab borehole & UST borehole). As the plant area and some other areas are not covered in sufficient detail to determine potential pollution sources, impacts, extent of pollution etc, an additional five (5) monitoring boreholes were drilled in 2011 (see Figure 7-1 & Table 7-1; BH7 – BH11).

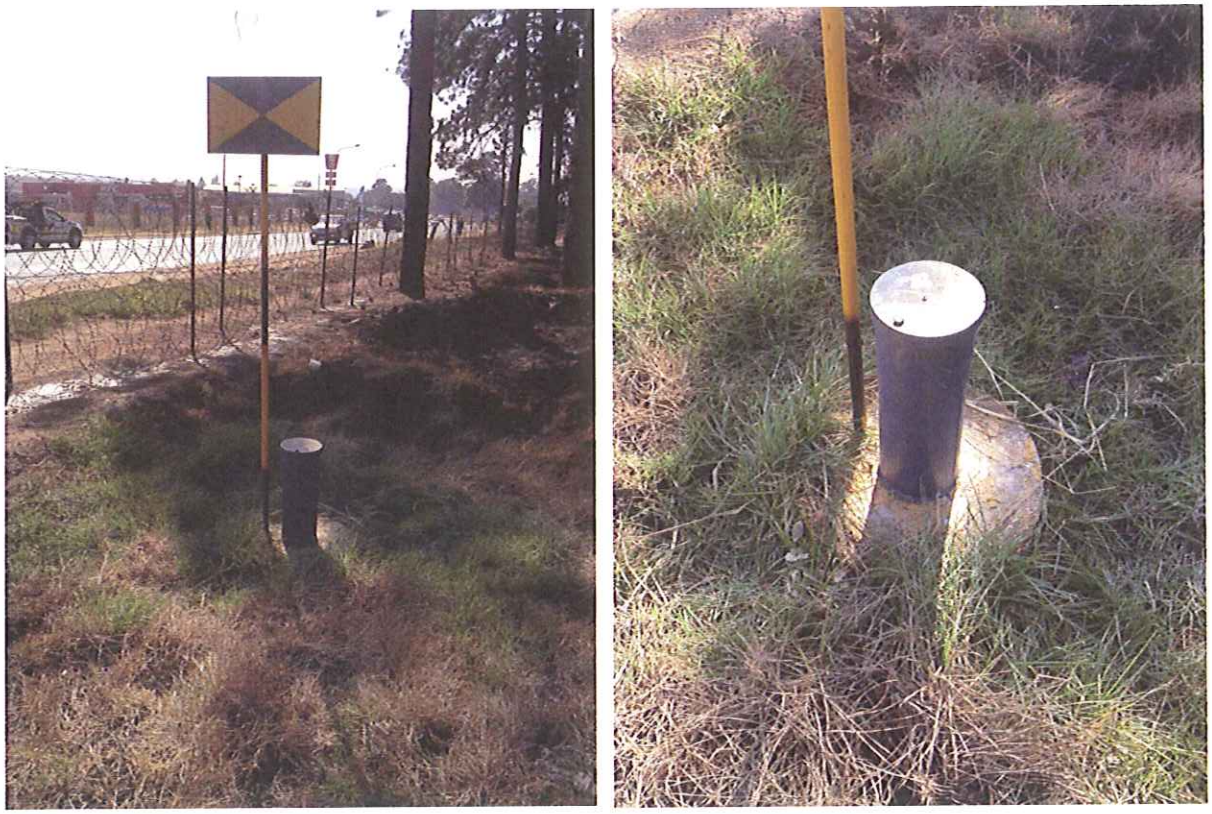

Plate 8-1: Example of a monitoring borehole

Monitoring frequency: Boreholes are generally monitored three (3) times a year. Monitoring frequency will be increased to quarterly to represent the four (4) seasons.

Monitoring parameters:

Physical:	pH
	Electrical Conductivity (EC) in mS/m
	Oxidation-Reduction Potential (ORP)
	Water level (metres below ground level)
Major cations:	Calcium (Ca)
	Magnesium (Mg)
	Sodium (Na)
	Potassium (K)
Major anions:	Nitrate (NO_3 as N)
	Sulphate (SO_4)
	Chloride (Cl)
	Fluoride (F)
Organics:	Hydrocarbons (HC)
Other:	Total Dissolved Solids (TDS)
	Alkalinity (Alk as $CaCO_3$)
	Acidity
	Iron (Fe)
	Aluminium (Al)
	Manganese (Mn)
	Barium (Ba)

Zircon (Zr)
Silica (Si)
Zinc (Zn)
Lead (Pb)
Cobalt (Co)
Copper (Cu)
Nickel (Ni)

The following parameters are currently also being monitored:
Chromium (Cr), Mercury (Hg), Arsenic (As), Cadmium (Cd), Vanadium (V), Silver (Ag), Phenolic compounds.

Table 7-1 below provides a summary of monitoring points, localities, purpose of monitoring, frequency of monitoring (six-monthly), sampling depth and parameters analysed at Rand Carbide.

Table 7-1: Groundwater monitoring points

Monitoring point	Locality & collar elevation:	Purpose:	Sampling depth (mbgl):	Parameters:
Existing monitoring points (drilled in 1989):				
Lab	25°52.547' S 29°13.514' E	Reference borehole		**Frequency of sampling:** Six-monthly **Physical:** pH; EC; ORP; water level **Major cations:** Ca; Mg; Na; K **Major anions:** NO_3 & NO_2; SO_4; Cl; F **Organics:** HC **Other:** TDS; Alk; Fe; Al; Mn; Ba; Sr; Zr; Si; Zn; Pb; Co; Cu, Ni
BH UST	Proximity to diesel and petrol UST	Monitoring containment of hydrocarbons in UST.		
BH 1	25° 51.864' S 29° 13.862' E 1 597.18 mamsl	South of waste dump; on perimeter (school); upstream of waste dump (no impact).	20	
BH 2 blocked	25° 51.707' S 29° 13.905' E 1 567.73 mamsl	North east of waste dump; impact of waste dump. Monitor spread of potential pollution plume towards residential areas.	18	
BH 3	25° 51.743' S 29° 13.799' E 1 576.18 mamsl	North west of waste dump; south of Harry's dam.	18	
BH 4	25° 51.709' S 29° 13.769' E 1 572 mamsl	North of Harry's dam; impact of Harry's dam.	20	
BH 5	25° 51.623' S 29° 13.864' E 1 556.25 mamsl	South of Komatsu. Monitor potential pollution plume from Rand Carbide towards north.	30	
BH 6	25° 51.601' S 29° 13.953' E 1 551.27 mamsl	East of Komatsu. North east corner of site (OR Tambo road). Lowest point on site.	12	
New monitoring points: (drilled November 2011 to intersect shallow weathered zone aquifer)				
BH 7 Artesian 0.2l/s	25° 51.778' S 29° 13.656' E 1 583.11 mamsl	East of plant; north of EMB	tap	**Frequency of sampling:** Six-monthly
BH 8	25° 51.824' S 29° 13.584' E	In plant area; north of raw materials	10	

Monitoring point	Locality & collar elevation:	Purpose:	Sampling depth (mbgl):	Parameters:
	1 585.43 mamsl	stockpiles		**Physical:** pH; EC; ORP; water level **Major cations:** Ca; Mg; Na; K; NH_4 **Major anions:** NO_3 & NO_2; SO_4; Cl; F **Organics:** HC **Other:** TDS; Alk; Fe; Al; Mn; Ba; Sr; Zr; Si; Zn; Pb; Co; Cu; Ni; Cr
BH 9	25° 51.751'S 29° 14.009' E 1 572.92 mamsl	Perimeter (monitor potential pollution plume moving off site); raw materials in eastern section of site	15	
BH 10	25° 51.664' S 29° 13.587' E 1 573.93 mamsl	North of plant.	25	
BH 11	25° 51.557'S 29° 13.730'E 1 562.75 mamsl	Northern perimeter – Middelburg road; monitor potential pollution plume moving off site	26	

Red indicates additional/new/recommended monitoring

7.2.2 Surface water monitoring

Monitoring points: Rand Carbide has three (3) existing surface monitoring points (see Table 7-2). The surface water monitoring was extended by adding another seven (7) points (see Table 7-2).

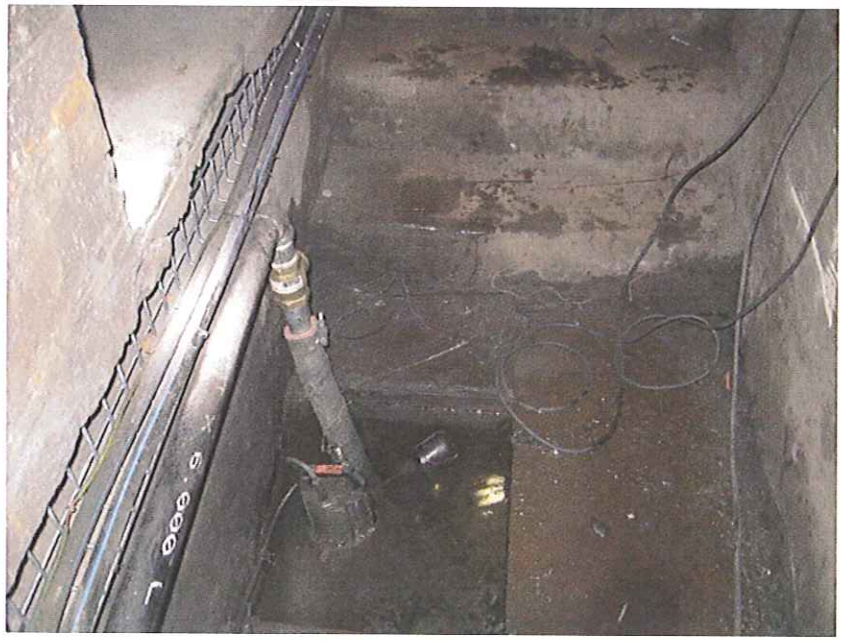

Plate 8-2: Example of surface water monitoring point: Spring water underneath Furnace E

Monitoring frequency: Points should be monitored monthly though monitoring currently takes place biannually.

Monitoring parameters:

Physical:
- pH
- Electrical Conductivity (EC) in mS/m
- Flow / volume

Major cations:	Calcium (Ca) Magnesium (Mg) Sodium (Na) Potassium (K)
Major anions:	Nitrate (NO_3 as N) Sulphate (SO_4) Chloride (Cl) Fluoride (F)
Organics:	Hydrocarbons (HC)
Other:	Total Dissolved Solids (TDS) Alkalinity (Alk as $CaCO_3$) Acidity Iron (Fe) Aluminium (Al) Manganese (Mn) Barium (Ba) Zircon (Zr) Silica (Si) Zinc (Zn) Lead (Pb) Cobalt (Co) Copper (Cu)

Table 7-1 below provides a summary of monitoring points, localities, purpose of monitoring, frequency of monitoring and parameters analysed at Rand Carbide.

Table 7-2: Surface water monitoring points

Monitoring point	Locality:	Purpose:	Frequency:	Parameters:
Spring 1	Furnace E	Reuse possibility	Monthly	**Physical:** pH; EC; flow/volume **Major cations:** Ca; Mg; Na; K; NH_4 **Major anions:** NO_3 & NO_2; SO_4; Cl; F **Organics:** HC **Other:** TDS; COD; SS; Alk; Fe; Al; Mn; Ba; Sr; Zr; Si; Zn; Pb; Co; Cu; Ni; Cr
Spring 2	Furnace F			
Spring 3	B9 conveyor sump.			
Harry's dam inlet	Inlet to dam	Storm water quality		
Harry's dam outlet	Discharge from dam.	Storm water discharges; discharges to veldt.		
Catchment sumps inlet	Inlet to sump 1	Storm water quality from plant		
Catchment sumps outlet	Outlet from sump 6	Effectiveness of sediment precipitation.		
Inlet to new Storm Water Control dam	Inlet to dam	2013; Storm water quality		
Outlet new Storm Water Control dam	Discharge from dam – only 1:50 year storm.	2013; Storm water discharge (if any)		
Washbay	At washbay	Hydrocarbon removal efficiency.		
Panorama				
Swartbos		At OR Tambo road (previously Swartbos)		

Red indicates additional/new/recommended monitoring

7.2.3 Bio-monitoring

There are no surface water bodies in close proximity to Rand Carbide and therefore no bio-monitoring is conducted.

Figure 7-1: Groundwater monitoring points (existing white; 2011 drilled - red)

7.3 Data management and reporting

Data collection: Rand Carbide does the surface water sampling. Regen Waters does the groundwater sampling according to a set programme and protocol for quality control and assurance purposes. All analyses are conducted by Regen Waters (Witbank) according to nationally (SANAS) or internationally approved methods. Regen Waters is a SANAS accredited laboratory and also conducts their own in-house quality control and assurance measures such as the following to validate their data:

- Duplicate analyses
- Blanks
- Standards
- Cation-anion balance
- Prescribed standard methods for analyses etc.

Data storage: The data from the laboratory is captured in an Excel database which has a spread sheet for each monitoring point indicating the following:

- Company name and site
- Name of monitoring point
- Frequency of monitoring (date of sampling)
- Parameters determined
- Units parameters are measured in
- SANS 241 standards / water quality objectives for the reserve
- Data from laboratory

Coordinates (locality) of monitoring points should also be included in this spread sheet in order to have all relevant information together. The coordinates of the boreholes are available and indicated on the site layout plan.

Data interpretation: Rand Carbide should do time-series graphs on specifically the main constituents of concern:

- Total Dissolved Solids (TDS) or Electrical Conductivity (EC)
- Sulphate (SO_4)
- Calcium (Ca)
- Manganese (Mn)

Rand Carbide compares these to SANS 241 guidelines currently. These parameters should be compared to the receiving/reserve water quality objectives (RWQO).

Reporting: Results should be reported and graphs presented during monthly meetings.

7.4 Waste monitoring

7.4.1 Solid process wastes

Waste materials: Material on the historic dump includes the following:

- Contaminated Ferro-silicon (40 tons/annum)
- Amorphous silica fume
- Tarry materials
- Oil soaked calcined anthracite
- Paste
- Char (80 tons/annum)
- Slag (64 tons/annum)
- Coal fines/dust (52 tons/annum)

- Aluminium (18 tons/annum)
- Silica/Quartz fines
- Char/coal fines
- Anthracite fines/dust
- Sweepings (coal dust etc.)
- Stoker refractory (large lumps)
- Stoker ash (fly ash)
- Ladle refractory
- Carbon stoker mix fines
- Refractory bricks
- Paper/wood

Analyses: Materials at EMB were independently analysed. Analyses from M&L Laboratory Services (Pty) Ltd indicated results for 5% TCLP extract of samples from the silo and cyclone crushed to -9.5mm (EPA 1311). The following metals were found to leach at detectable concentrations: Al, Mn, Fe, Zn, Pb, Co, Cu, Si, Sr, B, P, Ba, K, Mg, Ca. Refer to Appendix D for laboratory certificates.

7.5 Environmental Management System

Rand Carbide holds an ISO 14001:2004 certificate (valid until May 2014) for the manufacturing of ferrosilicon, silicon metal, electrically calcined anthracite, silica fume and Söderberg electrode paste. Please refer to Appendix A.

7.6 Recording of incidents

7.6.1 Incident investigation reports

All incidents (injuries, spillages etc.) will be recorded as per defined Safety, Health, Environment and Quality (SHEQ) standards. A standard format (incident investigation report) should be completed for each incident to allow further investigations into the matter.

The incident investigation report should contain the following information:
- Particulars and description of incident;
- The investigation panel;
- Root cause of incident;
- Corrective and preventative measures to prevent incident from recurring;
- Witness and Insured's statements;
- Photos and Work Instructions; and
- Risk assessments carried out for the tasks performed.

7.6.2 Emergency and contingency measures

Emergency and contingency plans are in place in conjunction with the necessary equipment and personnel on stand-by to manage such situations as and when necessary. Water is available for fire fighting (booster pumps) in the unfortunate event of a fire breaking out on the plant. Rand Carbide has no emergency water storage when the raw water supply from eMalahleni Municipality is interrupted for whatever reason. Operating procedures and planned maintenance systems will be established for inspection, maintenance, and to ensure effective and continuous operation and early detection of any malfunction or emergency incident.

7.7 Environmental Impact Register

Records of all the accident/incident investigations should be retained in and environmental impact register for a period of three years at the SHEQ Department.

7.8 Auditing and reporting

7.8.1 Audits and reviews

Each component within the IWWMP has an audit and performance review component associated with it. Regular review and auditing is important to ensure systems are up-to-date and still relevant for current situations. Evaluation is required to verify its appropriateness and suitability by comparing performance to objectives set. Changes or adjustments to systems are required where review/auditing highlights shortcomings or where gaps occur.

Performance should be measured against objectives.

All existing and new systems will be reviewed and modified to ensure continual improvement. An auditing programme will be established to facilitate this process. It is considered good practice to review or audit all systems at least annually. This includes monitoring programmes as discussed in this Chapter.

A checklist or procedure will also be put in place for audit purposes, which should include compliance auditing with respect to performance indicators (objectives/targets). Auditing should include physical aspects, procedural aspects (ISO or similar system), as well as behavioural (training, skills development) aspects.

An annual external audit by TUV is undertaken.

7.8.2 Reporting

Reporting is an essential component of any management system. The necessary reporting structures will be put in place to ensure that information is reported to the responsible persons, and that the necessary people (including authorities and stakeholders) are informed of any relevant water and waste (and general environmental) information. Reporting must include as a minimum, emergency situations or non-compliances, results of performance or compliance monitoring, malfunctions (operating errors, mechanical failures and/or loss of supply services), and stakeholder communication.