



**BIOMONITORING OF RIVERS
AT SIBANYE**

FACT SHEET

March 2017

Sibanye is actively involved in monitoring the health of rivers vulnerable to various land uses, including mining, within its areas of operation across South Africa.

BIOMONITORING RATIONALE

Biomonitoring involves the measuring of biological indicators to assess the condition of rivers. This includes evaluating the physical features of a river such as water quality, quantity and habitat. Biological indices are used to assign classes and categories to describe the state of the river reaches. The rationale for implementing biomonitoring to determine the state of river systems is based on differences in tolerance levels various taxonomic groups of organisms have to the physical and chemical properties of a freshwater system. Taxa will occur according to their tolerances and preferences in various water qualities, quantities and habitats.

While biomonitoring is a legal requirement of all the water use licences granted by the Department of Water and Sanitation (DWS) to our mining operations, at Sibanye it is also a means of investigating the state of rivers during high- and low-flow seasons. Multiple indicators of freshwater health are analysed to determine site-specific and catchment-based variations in species composition of aquatic organisms, as well as changes in habitat suitability, during seasonal changes in flow. Variations in water quality and quantity are assessed concurrently to aid interpretation of the results. Biomonitoring enables us to assess long-term trends and attribute changes in the environment to water quality or non-water quality related variables.

Sibanye's in-house biomonitoring model allows for legislated biannual biomonitoring as well the implementation of proactive interventions to mitigate potential impacts on the river systems and specialist input into proposed projects likely to influence freshwater systems.

Biomonitoring process



1 SITE SELECTION IS BASED ON:

- Water use being assessed
- Accessibility
- Presence of suitable sampling habitat
- Good representativity of entire river
- Availability of historical data



2 WATER QUALITY MONITORING:

- Hand-held water quality meters are used for on-site monitoring of: alkalinity, conductivity, dissolved oxygen and total dissolved solids
- Water samples are taken for laboratory analysis of salts, nutrients and metals, as per the requirements of the DWS



3 HABITAT MONITORING

- Site-specific monitoring of biotopes includes assessment of the suitability of invertebrate habitats. The biotopes monitored are:
 - stones
 - vegetation
 - gravel
 - sand
 - mud
- Reach-based assessments conducted of state of riparian and instream habitats



4 AQUATIC MACROINVERTEBRATE MONITORING

- Site-specific assessment of macro-invertebrate assemblage by sampling biotopes
- Reach-based assessment of macroinvertebrates based on site-specific data

(Macroinvertebrates are animals visible on the river bed.)

STATE OF THE RIVER SYSTEMS

As required by our water use licences, the South African Scoring System (version 5 – SASS5) is used to determine the taxonomic composition of macroinvertebrate aquatic organisms. A class can be determined per river site, based on the tolerances to water quality and habitat changes of the macroinvertebrate families found in the river systems. These classes, ranging from A to E/F, indicate the condition of the river system from pristine to severely impacted (see below). Similarly, the Macroinvertebrate Response Assessment Index (MIRAI) determines similar classes for larger catchment areas. The recently promulgated resource quality objectives for the Upper Vaal recommend that a MIRAI class D be maintained for most of the river reaches around Sibanye.

The majority of Sibanye’s river reaches satisfy the class D requirement, with the exception of the Wonderfonteinspruit at Cooke and Driefontein, and the Boschluispruit at Beatrix. The Wonderfonteinspruit has been severely impacted by excessive sewage inflows, as well as modification of the habitat to allow for mining. The poor quality of the Boschluispruit in 2016 was primarily attributed to low flows due to the drought. No resource quality objectives have been assigned to the platinum rivers at this stage.

The graphs below indicate the SASS5 results for each site (per mine and per river reach) for the high and low flow assessments in 2016. NA indicates that the site could not be assessed during that season.

Interpretation of biomonitoring classes

Class as per index	Interpretation
E/F	Critically modified
D	Largely modified
C	Moderately modified
B	Largely natural
A	Natural, unmodified

GOLD OPERATIONS

The catchments within the gold operations, which have been monitored by an in-house aquatic specialist, are affected by various land and water uses that are not limited to mining. Some comparison between systems in good and bad states are given below:

Water quality comparisons



Upper Wonderfonteinspruit

- Upstream of Sibanye’s operations, low flow assessment 2016
- Note foam and black water colour which are evidence of excessive sewage pollution



Lower Wonderfonteinspruit

- Downstream of discharges from Sibanye’s operations, low flow assessment 2016
- Note absence of foam and clear water colour

Habitat comparisons



Leeuspruit West

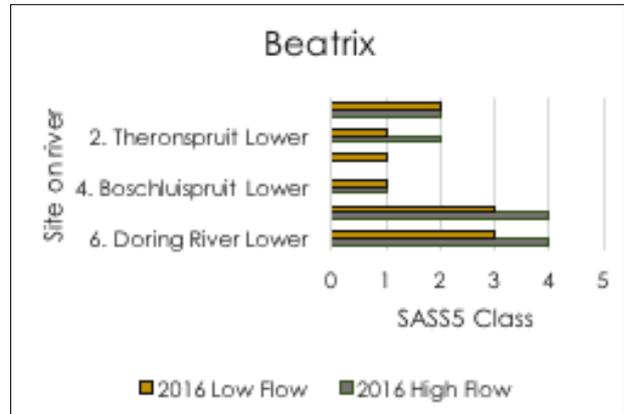
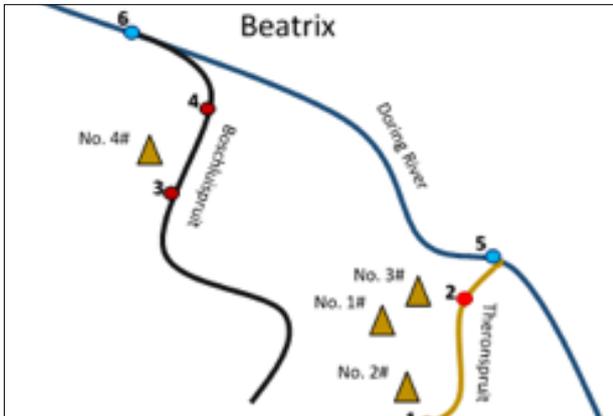
- Affected by agricultural activities, low flow assessment 2016
- Note excessive erosion and in-stream habitat destruction as a result of overgrazing



Leeuspruit West

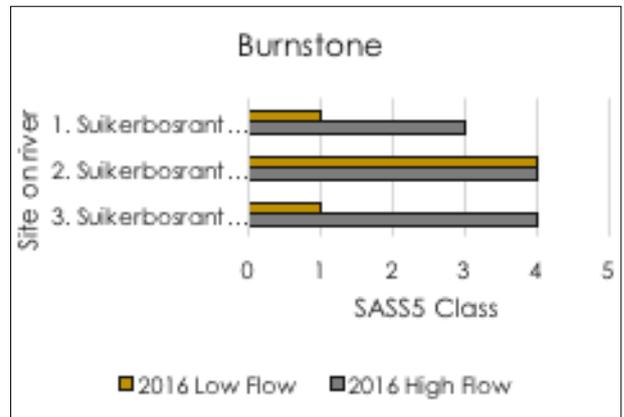
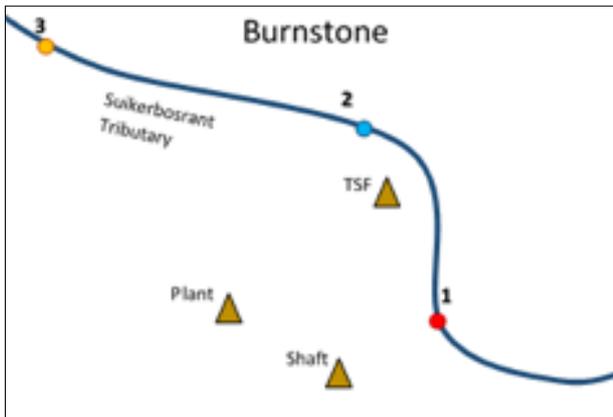
- Directly downstream of discharges from Sibanye’s operations, low flow assessment 2016
- Note good riparian and in-stream vegetation due to proper management of grazing

Beatrix



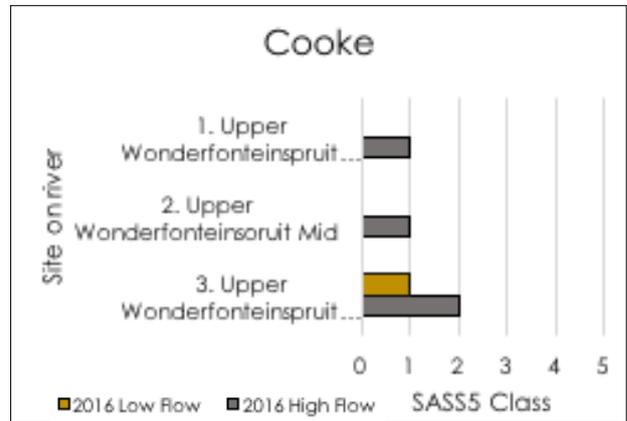
Mine	Catchment	Results	Interpretation
BEATRIX	Theronsspruit	Largely modified	<ul style="list-style-type: none"> Habitat deterioration due to farming and flooding during the low flow season
	Boschluisspruit	Critically modified	<ul style="list-style-type: none"> Upper reaches typically have very low flow Water quality and habitat impacted by mining and surrounding land-use
	Doring River	Largely natural	<ul style="list-style-type: none"> Good habitat and water quality System impacted by a flood event in the low flow season

Burnstone



Mine	Catchment	Results	Interpretation
BURNSTONE	Suikerbosrant Tributary	Moderately modified to largely natural	<ul style="list-style-type: none"> No detectable impacts from mining activities Large wetland system limits habitat availability Very low flow impacted results of low flow assessment

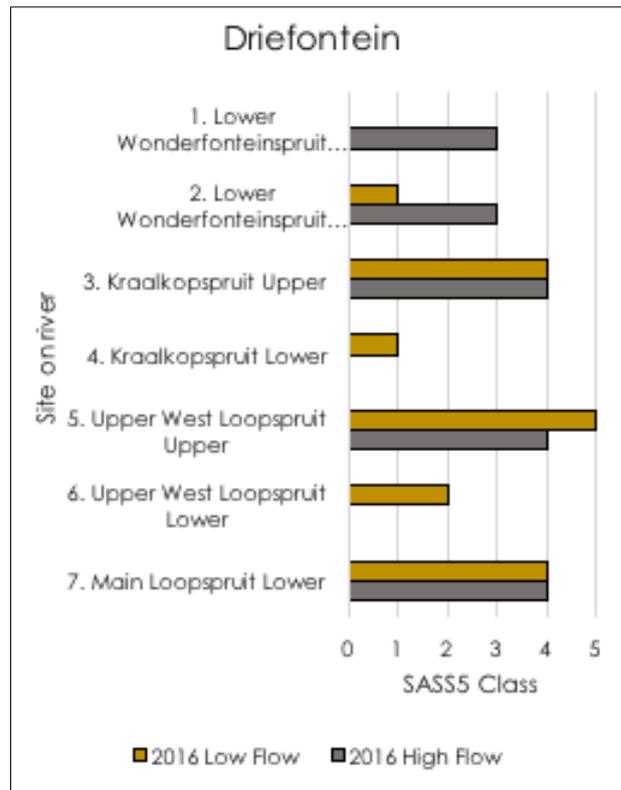
Cooke



Mine	Catchment	Results	Interpretation
COOKE	Upper Wonderfontein spruit	Critically modified	<ul style="list-style-type: none"> Water quality severely impacted by sewage Water quality also affected by mine water discharges Sampling in the uppermost reaches not possible during low flow due to excessive and toxic sewage inflow



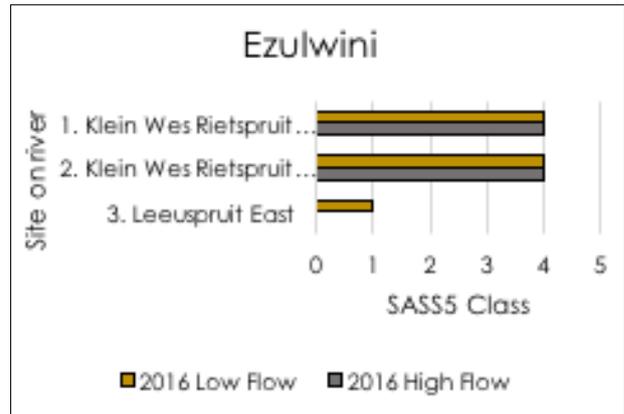
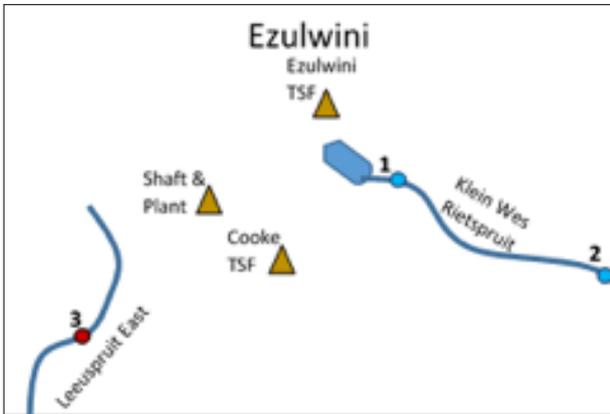
Driefontein



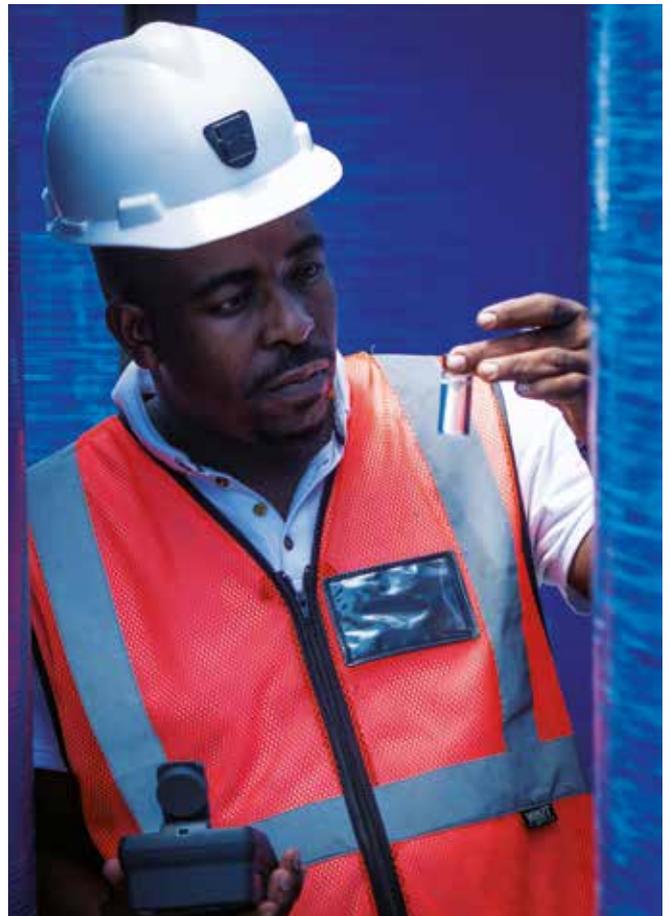
Mine	Catchment	Results	Interpretation
DRIEFONTEIN	Lower Wonderfonteinspruit	Largely modified	<ul style="list-style-type: none"> Habitat significantly impacted by the 1m Ø pipeline* and channels Change in the river's flow route during low flow caused upstream site to be dry Water quality impacted primarily by sewage inflows but also by mining discharges Habitat alterations due to overgrazing
	Kraalkopspruit	Moderately modified	<ul style="list-style-type: none"> Upstream site in largely natural condition Impacts from mining are minimal Drought affected the downstream site, reducing habitat availability and flow significantly Agricultural practices influenced water quantity and quality
	Upper West Loopspruit	Moderately modified to largely natural	<ul style="list-style-type: none"> Reference stream for Upper Vaal sites at Sibanye – not affected by mining activities Good habitat and water quality Poor results at downstream site due to very limited flow
	Main Loopspruit	Largely natural	<ul style="list-style-type: none"> Good habitat Not influenced by Driefontein mining activities

* This is a well-known historical pipeline in the Wonderfonteinspruit, installed to prevent flooding of the dolomitic areas to enable mining and reduce the risk of sinkholes in the area.

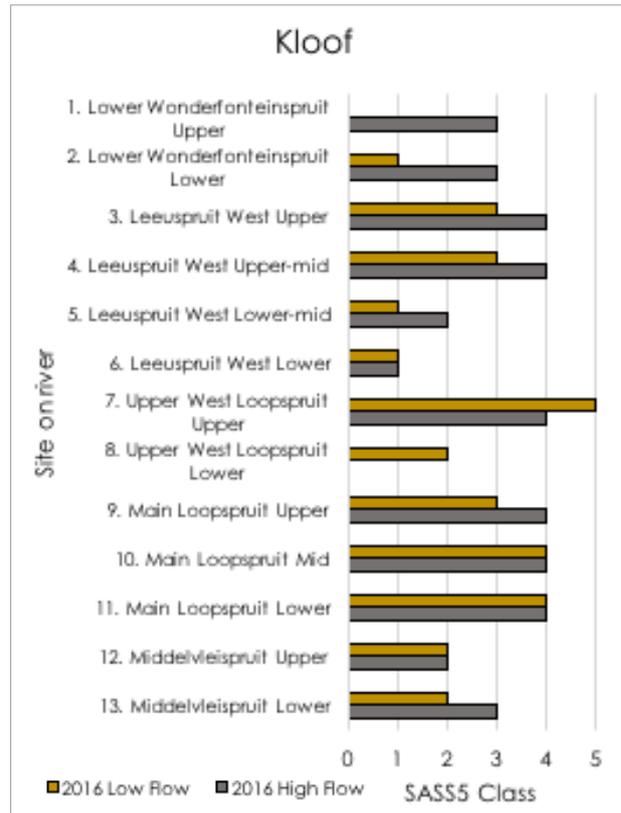
Ezulwini



Mine	Catchment	Results	Interpretation
EZULWINI	Klein Wes Rietspruit	Largely modified	<ul style="list-style-type: none"> Stream in fair condition owing to good flow resulting from underground mine water discharges Water quality impacted by mining and sewage, surrounding communities and agricultural activities
	Leeuspruit East	Critically modified	<ul style="list-style-type: none"> Stream in poor condition due to intermittent and low flows Habitat has been altered, possibly a result of illegal mining activities



Kloof

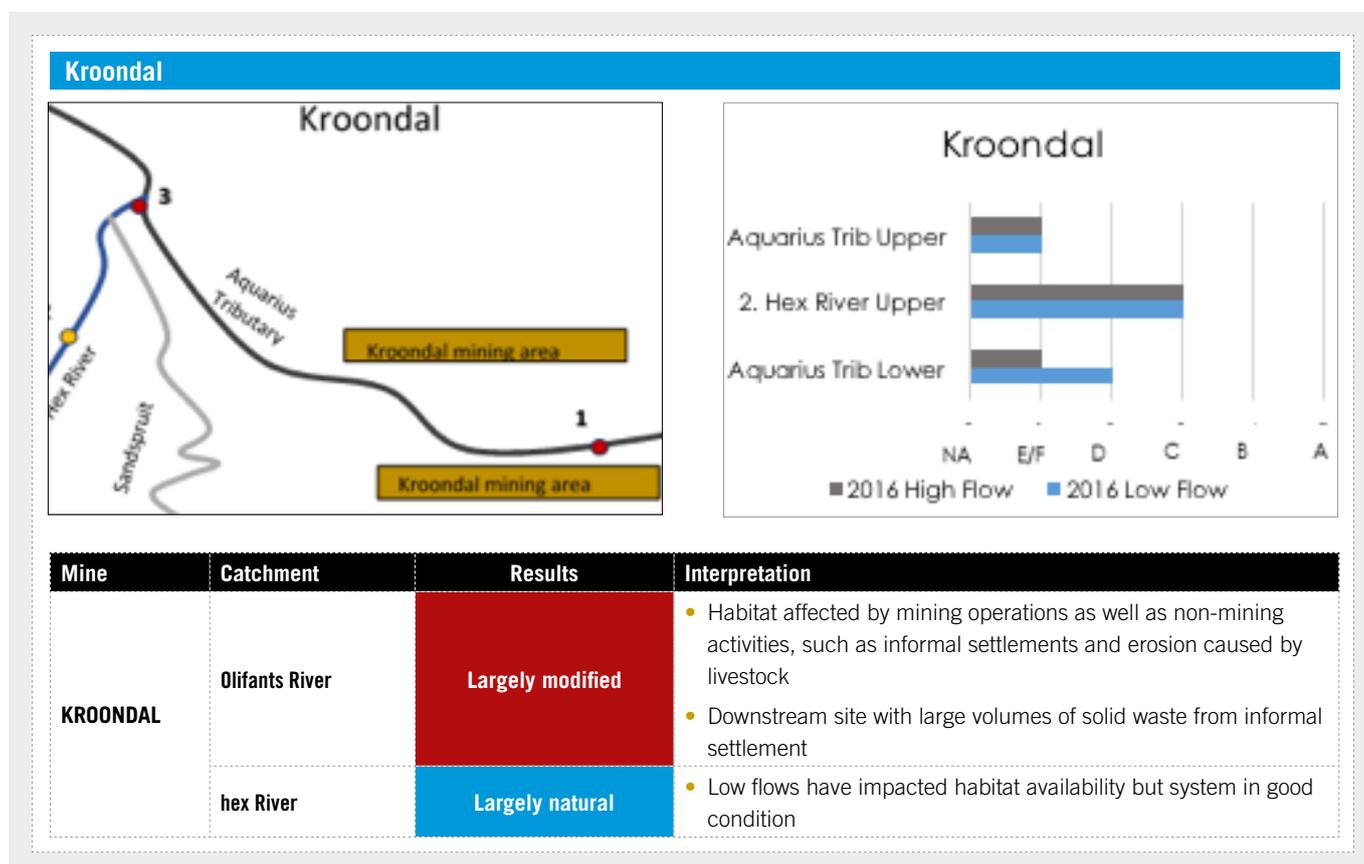
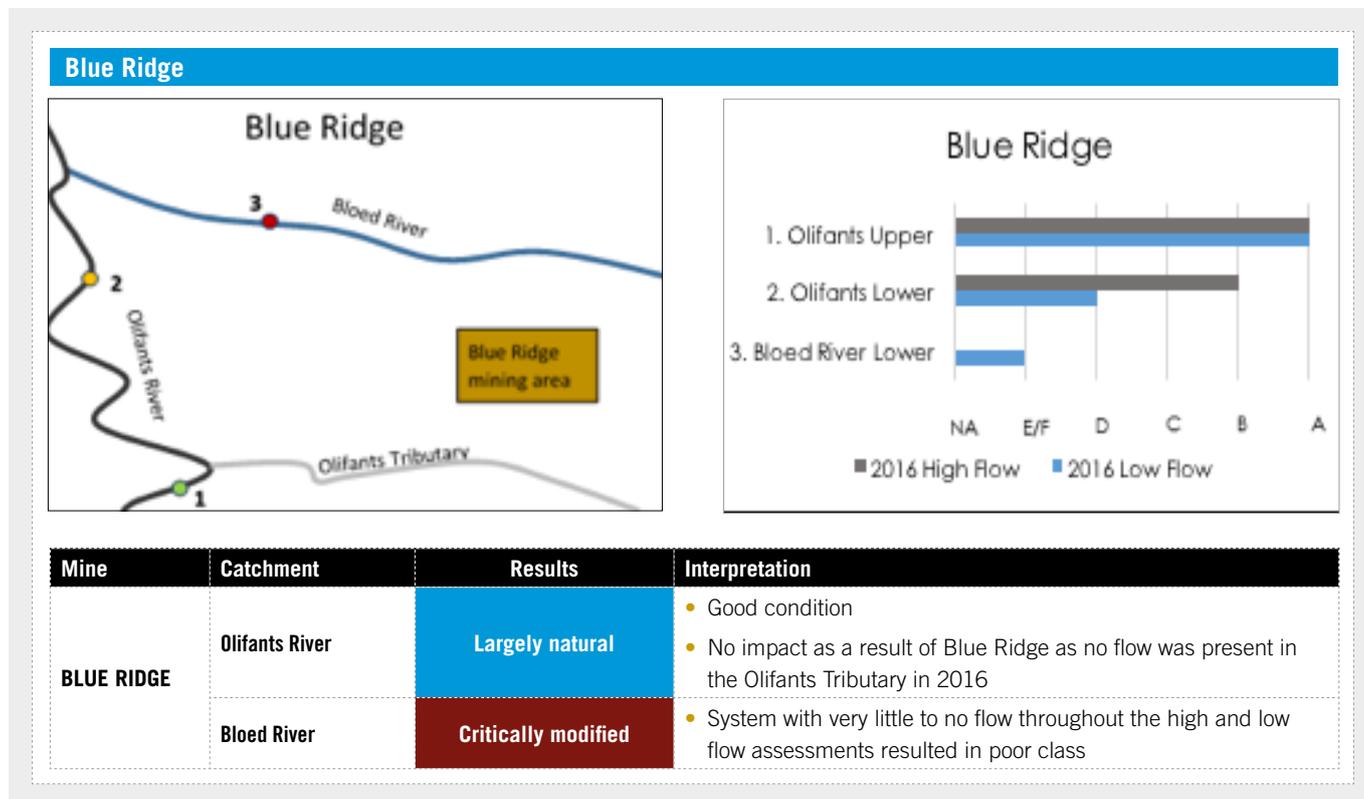


Mine	Catchment	Results	Interpretation
KLOOF	Lower Wonderfonteinspruit	Largely modified	<ul style="list-style-type: none"> Habitat significantly impacted by the 1m Ø pipeline* and channels Change in the river's flow route during low flow caused the upstream site to be dry Water quality impacted primarily by sewage inputs but also by mining discharges Habitat alterations due to overgrazing
	Leeuspruit West	Critically to moderately modified	<ul style="list-style-type: none"> Upstream sites in fairly good condition – water quality and habitat partially affected by mining and agriculture Downstream sites severely impacted by overgrazing, resulting in very poor stream condition
	Upper West Loopspruit	Moderately modified to largely natural	<ul style="list-style-type: none"> Reference stream for Upper Vaal sites at Sibanye – not influenced by mining activities Good habitat and water quality Poor results at downstream site due to very limited flow
	Main Loopspruit	Moderately modified to largely natural	<ul style="list-style-type: none"> Stream in good condition. Impacts are mainly nutrient-related as a result of mine sewage discharges and agricultural activities Some impact on habitat owing to damming and road crossings
	Middelveispruit	Largely modified	<ul style="list-style-type: none"> Poor stream condition due to altered habitat as a result of illegal mining and informal agriculture Currently, no Sibanye mining activities in catchment area, only dormant workings

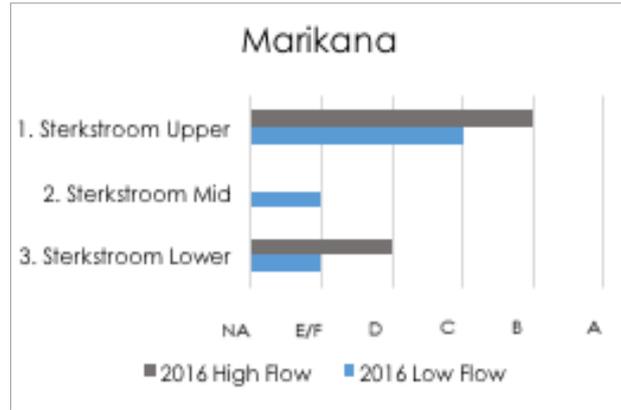
* This is a well-known historical pipeline in the Wonderfonteinspruit, installed to prevent flooding of the dolomitic areas to enable mining and reduce the risk of sinkholes in the area.

PLATINUM OPERATIONS

Biomonitoring of the rivers and waterways in and around the platinum operations will be conducted in-house from 2017. The interpretations of results presented below are based on the findings of the consultant reports appointed prior to Sibanye's taking over biomonitoring. A more comprehensive assessment of the water systems will be presented in the 2017 annual report.

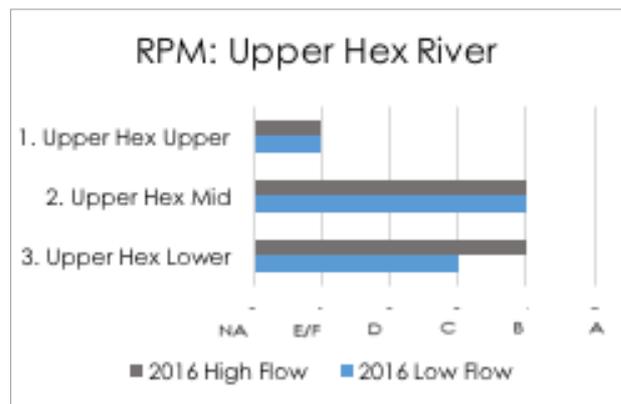


Marikana



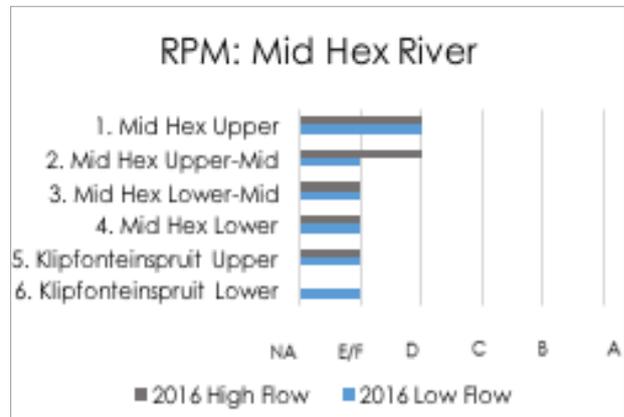
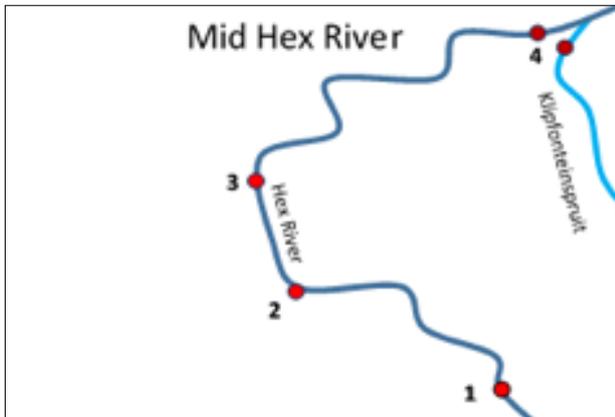
Mine	Catchment	Results	Interpretation
MARIKANA	Olifants River	Moderately modified	<ul style="list-style-type: none"> Low flows in the system were the most likely cause of the poor classes observed at site number 2 The Marikana mine is unlikely to have had an impact

Upper Hex River



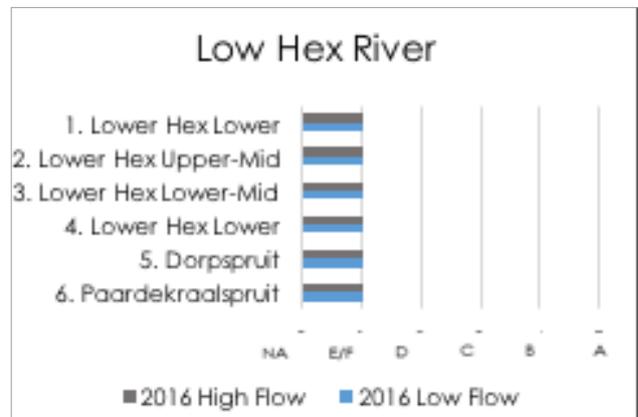
Mine	Catchment	Results	Interpretation
RUSTENBURG OPERATIONS	Upper Hex River	Largely natural	<ul style="list-style-type: none"> River in good condition Upstream site not flowing during assessments, resulting in deteriorated class

Mid Hex River



Mine	Catchment	Results	Interpretation
RUSTENBURG OPERATIONS	Mid Hex River	Largely natural	<ul style="list-style-type: none"> Poor habitat availability Water quality may be impacted by surrounding land uses including mining
	Klipfonteinspruit	Critically modified	<ul style="list-style-type: none"> Low flow and very limited habitat availability resulted in low class

Lower Hex River



Mine	Catchment	Results	Interpretation
RUSTENBURG OPERATIONS	Lower Hex River	Critically modified	<ul style="list-style-type: none"> Likely impacted by low flows, poor habitat and water quality impacts from mining and non-mining related sources.
	Dorpspruit	Critically modified	<ul style="list-style-type: none"> Attributed as the main source of deterioration in the upper reach of the Lower Hex River.
	PAARDEKRAALSPRUIT	Critically modified	<ul style="list-style-type: none"> Impacts along this stream may be as a result of mining activities but also attributed to other land use activities such as livestock and informal and formal settlements.

OPPORTUNITY FOR CATCHMENT-BASED MONITORING

As several of Sibanye's areas of operation overlap with those of local municipalities and the requirements set out in water authorisations are often similar, there is an opportunity for the sharing of costs among water users, such as municipalities among others, within the catchments related to the following monitoring requirements:

- Water quality monitoring at common points
- Biomonitoring
- Toxicity monitoring

A catchment management monitoring approach per river reach appears to also be in line with the DWS's approach, as evidenced by the recent promulgation of the resource quality objectives for the Upper Vaal. These objectives are to achieve certain qualities, quantities and ecological classes for the catchments.

Furthermore, a consolidated approach to water management will allow issues that have been identified by biomonitoring specialists and any necessary interventions in the catchment to be addressed jointly, or directed to the responsible authority, as applicable.

Such co-operative management of shared water resources and river environments may be formalised as a water user association, defined in the National Water Act, Act 36 of 1998, as operating "at a restricted localised level, and [being] in effect a co-operative association of individual water users who wish to undertake water-related activities for their mutual benefit."

Not only will such an association facilitate and benefit the ongoing management of our water resources, but future planning will improve significantly across the regions. Several municipalities surrounding our operations have approached Sibanye to initiate such mutually beneficial arrangements.