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DWS Report No: P WMA 12/T30/00/5314/13

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE MZIMVUBU WATER PROJECT

DEA REF. No 14/12/16/3/3/2/677 (Dam Construction)
14/12/16/3/3/2/678 (Electricity Generation)
14/12/16/3/3/1/1169 (Roads)

WATER QUALITY STUDY

FINAL
January 2015

WATER QUALITY STUDY FOR THE MZIMVUBU WATER PROJECT

Report Title:	***Water Quality Study***
Authors:	*Stephen van Staden (Scientific Aquatic Services)* *Dionne Crafford (Scientific Aquatic Services)*
Reviewed by:	*Dr Martin van Veelen (ILISO)*
Project name:	***Environmental Impact Assessment for the Mzimvubu Water Project***
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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE MZIMVUBU WATER PROJECT

LIST OF REPORTS

REPORT TITLE	**DWS REPORT NUMBER**
Inception Report	P WMA 12/T30/00/5314/1
Scoping Report	P WMA 12/T30/00/5314/2
Environmental Impact Assessment Report	P WMA 12/T30/00/5314/3
Environmental Management Programme	P WMA 12/T30/00/5314/14
Integrated Water Use License Application for the Mzimvubu Water Project: Technical Report	P WMA 12/T30/00/5314/4
Ntabelanga Dam borrow pits and quarry Environmental Management Plan	P WMA 12/T30/00/5314/5
Lalini Dam borrow pits and quarry Environmental Management Plan	P WMA 12/T30/00/5314/6
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Floral Impact Assessment	P WMA 12/T30/00/5314/10
Faunal Impact Assessment	P WMA 12/T30/00/5314/11
Heritage Impact Assessment	P WMA 12/T30/00/5314/12
Water Quality Study	P WMA 12/T30/00/5314/13
Aquatic Ecology Assessment	P WMA 12/T30/00/5314/15
Wetland Assessment	P WMA 12/T30/00/5314/16
Rapid Reserve Determination: Tsitsa River at Lalini	P WMA 12/T30/00/5314/17

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE MZIMVUBU WATER PROJECT

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DWS Report No: **P WMA 12/T30/00/5314/13**

Prepared for: Directorate – Options Analysis

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DECLARATION OF INDEPENDENCE

I, Stephen van Staden as authorised representative of Scientific Aquatic Services, hereby confirm my independence as a specialist and declare that neither I nor Scientific Aquatic Services have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Scientific Aquatic Services was appointed as environmental impact assessment specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for work performed, specifically in connection with the Water Quality Study for the Mzimvubu Water Project Environmental Impact Assessment. I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in my attached report.

Signed: Staden

Date: January 2015

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE MZIMVUBU WATER PROJECT

WATER QUALITY STUDY

Executive summary

Background

The Department of Water and Sanitation (DWS) commissioned the Mzimvubu Water Project, an integrated multi-purpose (domestic water supply, agriculture, power generation, transport, tourism, conservation and industry) project, with the intention of providing a socio-economic development opportunity for the Eastern Cape region.

Environmental authorisation is required for the infrastructure components of the project. The purpose of the Environmental Impact Assessment (EIA) is to assess the components of the project that are listed activities by the National Environmental Management Act (NEMA) for which the DWS has the mandate and intention to implement. The EIA process will provide the information that the environmental authorities require to decide whether the project should be authorised or not, and if so then under what conditions.

Impact Assessment Process

This report examines the water quality situation in the Mzimvubu-Keiskamma T35E Catchment. However, it is not intended to provide a detailed analysis of the water quality problems and their causes, but rather to provide a broad overview of the water quality situation and the trend, and to determine how this could be affected by the planned project. The water quality data provided by DWS from 4 of their stations was systematically analysed to determine which of the data sets were complete enough to base an interpretation on. 1 station situated upstream of the proposed Lalini Dam was selected. Water quality data was also collected by SAS during a single sampling event in April 2014.

The water quality is assessed in terms of electrical conductivity, pH, nitrate/nitrite and phosphorous. Water quality data was assessed according to a fitness for use range (water quality criteria), which was based on the Department of Water Sanitation's water quality guidelines.

A non-parametric statistic analysis was used to calculate the variability in water quality data from the river flow station. With non-parametric statistics the interquartile range, which lies between the 25th and the 75th percentile, is generally used to describe the central tendency or average conditions. For the purposes of this study the 90th percentile was included as it provides an indication of variability and can be used to assess the frequency of excursions into higher and possibly unacceptable water quality conditions.

Impact on water quality

Dams

*The release of cold and anaerobic bottom water during periods when the dams becomes stratified could impact on water quality. This can effectively be mitigated by the installation and correct operation of **multiple level outlets**.*

There is some risk of contamination from construction material and waste discharge during construction. This can be mitigated by the implementation of proper construction methods and effective waste management.

The sediment balance of the Mzimvubu River and associated estuary will be slightly altered during the life cycle of the project. During construction some increases in sedimentation of the Tsitsa River system and ultimately the Mzimvubu River system is deemed likely. During the operational phase of the two dams there will be reduced sediment input to areas below the dams. The reduced sediment load may lead to increased erosion and armouring of the Tsitsa River downstream of the dams. Sedimentation is unlikely to lead to negative impacts on the Mzimvubu River and the associated estuary and some improvements in the overall sediment balance of the system is considered possible.

The impact on water quality by fertilizers contained in the runoff from irrigated areas was determined by calculating the potential salinity level in the dam. There will be a slight increase in the conductivity and phosphorous levels in the dam. Although this is relevant, it is not significant and the water quality still falls within the ideal range.

Water Treatment Works (WTW)

It is proposed that this scheme has a single Water Treatment Works (WTW) to be located at the Ntabelanga Dam site. The works will be supplied with raw water from the dam outlet works to the WTW inlet works by gravity under all operating conditions. The water treatment processes will produce domestic water that will comply with SANS 241:2006. The removal of iron and manganese (if found to be present) will be achieved through aeration. The final choice of coagulant to be used will need to be acceptable to the eventual scheme operator. Sludge will be withdrawn from the sludge collection system and fed into a holding tank before being discharged to the backwash recovery tanks along with filter backwash water. Sludge produced from the settlement and filtration processes will be stored in sludge settlement tanks and drying beds which will periodically need to be dewatered and de-sludged, in an environmentally acceptable manner.

Wastewater Treatment Works (WWTW)

Wastewater treatment plants will be required to treat effluents produced by the Ntabelanga as well as the Lalini Dam operations centre and housing. This will be appropriately sized for this purpose and it is probable that this requirement could be met by using a screening and pre-treatment process followed by a reed bed system.The plants would be designed to treat to the standards as set out in the General Authorisation published in Government Notice No. 665 of 6 September 2013.

Hydropower scheme

The conjunctive use hydropower scheme (i.e. Ntabelanga Dam in conjunction with the Laleni Dam and hydropower scheme), is expected to produce approximately 35 000 kVA on a continuous basis. The proposed infrastructure configuration to generate hydropower is the development of the Laleni Dam for storage and the development of an approximately seven kilometre long pipeline and tunnel to drop and discharge the releases approximately 330m into the Tsitsa River gorge downstream of the Tsitsa Falls. The temperature of the water released from the Lalini hydropower plant will be controlled by the conditions in the proposed Lalini Dam near the intake. Downstream, the temperature is modified by ambient conditions and the inflow of the Ngcolora tributary. The increase in temperature from the outlet will be negligible. The fish species and invertebrate species that occur in this stretch of the river are not very susceptible to temperature

Recommended mitigation measures during construction

The following water quality monitoring and water management measures should be implemented during the construction phase to mitigate possible negative impacts on water quality:

- *A baseline water quality monitoring programme should be implemented for a year prior to the start of construction, at four sampling points associated with the two dam sites;*
- *The contractor must provide a water management method statement for the construction site, which deals with storm water and wastewater management;*
- *Monitor water quality in the river during the construction contract;*
- *Provide storm water drainage at all construction areas;*
- *Provide settlement ponds and proper treatment for contaminated water;*
- *Provide method statements and obtain approval prior to work in rivers, wetlands and aquifers, prior to excavating trenches and dewatering; and*
- *Provide proper facilities for washing and cleaning of equipment, silt and erosion control, and wastewater treatment.*

Conclusion

In terms of water quality there is therefore no significant effect on the environment from the construction of the proposed new dams.

The water quality could be affected by decomposing vegetation during first filling of the dams. Seeing that both the Ntabelanga and Lalini Dams have a very small woody component with the area dominated by grass, bush removal is recommended, but the amount of biomass is too little to cause serious oxygen depletion even over the short term.

On the whole, the surface water quality is fit for all users and is such that no water quality problems are expected to occur. The dams will be able to provide water of an acceptable quality to all users.

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE MZIMVUBU WATER PROJECT – WATER QUALITY STUDY

DEA REF No. 14/12/16/3/3/2/677 (Dam construction application)
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Acronyms and abbreviations

BID	Background Information Document
°C	Degrees Celsius
DEA	Department of Environmental Affairs
DM	District Municipality
DSR	Draft Scoping Report
DWS	Department of Water Affairs
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme
FSR	Final Scoping Report
GN	General Notice
I&AP's	Interested and Affected Parties
kW	Kilowatt
ℓ/s	Litres per second
m	Meter
MAR	Mean Annual Runoff
NEMA	National Environmental Management Act
NO2	Nitrogen dioxide
NO3	Nitrate
PO4	Phosphate
PARSA	Parasitological Society of South Africa
SA RHP	South African River Health Program
SACNASP	South African Council for Natural Scientific Professions
SASS	South African Scoring System
SAS	Scientific Aquatic Services
TP	Total phosphate
WMMS	Water Management Method Statement
WTW	Water Treatment Works
WWTM	Waste Water Treatment Works
ZSSA	Zoological Society of Southern Africa

List of Units

MW	Mega Watt
m	Meters
km^2	Square Kilometers
ha	Hectare
°C	Degrees Celsius
%	Percentage
Ha	Hectares
mS	Millisiemens
L	Litre
mL	Millilitre

1. INTRODUCTION

1.1 BACKGROUND

The Department of Water and Sanitation (DWS) commissioned the Mzimvubu Water Project, an integrated multi-purpose (domestic water supply, agriculture, power generation, transport, tourism, conservation and industry) project, with the intention of providing a socio-economic development opportunity for the Eastern Cape region.

Environmental authorisation is required for the infrastructure components of the project. The purpose of the Environmental Impact Assessment (EIA) is to assess the components of the project that are listed activities by the National Environmental Management Act (NEMA) for which the DWS has the mandate and intention to implement. The EIA process will provide the information that the environmental authorities require to decide whether the project should be authorised or not, and if so then under what conditions.

As part of this EIA process Scientific Aquatic Services have been contracted to undertake a Water Quality Study.

1.2 PURPOSE OF THIS REPORT

Scientific Aquatic Services (SAS) was appointed to undertake a water quality study as part of the environmental assessment and authorisation process for the proposed Mzimvubu water project in the Eastern Cape.

This report provides an assessment of the water quality in the Mzimvubu - Keiskamma T35E Catchment in terms of electrical conductivity (EC), pH, nitrite and nitrate (N02 / N03) and phosphorous (P04). The purpose of the water quality investigation is to determine the current water quality situation and the trend, and then to determine how this could be affected by the planned project. Should there be any detrimental effects, mitigation measures are suggested.

The report focuses on the water quality information that was gathered during the past 6 years as well as water quality data collected by SAS during a single sampling event in April 2014.

The intention of this report is not to provide a detailed analysis of the water quality problems, potential problems and their causes, but rather to provide an overview of the fitness-for-use of current surface water of the Tsitsa River.

The information provided during the EIA process, of which this report is part of, will be used to:

- Determine the impact of the proposed dams and pipeline developments on the water quality within the local area as well as potential impacts on water quality downstream of the proposed dams.

- To contribute to the pre-construction and construction Environmental Management Programme (EMPR) in terms of the water quality issues associated with the proposed project.

1.3 DETAILS AND EXPERTISE OF THE SPECIALIST

Stephen van Staden
SACNASP REG.NO: 400134/05

Stephen van Staden completed an undergraduate degree in Zoology, Geography and Environmental Management at Rand Afrikaans University (RAU). On completion of this degree, he undertook an honours course in Aquatic health through the Zoology department at RAU. In 2002 he began a Masters degree in environmental management, where he did his mini dissertation in the field of aquatic resource management, also undertaken at RAU. At the same time, Stephen began building a career by first working at an environmental consultancy specialising in town planning developments, after which he moved to a larger firm in late 2002. From 2002 to the end of 2003, he managed the monitoring division and acted as a specialist consultant on water resource management issues and other environmental processes and applications. In late 2003, Stephen started consulting as an independent environmental scientist, specialising in water resource management under the banner of Scientific Aquatic Services. In addition to aquatic ecological assessments, clients started enquiring about terrestrial ecological assessments and biodiversity assessments. Stephen, in conjunction with other qualified ecologists, began facilitating these studies as well as highly specialised studies on specific endangered species, including grass owls, arachnids, invertebrates and various vegetation species. Scientific Aquatic Services soon became recognised as a company capable of producing high quality terrestrial ecological assessments. Stephen soon began diversifying into other fields, including the development of EIA process, EMPR activities and mine closure studies.

Stephen has experience on well over 1000 environmental assessment projects with specific mention of aquatic and wetland ecological studies, as well as terrestrial ecological assessments and project management of environmental studies. Stephen has a professional career spanning more than 10 years, of which almost the entire period has been as the owner and Managing member of Scientific Aquatic Services and the project manager on most projects undertaken by the company.

Stephen is registered by the SA RHP as an accredited aquatic bio monitoring specialist and is also registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) in the field of ecology. Stephen is also a member of the Gauteng Wetland Forum and South African Soil Surveyors Association (SASSA).

Dr Dionne Crafford
SACNASP REG.NO: 400146/14

Dionne Crafford matriculated in 1993 and obtained a BSc Ecology degree from the University of Pretoria in 1996. He obtained his BSc (Hons) Zoology degree with distinction at the same university in 1997, where he was awarded the Zoological Society of Southern Africa (ZSSA) award for the best honours student in Zoology. His honours project focused on behavioural ecology (grass owl acoustics).

He spent 1998 in the United States of America exploring various warm water fly fishing opportunities, before returning to enrol for an MSc in Zoology at the Rand Afrikaans University in 1999. He obtained the degree with distinction in 2000 and was awarded the Neitz Medallion for the best MSc in Zoology by the Parasitological Society of Southern Africa (PARSA). His MSc project was on aquatic environmental management/biological monitoring using catfish and their parasites as indicators of water quality.

From 2001 to 2006 he was first employed as "Veterinary Researcher" and later "Specialist Veterinary Researcher" by former Intervet at their Malelane research facility. From 2003 to 2006 he also performed part-time fly fishing guiding services for the former Fly Fishing Outfitters (Nelspruit). He moved to Bloemfontein in 2007 where he was employed as "Assistant Manager: Endoparasitology" at ClinVet International (Pty) Ltd from 2007 to 2012. In 2009 he enrolled for a part-time PhD in Zoology (monogenean parasites of freshwater fish) at the University of Johannesburg and received his degree in 2013. As from 2013 he is employed as Associate Scientific Writing Manager at ClinVet and also performs scientific writing services for Scientific Aquatic Services. In the latter capacity he has participated in a number of studies relating to aquatic biomonitoring and toxicity testing.

Dr Martin van Veelen

Dr. Martin van Veelen is the Managing Director of the ILISO Consulting Environmental Management (Pty) Ltd and a Professional Engineer with a PhD in aquatic health. He is a Fellow of the South African Institution of Civil Engineers, a member of the South African Society of Aquatic Scientists, of the Environmental Scientific Association, of the International Water Association, of the Water Institute of South Africa, and of the Vaal River Catchment Association. He is a certified Environmental Assessment Practitioner with 38 years experience who specialises in project management, environmental impact assessments and water resource planning. He specifically has extensive experience in water quality, especially water quality management, water quality monitoring and water quality assessment. Martin has experience in managing projects that involve multi-disciplinary teams, and public consultation and participation, in South Africa and abroad.

1.4 STRUCTURE OF THIS REPORT

This specialist study is undertaken in compliance with Regulation 32 of GN 543. **Table 1** indicates how the requirements of Regulation 32 of GN 543 have been fulfilled in this report.

Table 1: Report content requirements in terms of Regulation 32 of GN 543

Regulatory Requirements in terms of Regulation 32 of GN 543	Section of Report
(a) The person who prepared the report; and the expertise of that person to carry out the specialist study or specialised process.	Chapter 1
(b) a declaration that the person is independent	Page iv
(c) an indication of the scope of, and the purpose for which, the report was prepared	Chapters 1
(d) a description of the methodology adopted in preparing the report or carrying out the specialised process	Chapter 3
(e) a description of any assumptions made and any uncertainties or gaps in knowledge	Chapter 4
(f) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Chapters 5
(g) recommendations in respect of any mitigation measures that should be considered by the applicant and the competent authority	Chapters 7
(h) a description of any consultation process that was undertaken during the course of carrying out the study	Chapters 8
(i) a summary and copies of any comments that were received during any consultation process	Chapters 9
(j) any other information requested by the competent authority.	Chapters 10

2. PROJECT BACKGROUND SUMMARY

2.1 LOCALITY

The project footprint spreads over three District Municipalities (DMs) namely the Joe Gqabi DM in the north west, the OR Tambo DM in the south west and the Alfred Nzo DM in the east and north east.

The proposed Ntabelanga Dam site is located approximately 25 km east of the town of Maclear and north of the R396 Road. The proposed Lalini Dam site is situated approximately 17 km north east of the small town Tsolo. Both are situated on the Tsitsa River.

2.2 MAIN PROJECT COMPONENTS

Water Resource Infrastructure includes:

- A dam at the Ntabelanga site with a storage capacity of 490 million m^3;
- A dam at the Lalini site with a storage capacity of approximately 150 million m^3;
- A pipeline and tunnel, and a power house at the Lalini Dam site for generating hydropower;
- Five new flow measuring weirs will be required in order to measure the flow that is entering and released from the dams. These flow gauging points will be important for monitoring the implementation of the Reserve and for operation of the dams.
- Wastewater treatment works at the dam sites;
- Accommodation for operations staff at the dam sites; and
- An information centre at each of the dam sites.

The Ntabelanga Dam will supply potable water to 539 000 people, rising to 730 000 people by year 2050. The domestic water supply infrastructure will include:

- A river intake structure and associated works;
- Water treatment works;
- Potable bulk water distribution infrastructure for domestic and industrial water requirements (primary and secondary distribution lines);
- Bulk treated water storage reservoirs strategically located; and
- Pumping stations.

The Ntabelanga Dam will also provide water to irrigate approximately 2 900 ha. This project includes bulk water conveyance infrastructure for raw water supply to edge of field.

About 2 450 ha of the high potential land suitable for irrigated agriculture are in the Tsolo area and the rest near the proposed Ntabelanga Dam and along the river, close to the villages of Machibini, Nxotwe, Culunca, Ntshongweni, Caba, Kwatsha and Luxeni.

There will be a small hydropower plant at the Ntabelanga Dam to generate between 0.75 MW and 5 MW (average 2.1 MW). This will comprise a raw water pipeline from the dam to a building containing the hydropower turbines and associated equipment, and a discharge pipeline back to the river just below the dam wall. The impact is expected to be similar to that of a pumping station.

Another small hydropower plant will be constructed at the proposed Lalini Dam.

The larger hydropower plant at the Lalini Dam and tunnel (used conjunctively with the Ntabelanga Dam) will generate an average output of 30 MW if operated as a base load power station and up to 150 MW if operated as a peaking power station. The power plant will require a pipeline (approximately 4.6 km) and tunnel (approximately 3.2 km) linking the dam to the power plant downstream of the dam and below the gorge.

The power line to link the Lalini power station to the existing Eskom grid will be approximately 13 km. Power lines will be constructed to supply power for construction at the two dam sites and for operating five pumping and booster stations along the bulk distribution infrastructure.

The area to be inundated by the dams will submerge some roads. Approximately 80 km of local roads will therefore be re-aligned. Additional local roads will also be upgraded to support social and economic development in the area. The road design will be very similar to the existing roads as well as be constructed using similar materials.

The project is expected to cost R 12.45 billion and an annual income of R 5.9 billion is expected to be generated by or as a result of the project during construction and R 1.6 billion per annum during operation. It will create 3 880 new skilled employment opportunities and 2 930 un-skilled employment opportunities during construction.

2.3 ALTERNATIVES

The following project level alternatives will be assessed:

- Three hydro power tunnel positions and associated power lines;
- Peak versus Base load power generation;
- Three different dam sizes for the Lalini Dam; and
- The no project option.

For the construction camps, pipeline routes and new roads, the specialist will identify any sensitive areas and deviations to avoid these will be proposed in consultation with the technical team.

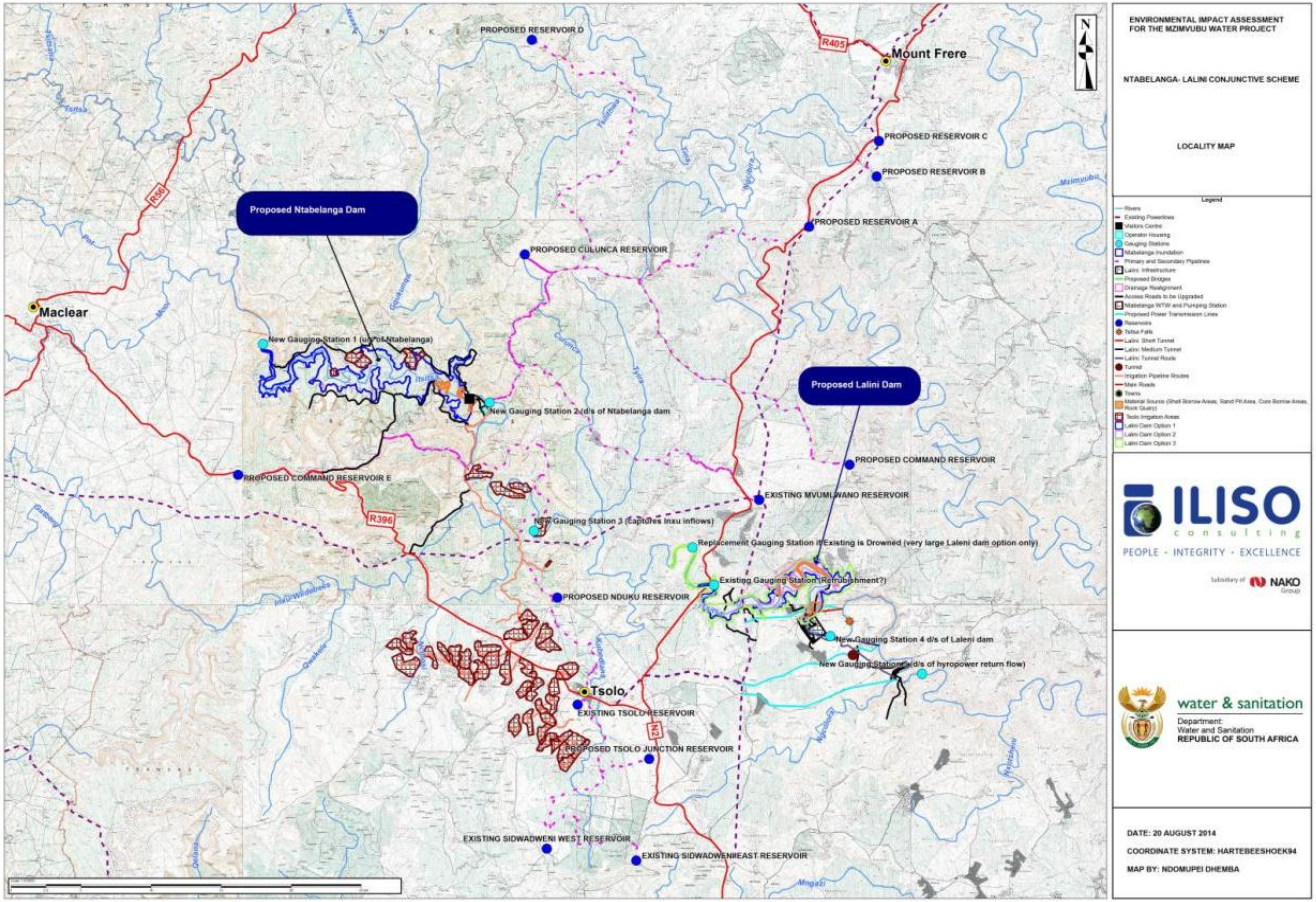

Figure 1: Locality map

3. METHODOLOGY

The key issues identified during the Scoping Phase informed the terms of reference of the specialist studies. Each issue consists of components that on their own or in combination with each other give rise to potential impacts, either positive or negative, from the project onto the environment or from the environment onto the project. In the EIA the significance of the potential impacts will be considered before and after identified mitigation is implemented, for direct, indirect, and cumulative impacts, in the short and long term.

A description of the nature of the impact, any specific legal requirements and the stage (construction/decommissioning or operation) will be given. Impacts are considered to be the same during construction and decommissioning.

The following criteria will be used to evaluate significance:

- **Nature:** This is an appraisal of the type of effect the activity is likely to have on the affected environment. The description includes what is being affected and how. The nature of the impact will be classified as positive or negative, and direct or indirect.

- **Extent and location:** This indicates the spatial area that may be affected (**Table 2**).

Table 2: Geographical extent of impact

Rating	Extent	Description
1	Site	Impacted area is only at the site – the actual extent of the activity.
2	Local	Impacted area is limited to the site and its immediate surrounding area
3	Regional	Impacted area extends to the surrounding area, the immediate and the neighbouring properties.
4	Provincial	Impact considered of provincial importance
5	National	Impact considered of national importance – will affect entire country.

- **Duration:** This measures the lifetime of the impact (**Table 3**).

Table 3: Duration of Impact

Rating	Duration	Description
1	Short term	0 – 3 years, or length of construction period
2	Medium term	3 – 10 years
3	Long term	> 10 years, or entire operational life of project.
4	Permanent – mitigated	Mitigation measures of natural process will reduce impact – impact will remain after operational life of project.
5	Permanent – no mitigation	No mitigation measures of natural process will reduce impact after implementation – impact will remain after operational life of project.

- **Intensity/severity:** This is the degree to which the project affects or changes the environment; it includes a measure of the reversibility of impacts (**Table 4**).

Table 4: Intensity of Impact

Rating	Intensity	Description
1	Negligible	Change is slight, often not noticeable, natural functioning of environment not affected.
2	Low	Natural functioning of environment is minimally affected. Natural, cultural and social functions and processes can be reversed to their original state.
3	Medium	Environment remarkably altered, still functions, if in modified way. Negative impacts cannot be fully reversed.
4	High	Cultural and social functions and processes disturbed – potentially ceasing to function temporarily.
5	Very high	Natural, cultural and social functions and processes permanently cease, and valued, important, sensitive or vulnerable systems or communities are substantially affected. Negative impacts cannot be reversed.

- **Potential for irreplaceable loss of resources:** This is the degree to which the project will cause loss of resources that are irreplaceable (**Table 5**).

Table 5: Potential for irreplaceable loss of resources

Rating	Potential for irreplaceable loss of resources	Description
1	Low	No irreplaceable resources will be impacted.
3	Medium	Resources can be replaced, with effort.
5	High	There is no potential for replacing a particular vulnerable resource that will be impacted.

- **Probability:** This is the likelihood or the chances that the impact will occur (**Table 6**).

Table 6: Probability of Impact

Rating	Probability	Description
1	Improbable	Under normal conditions, no impacts expected.
2	Low	The probability of the impact to occur is low due to its design or historic experience.
3	Medium	There is a distinct probability of the impact occurring.
4	High	It is most likely that the impact will occur
5	Definite	The impact will occur regardless of any prevention measures.

- **Confidence:** This is the level of knowledge or information available, the environmental impact practitioner or a specialist had in his/her judgement (**Table 7**).

Table 7: Confidence in level of knowledge or information

Rating	Confidence	Description
1	Low	Judgement based on intuition, not knowledge/ information.
2	Medium	Common sense and general knowledge informs decision.
3	High	Scientific / proven information informs decision.

- **Consequence:** This is calculated as extent + duration + intensity + potential impact on irreplaceable resources.

- **Significance:** The significance will be rated by combining the consequence of the impact and the probability of occurrence (i.e. consequence x probability = significance). The maximum value which can be obtained is 100 significance points (**Table 8**).

Table 8: Significance of issues (based on parameters

Rating	Significance	Description
1-14	Very low	No action required.
15-29	Low	Impacts are within the acceptable range.
30-44	Medium-low	Impacts are within the acceptable range but should be mitigated to lower significance levels wherever possible.
45-59	Medium-high	Impacts are important and require attention; mitigation is required to reduce the negative impacts to acceptable levels.
60-80	High	Impacts are of great importance, mitigation is crucial.
81-100	Very high	Impacts are unacceptable.

- **Cumulative Impacts:** This refers to the combined, incremental effects of the impact, taking other past, present and future developments in the same area into account. The possible cumulative impacts will also be considered.

- **Mitigation:** Mitigation for significant issues will be incorporated into the EMPR.

4. ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

4.1 SOURCE OF DATA

4.1.1 Temporal Distribution

Water quality data from the selected water quality monitoring stations that fall within the study area were obtained from the DWS . Only one of the datasets contained sufficient information and includes results from the early 1970's to 2014 as listed in **Table 9** and **Figure 2**.

Table 9: Water quality monitoring station used in study

Drainage Region	Station No.	Station Name	Date of First Sample	Date of Last Sample	No of Samples taken
T35L	T3H006Q01	TSITSA RIVER AT N2 BRIDGE TO QUMBU	1971/09/18	2014/01/17	221

4.1.2 Spatial Distribution

Once-off water quality samples were also collected at four points on the Tsitsa River. One point (TS1) was above the position of the proposed Ntabelanga Dam with another point (TS4) just below this dam. Further downstream two points (TS7 and TS8 respectively) were located before and after the position of the proposed Lalini Dam. In addition five other assessment points were identified on tributaries of the Tsitsa River in the greater study area.

Table 10 presents geographic information with regards to the once-off sampling points on the Tsitsa River and associated tributaries assessed. **Figure 3** visually presents the locations of the various points along the various river systems, assessed either in the current assessment or by accessing information available from the literature review and historical data collected.

Table 10: Location of the water sampling points with co-ordinates

Site	Detailed Site Description	GPS coordinates	
		South	**East**
Riverine assessment points			
TS1	Site on the **Tsitsa River** upstream of the proposed Ntabelanga Dam and road upgrades development	31°06’19.63”	28°30’50.16”
TS4	Site on the **Tsitsa River** downstream of the proposed Ntabelanga Dam and road upgrade development	31°07’07.29’’	28°40’11.38’’
TS7	Site on the **Tsitsa River** upstream of the proposed Lalini Dam development	31°14’43.06’’	28°50’30.74’’
TS8	Site on the **Tsitsa River** downstream of the proposed Lalini Dam development	31°14’19.00’’	28°56’14.15’’
TS2	Site on an **unnamed tributary of the Tsitsa River** upstream of the proposed Ntabelanga Dam and road upgrade development	31°06’13.72’’	28°30’53.72’’
TS3	Site on an **unnamed tributary of the Tsitsa River** upstream of the proposed Ntabelanga Dam and road upgrade development	31°06’59.53”	28°30’50.13’’
TS5	Site on an **unnamed tributary of the Tsitsa River** at the starting point of the proposed road upgrade development	31°13’12.12’’	28°37’51.91’’
TS6	Site on the **Inxu River** (tributary of the Tsitsa river) at the starting point of the proposed road upgrade development	31°12’37.94’’	28°37’36.51’’
TS9	Site on an **unnamed tributary of the Tsitsa River** directly associated with the proposed pipeline development	31°20’08.51’’	28°45’54.20’’

Water samples were collected by a South African River Health Program (SA RHP) accredited assessor from these sites and submitted for analyses.

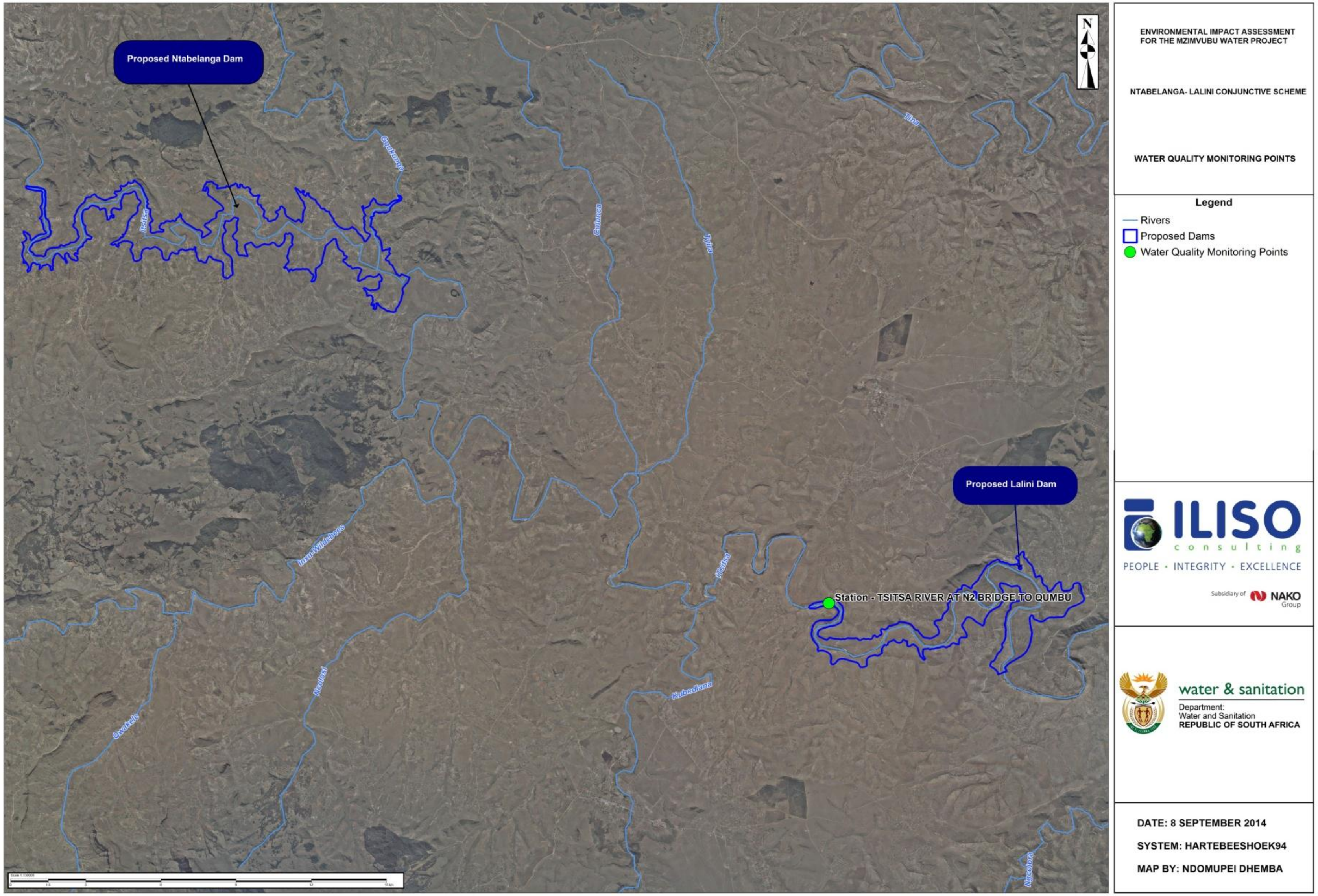

Figure 2: Location of Water Quality Monitoring Point

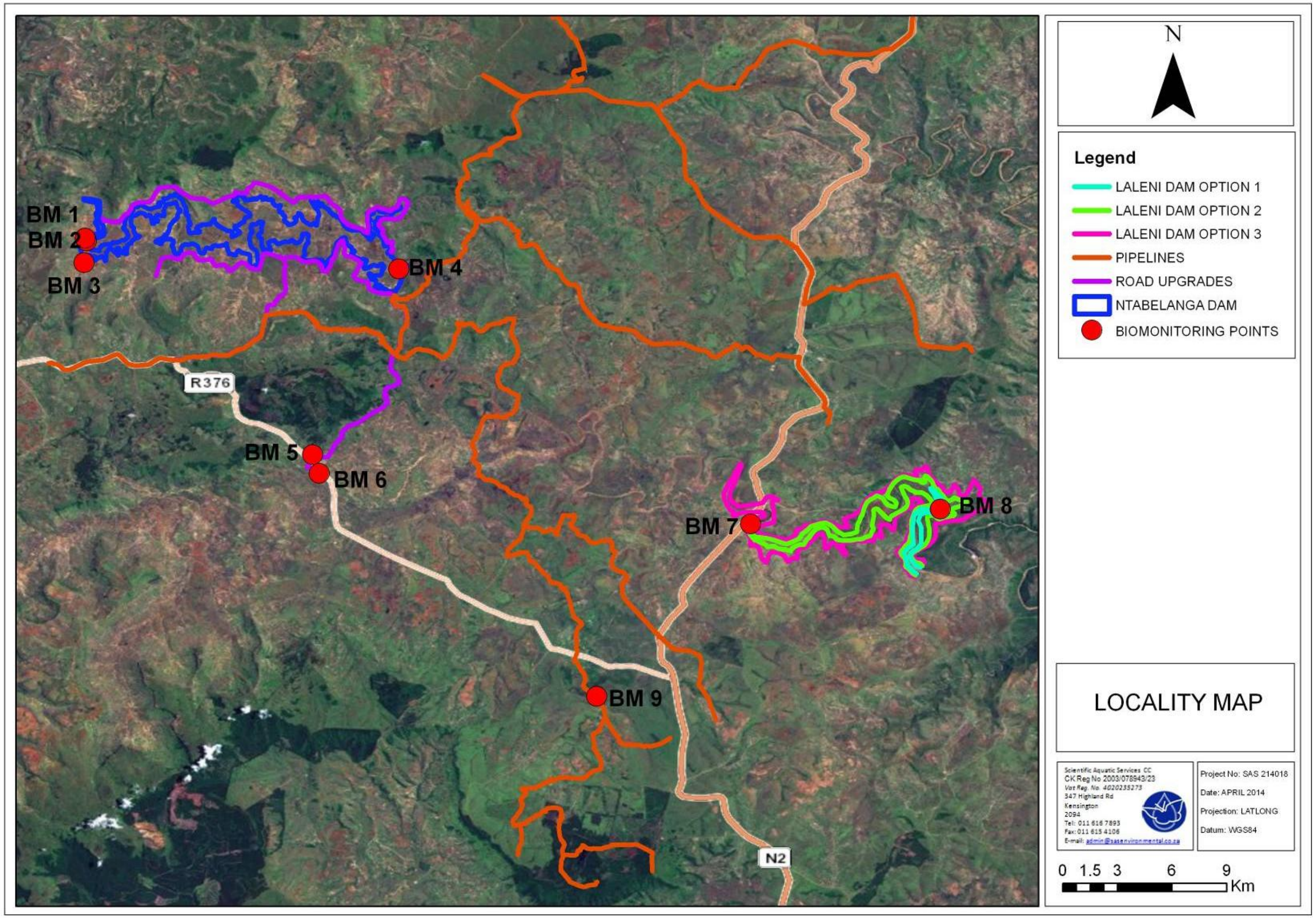

Figure 3: Digital satellite image of the study area showing assessment sites on the Tsitsa River (TS1, TS4, TS7 and TS8) as well as on tributaries of this river (TS2, TS3, TS5, TS6 and TS9) depicted on an aerial photograph in relation to surrounding areas.

4.2 DATA MANIPULATION

In order to analyse the water quality data provided by DWS the data had to be prepared and any missing values had to be estimated. This was conducted using a systematic approach. The first step was to extract data for the study period (January 2008 to December 2013). This study period was chosen as being representative of the current water quality situation, but long enough to detect trends. In the second step, the datasets were filtered to monthly values in order to remove any bias due to periods of intensive sampling. In this step the first sample taken in a month was used. The third step involved calculating values missing for incomplete datasets using one of the following two methods:

(1) If there was no measured value for a single month, between two months that had values, then one of two steps was taken:

Step A: If the previous month had more than one value then the last value of that month was used as long as this value was from a sample taken on a date after the 20th of the month.

Step B: If such a value did not exist, then the value was determined by interpolation (the average of the month immediately prior and the month immediately after the month for which there was no value).

(2) If there are no measured values for two consecutive months, then the data was interpolated. The calculation for this extrapolation is as follows:
For the first month {month x} of the two months without data, the value of the month preceding the two months without data {month a} is subtracted from the first month immediately after the two months without data {month b}. This difference (month b - month a) is divided by three and added to the value of month a (month x = {month b-month a}/3+month a).
For the second month without data {month y} the difference (month b - month a) Is divided by three and multiplied by two and then added to the value of month a (month y = {month b-month a}/3 x 2 + month a).

If there are more than two consecutive months without measured data, then no attempt was made to fill in the missing months and the full period was left blank.

4.3 COMPLETENESS OF DATA

To evaluate the completeness of the data set from the river flow station over the 6 year period of 2008 to 2013, the percentage of completeness was calculated. The percentage of completeness reflects the number of measured values after data sets have been filtered to monthly values and missing values had been filled in (see the discussion on data manipulation above describing how the data was filtered to monthly values and missing values filled in).

The percentage of completeness was then used to screen data sets to determine if there are sufficient values for statistical purposes. The percentage completeness is calculated as:

$$\%\text{Completeness} = \frac{[\text{Tot No. of Months with Data (Ts)}]}{[\text{Total No of Months}]} \times 100$$

The following rules were applied to determine whether or not the dataset could be used:

1. Only data sets that were at least 70% complete were considered,
2. Only data sets that complied with the first rule and had data from at least 2008 onwards were selected.

For the sampling point the patched data series was 100% complete over the selected period. It is therefore possible to complete a reasonably comprehensive analysis of the water quality situation.

4.4 DATA ANALYSIS

Water quality in a natural stream, which is determined by the concentrations of variables in the water body, is the result of a number of random processes, including rainfall, runoff, anthropogenic activities, geology etc. Water quality is therefore rarely static, but changes over time and space. It is seldom the instantaneous concentration that has an impact on the water user, but rather the average concentration. For this reason individual water quality measurements (or data) are of little use to water quality managers and regular measurements over a number of years is required.

To answer the questions “what is the water quality” and “how has the water quality changed” non-parametric statistics were used to calculate the variability, which is a measure of how water quality may differ over time. With non-parametric statistics the interquartile range, which lies between the 25th and the 75th percentile, is generally used to describe variability, while the median value (50th percentile is an indication of the central tendency or average). For the purposes of this study the 90th percentile was included as it can be used to assess the frequency of excursions into higher and possibly unacceptable water quality conditions.

Only data over the last six years (January 2008 to December 2013) was used to determine the current water quality. This was done in order to have a reasonable number of data points on which to base the calculated statistics, but not going back too far in time to have the assessment influenced by any trends that may be present. The current water quality was based on the calculation of the median, 75th percentile and the 90th percentile.

4.5 WATER QUALITY ASSESSMENT

4.5.1 Variables of Concern

The objective of the study is not to perform an in-depth analysis of water quality in the study area (i.e. the objective was not to detect any pollution from other sources), but rather to determine whether or not the proposed project will affect the water quality, or vice versa. For this reason indicator variables were chosen that are indicative of the fitness for use of the water:

- **Electrical Conductivity (EC)**: Is an indicator of the salinity of the water. This affects both domestic use as well as irrigation. The aquatic ecosystem is only affected if the salinity deviates significantly from the natural background value.

- **pH**: The pH in itself does not affect the user or use of the water, but it is an indicator of characteristics such as the acidity or alkalinity of the water, which in turn is an indication of possible aggressive or corrosive properties. Health impacts are normally limited to irritation of mucous membranes or the eyes when swimming. The aquatic ecosystem is affected by deviations from the natural background value.

- **Nitrate/Nitrite (NO3/NO2)**: Has a health effect on humans (particularly babies), and is also an indication of contamination from human activities in the catchment, notably the discharge of treated waste water. Nitrite has a toxic effect on aquatic organisms, particularly those organisms that use gills to breathe under water.

- **Phosphate (PO4)**: Has no direct effect on the use of water, but is an indicator of contamination from activities in the catchment such as waste water discharge and fertilisers from agricultural activities. Elevated concentrations of phosphate can lead to algal blooms in standing water which affect users and the aquatic ecosystem negatively.

4.5.2 Water Quality Criteria, Guidelines and Fitness for Use

Water quality does not suddenly change from “good” to “bad”. Instead there is a gradual change between categories. This is reflected by the fitness-for-use range which is graded to indicate the increasing risk of using the water.

Water quality criteria are discrete values that describe a specific effect as a result of a particular set of conditions. An example would be the toxicity of a substance as determined in a laboratory (the LC50 value for mercury dissolved in water with respect to daphnia). These criteria are then used to develop guidelines, which describe the effect on a user who is exposed to an ever increasing concentration or changing value.

Water quality guidelines can be used to describe fitness-for-use. The fitness-for-use range can be divided into four categories, ranging from “ideal” to “unacceptable”. These categories are described as:

Ideal	:	the user of the water is not affected in any way;
Acceptable	:	slight to moderate problems are encountered;
Tolerable	:	moderate to severe problems are encountered; and
Unacceptable	:	the water cannot be used under normal circumstances.

The fitness-for-use range is also colour coded for ease of interpretation of information (**Table 11**).

Table 11: Colour codes assigned to fitness for use ranges

Fitness for use range	Colour code
Ideal	Blue
Acceptable	Green
Tolerable	Yellow
Unacceptable	Red

The DWS water quality guidelines make provision for five water use categories, namely domestic, recreation, industrial, agricultural (irrigation, livestock watering, and aquaculture), and the aquatic ecosystem. For the purposes of this study only three out of the five water use categories have been taken into account, namely domestic use, agricultural use (irrigation) and the aquatic ecology. The underlying principle is that, if the water is fit for human consumption, it is safe to swim in, and if it is fit for domestic use, industrial users should not be affected unduly.

4.5.3 Fitness for use categories

Water quality guidelines describe the fitness for use of the water. The biological, chemical or physical data is analysed and the results are compared against the guidelines to assess the water quality of a resource. It is necessary that water quality guidelines be developed for each water use and for each variable of concern. The basis of these guidelines can be found in the South African Water Quality Guidelines, Volumes 1 to 7 (DWS, 1996a-g).

The DWS guidelines are user-specific, making it possible to have many different guidelines for each of the water quality variables (depending on how many user groups are affected by the same variable). For each user group a particular set of guidelines for water quality is relevant (developed by DWS). The guidelines provide a description of the effect that changes in water quality will have on the user, and not an interpretation of whether this is acceptable or not. From these guidelines the cut-off values for the different fitness-for-use categories have been set. A breakdown of these values is given in **Table 12**.

Table 12: User specific guidelines

Variable	Units	Colour Ranges			
		Blue	Green	Yellow	Red
DOMESTIC					
Total Ammonia	mg/l N				
Electrical Conductivity	mS/m	< 70	70 to 150	150 to 370	>370
pH	pH units at 25^0 C	5.0 to 9.5	4.5 to 5.0 9.5 to 10	4.0 to 4.5 10.0 to 10.5	<4.5 >10.5
Nitrate/Nitrite	mg/l N	< 6.00	6 to 10	10 to 20	> 20
Phosphate	mg/l P				
Sulphate	mg/l SO_4	0 to 200	200 to 300	300 to 400	>400
Chloride	mg/l Cl	<100	100 to 200	200 to 600	< 600
AGRICULTURE					
Total Ammonia	mg/l N				
Electrical Conductivity	mS/m	< 40	40 to 90	90 to 270	>270
pH	pH units at 25^0 C	6.5 to 8.5	<6.5 >8.5		
Nitrate/Nitrite	mg/l N				
Phosphate	mg/l P				
Sulphate	mg/l SO_4	< 1000	1000 to 1500	1500 to 2000	> 2000
Chloride	mg/l Cl	< 100	100 to 175	175 to 350	>350
AQUATIC ECOLOGY					
Total Ammonia	mg/ l N	<0.140	0.140 to 0.300	0.300 to 2.00	> 2.00
Electrical Conductivity	mS/m				
pH	pH units at 25^0 C	6.5 to 8.5	5.5 to 6.5 8.5 to 9.0	5.0 to 5.5 9.0 to 9.5	< 5.00 >9.5
Nitrate/Nitrite	mg/l N				
Phosphate	mg/l P	< 0.005	0.005 to 0.025	0.025 to 0.250	> 0.250
Sulphate	mg/l SO_4				
Chloride	mg/l Cl				

The cut-off values for the fitness for use categories are per user and per variable and can be used to assess the fitness for use of the Mzimvubu Water Project study area for individual users or user categories such as domestic, agriculture, industry, recreation and the aquatic ecosystem. The study focused on domestic and agriculture water uses. In order to determine the fitness for use of the Mzimvubu study area as a whole, the different fitness for use categories for different users affected by the same variable have been reconciled. This was done by selecting the most stringent value for each cut-off value in order to arrive at the management levels. A summary of these values are given in **Table 13**.

Table 13: Combined fitness for use categories

Variable	Units	Colour Ranges			
		Blue- Ideal	Green-Acceptable	Yellow-Tolerable	Red - Unacceptable
Total Ammonia	**mg/l N**	<0.140	0.140 to 0.300	0.300 to 2.00	> 2.00
Electric Conductivity	**mS/m**	< 40.0	40 to 90	90 to 270	>270
pH	**pH units at 25^0 C**	6.5 to 8.5	5.5 to 6.5 8.5 to 9.0	5.0 to 5.5 9.0 to 9.5	<5.0 >9.5
Nitrate/Nitrite	**mg/l N**	< 6.00	6.00 to 10	10 to 20	> 20
Phosphate	**mg/l P**	< 0.005	0.005 to 0.025	0.025 to 0.250	> 0.250
Sulphate	**mg/l SO_4**	0 to 200	200 to 300	300 to 400	>400
Chloride	**mg/l Cl**	<100	100 to 200	200 to 600	>600

The explanation of how the cut-off values for the water quality variables were decided on are as follows:

a) Electrical Conductivity (EC): The agricultural guideline for irrigation is the most stringent. The ideal range in this guideline falls between 0 and 40 mS/m.

b) pH: The fitness for use for the pH category simply represents a combination of all the user-specific guidelines to form the most stringent.

c) Nitrate and Nitrite (NO_3 / NO_2): The user group that is most sensitive is domestic use, and the guideline is therefore based on this.

d) Phosphorous ($P0_4$): The only guideline for phosphorous is in the ecological user group.

4.5.4 Fitness for use assessment

In the foregoing chapters the fitness-for-use categories have been developed. What is now needed is to assess the water quality on the basis of the statistical distribution of the measurements over the various categories. Obviously, if all the statistics (median, 75th percentile and 90th percentile) fall in the "ideal" range, then the water is ideal. The same is true for the other categories. The rules for determining the overall fitness for use are shown in **Table 14**.

Table 14: Fitness for use assessment criteria

Fitness for use range in which the variable falls			Water quality assessment category	Colour code
Median	75th percentile	90th percentile		
Ideal	Ideal	Ideal	Ideal	**Blue 1**
Ideal	Ideal	Acceptable	Acceptable	**Green 2**
Ideal	Acceptable	Acceptable		
Acceptable	Acceptable	Acceptable		
Ideal	Ideal	Tolerable		
Ideal	Acceptable	Tolerable	Tolerable	**Yellow 3**
Acceptable	Acceptable	Tolerable		
Acceptable	Tolerable	Tolerable		
Tolerable	Tolerable	Tolerable		
Any other combination			Unacceptable	**Red 4**

The above is a methodology to test a set of data in a consistent and unbiased manner, taking into consideration the water quality, of each of the variables of concern, for the full range of fitness-for-use (Ideal to Unacceptable) of the water quality for a specific resource. In this methodology the full time span of the water quality of the resource is checked in an acceptable scientific manner in the same way one sample would be checked for fitness-for-use.

4.5.5 Spatial Analysis

4.5.5.1 Water quality assessment results for the Tsitsa River (TS1, TS4, TS7 and TS8)

Fitness for use – Tsitsa River sites – April 2014

Results in terms of fitness for use are presented in **Table 15**.

Table 15: Selected variables assessed in terms of fitness for use combined for use categories.

Analyses in mg/ℓ (Unless specified otherwise)	Sample Identification			
	TS1	TS4	TS7	TS8
pH	7.7	7.8	7.9	7.9
Electrical Conductivity (EC) in mS/m	8.3	8.5	13.9	10.5
Sulphate as SO_4	<5	<5	<5	<5
Nitrate as N	0.2	<0.2	0.3	0.2
Ortho Phosphate as P	<0.2	<0.2	<0.2	<0.2
Free & Saline Ammonia as N	0.4	<0.2	<0.2	<0.2

Color code key:	
Blue	Ideal
Green	Acceptable
Yellow	Tolerable
Red	Unacceptable
No color	Fitness for use not available

All variables for which fitness for use criteria were established, indicate ideal concentrations/conditions. Negligible spatial variation in water quality was observed.

4.5.5.2 Water quality assessment results for the Inxu River (TS6) and the smaller unnamed tributaries of the Tsitsa River (TS2, TS3, TS5 and TS9)

Fitness for use – selected unnamed tributaries of the Tsitsa River sites – April 2014

Results in terms of fitness for use are presented in **Table 16**.

Table 16: Selected variables assessed in terms of fitness for combined use categories.

Analyses in mg/ℓ (Unless specified otherwise)	Sites		
	TS2	**TS3**	**TS5**
pH	7.8	7.8	7.8
Electrical Conductivity (EC) in mS/m	7.7	16.2	10
Sulphate as SO_4	<5	<5	<5
Nitrate as N	0.3	<0.2	0.2
Ortho Phosphate as P	<0.2	<0.2	<0.2
Free & Saline Ammonia as N	<0.2	<0.2	<0.2

All variables for which fitness for use criteria were established, indicate ideal concentrations/conditions. Negligible spatial variation in water quality was observed.

5. RESULTS

5.1 WATER QUALITY ASSESSSMENT – TEMPORAL DISTRIBUTION

The data set used to calculate the values in **Table 17** are based on monthly data over a period of 6 years (2008 – 2013).

Table 17: Water quality assessment for Station: Tsitsa River at N2 Bridge to Qumbu (T3H006Q01)

	EC (mS/m)	pH	NO_3+NO_2 – N (mg/ℓ)	PO_4-P (mg/ℓ)
Median	11	8	0.2	0.01
75th Percentile	16	8	0.2	0.03
90th Percentile	20	8	0.35	0.05
Concluding water quality assessment	B	B	B	Y

Table 17 depicts the fitness for use category for the sampling point that was analysed. The water quality falls mostly in the ideal range, except in terms of phosphate. The catchment is in a natural state with little, if any, contamination by nutrients. The dam will essentially be in an oligotrophic state and contain limited concentrations of salts and an ideal pH value.

5.2 TRENDS

Station T3H006Q01 is used to determine the water quality trend in the Tsitsa River downstream of the proposed Ntabelanga dam and upstream of the proposed Lalini dam.

A time series for the different variables at the monitoring point is included below and a summary of the trends is shown in **Table 18**. A "1" denotes a decrease in concentration or value, while a "2" denotes an increase or positive trend. A "0" means that there is no change over the period under review.

Table 18: Trend analysis

Station Name	Station No.	EC (mS/m)	pH	NO_3+NO_2 – N (mg/ℓ)	PO_4-P (mg/ℓ)
TSITSA RIVER AT N2 BRIDGE TO QUMBU	T3H006Q01	2	0	2	2

Although there is an increase in EC, NO_3/NO_2 and PO_4, the changes in water quality are small, and not significant in terms of fitness for use. Even at the 90th percentile value, the water quality still falls mostly in the ideal range in the upper reaches.

Conductivity in the Tsitsa River varies between 6 and 19 mS/m and reflects seasonal changes with the EC being high during periods of low flow and then lower during and after the rainy seasons (**Figure 4**). Nitrates/Nitrite levels vary between 0.1 and 1 mg/ℓ (**Figure**

5), pH levels between 7 and 8 (**Figure 6**) and Phosphate levels between 0.01 and 0.02 mg/ℓ (**Figure 7**). The graphs for all the variables reflect seasonal changes. No significant trends can be established.

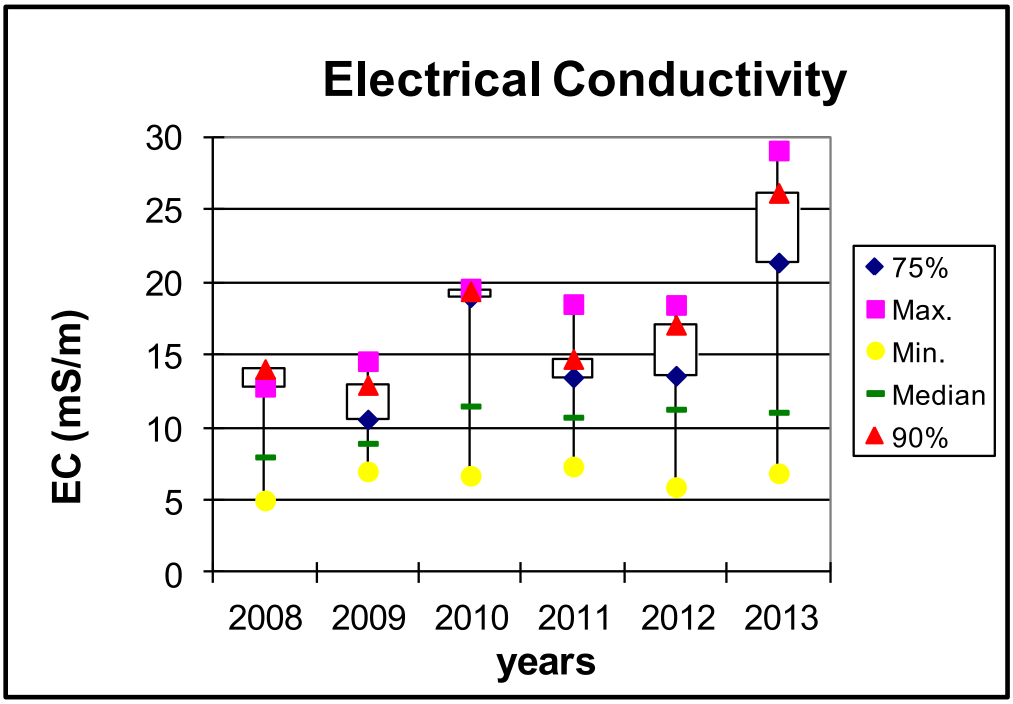

Figure 4: Conductivity in the Tsitsa River

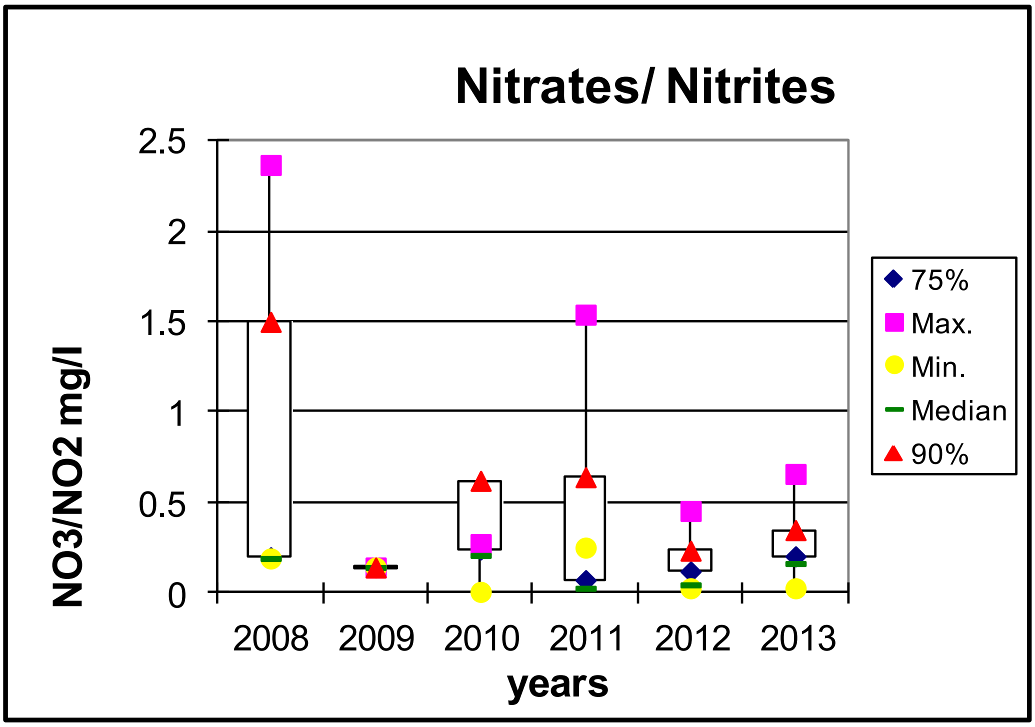

Figure 5: Nitrates/Nitrites in the Tsitsa River

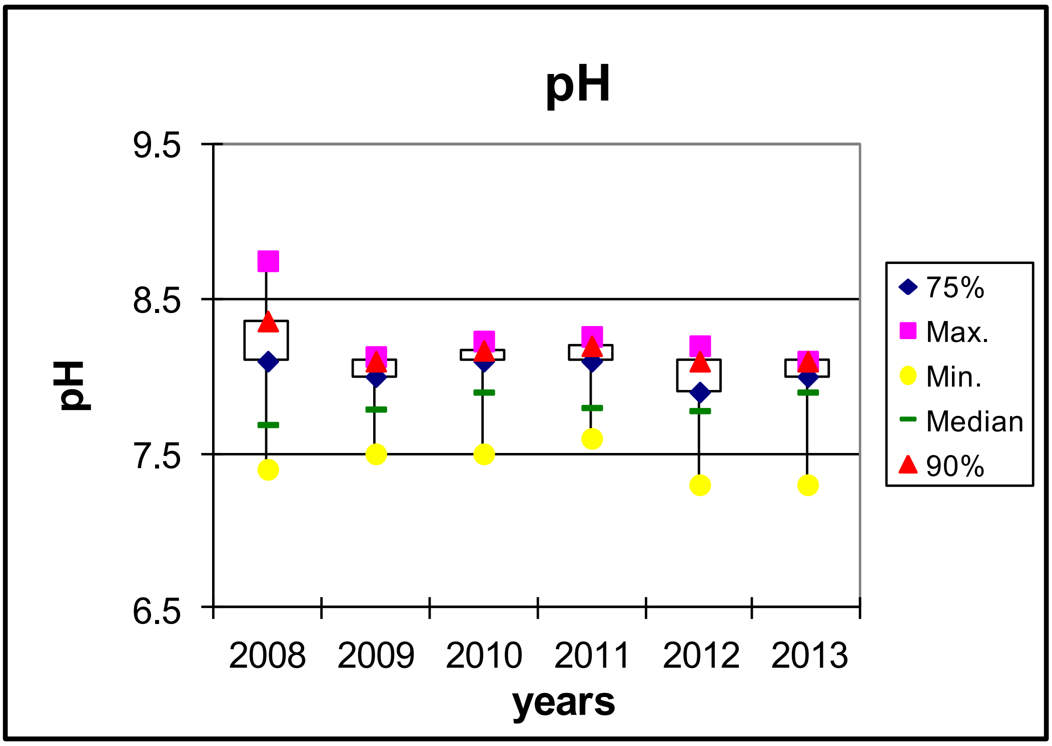

Figure 6: pH in the Tsitsa River

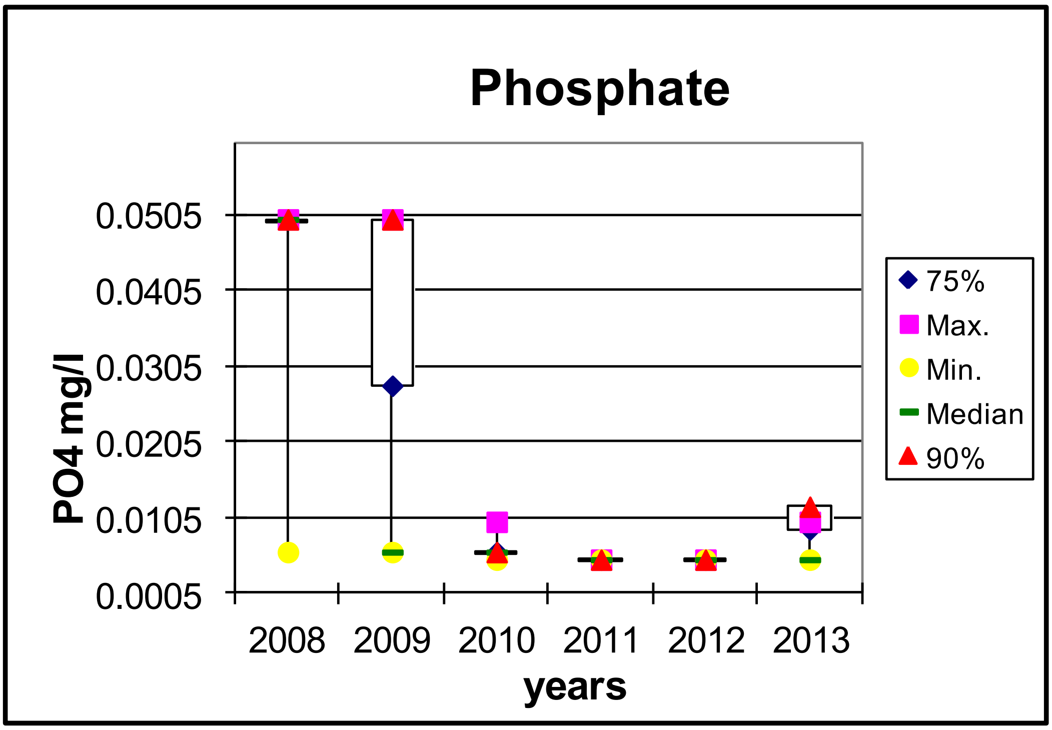

Figure 7: Phosphate in the Tsitsa River

5.3 EXPECTED WATER QUALITY IN THE DAMS

The issues with respect to water quality centre around two effects. The first is the storage of a large quantity of water in the proposed dams, which can lead to eutrophic conditions and an increase in salinity due to the concentrating effect of evaporation losses. These problems tend to be accentuated during periods of prolonged low inflow.

The second issue is a possible change in water quality in the river downstream of the dams. The change can be far-reaching, such as a cumulative change in salinity as a result of reduced flows, or it can be of a local nature, such as changes in temperature directly downstream of the dam due to the release of colder bottom water.

In both cases the impact should be assessed in terms of fitness for use to the users of the water (including the aquatic ecosystem). In this respect the possible positive effect on future users who currently use borehole water should not be neglected.

The water quality in the dams is dependent on two aspects, namely the quality of the water that flows into the dams, as well as the size of the dams. The water quality of the dams will be less variable than that of the river, as the volume of water stored in the dams will act as a buffer to sudden changes.

The mean annual runoff (MAR) at the Ntabelanga Dam is 415 million m^3 per annum which makes it a 1.2 MAR dam. This means that on average the dam water will be replaced once per year.

The incremental MAR at the Lalini Dam is 413 million m^3 per annum, which makes this dam a 0.36 MAR dam. This means that the water will be replaced on average 2.75 times per year

The Lalini Dam is therefore relatively small, and will be augmented by water from the Ntabelanga Dam as water is released for power generation. The quality of the water in the Lalini Dam will therefore tend to be the same as in the Ntabelanga Dam. The proposed dams will together have a capacity of just more than the mean annual runoff of the river, which means that under average conditions the retention of water in the dams will be more than one year. The critical condition will occur under drought conditions, when there is not much contribution from low salinity storm water and evaporation losses will be high.

Under drought conditions the quality of the water in the dams will tend towards the higher end of the observed record in the river, but will still have some benefit of retained good quality water. It is therefore predicted that the quality of the water in the dams will mostly be better or equal to the 75th percentile value of the observed historic record in the river. The 75th percentile (predicted water quality in the dam under drought conditions) is the concentration/value that is not exceeded for 75% of the time. It is the top of the interquartile range (25th to 75th percentile), which is where the water quality falls for 50% of the time (for 25% of the time it is better, and for 25% of the time it is worse than the interquartile range). It is therefore a relatively conservative value, and if the quality of the water is still good under these conditions the impact of storing water will be negligible.

It should be noted that the water quality in the dams will mostly (95% of the time) be better than the predicted value, which is a worst case scenario.

The values depicted in **Table 19** were calculated from the observed values at T3H006Q01.

Table 19: Predicted water quality in the dam (75th percentile)

EC	pH	$NO_3 + N0_2$ - N	PO_4 - P
15	8	0.16	0.02

Apart from phosphate which falls in the acceptable range, the water quality falls in the ideal range.

The trophic classification is determined by the mean annual concentration of TP (Total phosphate) and chlorophyll (Walmsley and Butty, 1980). **Table 20** demonstrates the different trophic classification and **Table 21** provides a definition of each trophic level.

Table 20: Trophic Classification

Trophic Status	TP concentration (µg/l)	Chlorophyll concentrations (µg/l)
Oligotrophic	<15	<3
Mesotrophic	15-47	3-9
Eutrophic	>47	>9

Source: (Walmsley and Butty, 1980)

Table 21: Trophic Definition

Oligotrophic Mesotrophic	Low in nutrients and not productive in terms of aquatic animal and plant life.
Eutrophic	Rich in nutrients, very productive in terms of aquatic animal and plant life and showing an increasing signs of water quality problems.
Hypertrophic	Very high nutrient concentrations where plant growth is determined by physical factors. Water quality problems are serious and can be continuous.

Source: http://www.DWS.gov.za/iwqs/eutrophication/NEMP/nempdam.htm (DWS 2003)

The predicted phosphate concentration is 0.02 mg/l P which puts it in the Oligotrophic range. A concentration of less than 0.16 mg/ℓ P will result in nuisance conditions occurring for less than 20% of the time, this is seen as tolerable.

Stratification often occurs in large water bodies during the spring and summer periods. It is essentially the development of distinct layers of different temperature, density and/or water quality at various depths in a water body and the restriction of mixing throughout the water column.

During winter and early spring, most water bodies are well mixed throughout their water column. Thermal stratification develops in late spring or summer when the upper layers of the dam are heated by solar radiation. The surface water layer heats up faster than the heat can disperse into the lower depths of the dam. The resultant difference in the density of the surface and bottom layers retards circulation within the water column and can lead to the top and bottom layers having significantly different water temperature and water qualities.

Oxygen input into a water body normally occurs by diffusion at the interface between air and water and by photosynthesis in the photic zone. Oxygen is consumed largely at the bottom of a dam by the decomposition of organic material on the dam floor. In a stratified water body, water circulation is restricted and oxygen is therefore not carried from the surface layer to the bottom layer, resulting in a rapid depletion of oxygen in this layer during the summer months.

There are three defined depth layers that develop as a water body becomes stratified:

- Epilimnion - the surface layer of warm, generally well oxygenated water, circulated by wind action and minor currents;
- Hypolimnion - the bottom water layer of cooler water, generally anoxic and isolated from wind and thermal effects;
- Metalimnion - the layer between the epilimnion and the hypolimnion, a zone of steep decline in temperature and dissolved oxygen with depth.

The thickness and depth of the epilimnion, metalimnion and hypolimnion layers in a stratified storage are influenced by many factors, such as temperature variation, wind mixing and flow through a dam. Once the dam has stratified, a large amount of energy is often required to break down the layers while summer conditions persist. In autumn, stratification is normally naturally broken down (a process called "turnover" of the water body) by a decrease in surface temperatures and by wind induced mixing. Isothermal conditions are normally present in dams during winter and into spring, until a rise in ambient temperatures may initiate the next season's stratification.

In South Africa the metalimnion is normally found at a depth of about 8 m, while the layer itself is between 1 m and 2 m thick. It is highly probable that the proposed dam will become stratified in summer, especially at the dam wall, as the depth of the dam at the wall is more than 30 m. The dam wall at Lalini Dam will have a maximum height of 56 m and 66 m at Ntabelanga Dam. This means that any bottom outlets will release cold (14° C to 18° C), anoxic water into the river where the temperature in summer is around 28° C, to the detriment of the aquatic life. The effect would disappear a short distance downstream of the dam, and is therefore fairly localised and seasonal.

It is difficult to predict how far downstream the effect will persist. The water will become aerated quickly, especially if the water is released in the form of a jet from valves in the dam wall. The effect of temperature may persist for some kilometres, depending on the flow rate and depth. The Tsitsa River below the proposed Ntabelanga dam and downstream of the Lalini Dam is relatively shallow and the flow is slow. The effect of temperature is expected to be effectively dissipated about 15 km downstream of the dam wall, at which point the temperature will only differ slightly from the natural background temperature.

Stratification is predicted to occur in the proposed new dams, and the release of cold, anoxic bottom water will have a detrimental effect on water quality and aquatic life up to a distance of about 15 km downstream of the dam wall. To overcome this effect a multiple level outlet structure must be installed, with outlets at no more than 6.5 m intervals, starting 7 m below the full supply level of the dam.

5.4 SEDIMENTATION

The sediment deposited in a dam will decrease its live storage, and, hence, its lifespan, by decreasing the volume of water it can hold. The amount of sediment that will be deposited annually was determined by using the empirical Roosenboom Method to calculate the sediment deposition in each dam (Department of Water Affairs, 2013).

Sedimentation volumes were calculated for both dam sites, with the Lalini Dam sedimentation being calculated on the incremental catchment area downstream of the Ntabelanga Dam, as the Ntabelanga Dam is assumed to trap all sediment from its contributing catchment.

The sediment yield was determined and converted to the sediment consolidation volume (based on a 50-year bulk sediment density of 1.35 t/m^3) for 50 years (V_{50}) for different percentiles of non-exceedance. After considering the sediment loads and erosion potential in the catchment, the V_{50} value would be adopted using the 80% assurance of non-exceedance. This is due to the extremely high erosion potential in the area (Department of Water Affairs, 2013).

A summary of the selected V_{50} sedimentation allowance volumes for the Ntabelanga Dam catchment and incremental Lalini Dam catchment is shown in **Table 22** and **Table 23** respectively. A comparison of sedimentation yields in the Tsitsa River system is shown in **Figure 8**.

Table 22: Summary of Sedimentation V_{50} Values for the Ntabelanga Dam Site

WRC Method	Confidence Band	Factor	Sediment Load (t/a)	Sediment Yield (t/km^2/a)	50 Year Sediment Yield (t/km^2)	V_{50} (million m^3)
Empirical	50%	1.05	947 943	494	24 700	18.296
Empirical	80%	2.05	947 943	964	48 200	35.704
Empirical	90%	2.75	947 943	1 293	64 650	47.889
Empirical	95%	3.65	947 943	1 716	85 800	63.556

Table 23: Summary of Incremental Catchment Sedimentation V_{50} Values for the Lalini Dam Site

WRC Method	Confidence Band	Factor	Sediment Load (t/a)	Sediment Yield (t/km^2/a)	50 Year Sediment Yield (t/km^2)	V_{50} (million m^3)
Empirical	50%	0.95	1 012 999	400	20 000	14.815
Empirical	80%	2.00	1 012 999	842	42 100	31.185
Empirical	90%	2.70	1 012 999	1 137	56 850	42.111
Empirical	95%	3.50	1 012 999	1 474	73 700	54.593

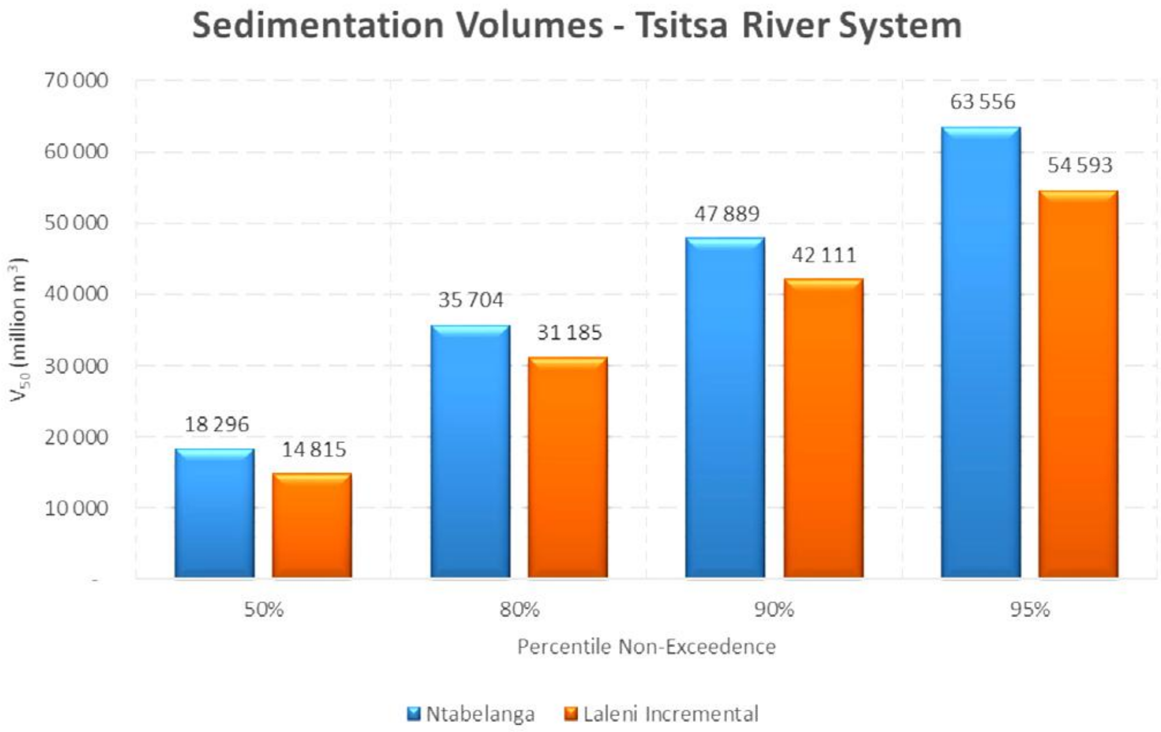

Figure 8: Comparison of Sediment Yields in the Tsitsa River (Department of Water Affairs, 2013)

Sedimentation volumes over 50 years were accounted for based on an assessment of the Ntabelanga Dam catchment with the resultant sedimentation V_{50} values equating to 35.704 million m^3.

Sedimentation volumes over 50 years were accounted for based on an assessment of the incremental contributing catchment of the Lalini Dam, below the Ntabelanga Dam. The incremental sedimentation V_{50} values used in this study were 31.185 million m^3, which resulted in a total allowance of 66.889 million m^3.

Initially the sediment load in the river downstream will reduce significantly. This is unavoidable. Coarse sediment will settle at the inlet to the dam and finer suspended material will be carried through.

The sediment balance of the Mzimvubu River and associated estuary will be slightly altered during the life cycle of the project. During construction some increases in sedimentation of the Tsitsa River system and ultimately the Mzimvubu River system is deemed likely. The significance of these impacts is however considered limited as the duration of the impact will be limited to relatively short periods of time. During the operational phase of the two dams there will be reduced sediment input to areas below the dams. Although the reduced sediment load may lead to increased erosion and armouring of the river downstream of the dams this impact is not considered highly significant. The aquatic macro-invertebrate community of the Tsitsa River relies on fast flowing water and a substrate free of sediments on the rocky substrate. Based on the findings of the Environmental Water Requirements assessment for the Ntabelanga Dam and the hydroelectric scheme associated with the Lallini Dam sedimentation of the Tsitsa River is currently a significant issue in the system. The reduced sediment load downstream of the dams therefore has the potential to improve the aquatic ecology in these sections of the system.

The Mzimvubu catchment is severely impacted by the erosion of soils due to the highly erodible nature of the soils in the catchment as well as the topography in the catchment and the associated agricultural practices in the catchment. The reduced sediment input that will occur from the Tsitsa River into the Mzimvubu River system is unlikely to lead to negative impacts on the Mzimvubu River and the associated estuary and some improvements in the overall sediment balance of the system is considered possible.

5.5 CONTAMINATION OF WATER BY FERTILIZERS

The impact on water quality by fertilizers contained in the runoff from irrigated areas was determined by calculating the potential salinity level in the dam, as shown below.

$$\frac{\textit{(return flow x return concentration) + (inflow x inflow\_concentration)}}{\textit{return flow + inflow}} = \textit{salinity in dam}$$

The irrigation return flow from the irrigated areas can be expected to be 10% of the water that is applied. Some over-irrigation is required to prevent a salt build-up in the root zone, while too much over-irrigation will lead to soil leaching, as well as unnecessary cost and reduced water use efficiency.

The salt concentration in the irrigation return flow will on average be three times the concentration of the applied water. This salt balance was used to calculate the increase in salinity for the stored water in the dam.

The conductivity in the dam will increase by 2% (from 10.3 mS/m to 10.5 mS/m). Although this increase is relevant it is not significant, due to the limited absolute value of change and the water quality still falls within the ideal range.

The contribution from phosphorus will increase by 2% (from 0.0200 mg/ℓ to 0.0204 mg/ℓ). Although this increase is relevant it is not significant and the water quality still falls within the acceptable range.

5.6 WATER TREATMENT WORKS

It is proposed that this scheme has a single WTW located at the Ntabelanga Dam site.

These works will be supplied with raw water from the dam outlet works to the WTW inlet works by gravity under all operating conditions. Water can be drawn off from the dam at different levels based upon the monitored limnology conditions, in order to obtain the best quality water given the seasonal and depth variations that occur in normal dam operation.

The normally preferred condition is to draw off water from as near to the dam surface as possible without experiencing vortexing problems at the drawoff point. It is recommended that reservoir stratification modelling be undertaken during the detailed design stage so that, in conjunction with reserve determination specialists, a set of operating rules can be established for EWR and optimum drawoff elevation can be established.

Based upon the nature and land use of the catchment upstream of the dam, the water treatment processes required to reduce the contaminant levels to comply with SANS 241:2006 would typically include processes to deal with the following:

- Possibly iron
- Possibly manganese
- Possible nitrates and phosphates
- Turbidity
- Suspended solids
- Microbiological
- Disinfection

Removal of iron and manganese (if found to be present) is normally achieve through aeration, but other chemical treatment processes can also be considered.

An aeration cascade is allowed for, to improve taste by introducing oxygen from the atmosphere into the water. In addition to assist (if required) in the oxidation of iron and manganese, this also provides for flash mixing for the addition of chemicals.

The final choice of coagulant to be used at the WTW will be developed during the final design of the works, (typically procured via a Design and Construct Contract), which process will need to be acceptable to the eventual scheme operator. For feasibility design purposes it has been assumed that aluminium sulphate will be used as the coagulant, in conjunction with a polymer.

Identical modular banks of flocculator/clarifiers operating in parallel should be allowed for, with each bank sized to be a proportion of the total ultimate design flow (2050 peak). Thus it would be possible to develop the works in stages if deemed to be appropriate.

The size of these clarifiers would be such that they would have an upflow rate of between 1.5 and 1.9 m/hr, depending upon the results of water quality and jar testing.

Clarified water will be collected in a peripheral launder (channel) and will flow under gravity to the filtration system. Sludge will be withdrawn from the sludge collection system and fed into a holding tank before being discharged to the backwash recovery tanks along with filter backwash water.

Other types of clarifier design might be suitable, but this will depend upon the water quality as well as the proprietary processes that would be proposed by specialist bidders during the design and build tendering process. After settlement, filtration would typically be via rapid gravity filters with a backwash system. If taste and odour problems are identified through a water quality sampling, then this process might also need to be supplemented by using carbon treatment. Again, these filters can be developed in a modular pattern to allow for staged development. Cognisance will need to be taken of the number of filters to be backwashed per day and allowance made for the WTW output to be maintained even when these filter beds are off-line for backwashing. The areas of these filter beds are based upon gravity flow rates of between 8 and 12 m/hr.

Sludge produced from the settlement and filtration processes will be stored in sludge settlement tanks and drying beds which will periodically need to be dewatered and de-sludged, in an environmentally acceptable manner.

It is proposed that all the residuals produced by the works be dried and disposed of off-site. Drying beds are allowed for dewatering the residuals generated by the plant as the technology is considered appropriate for the plant location. The volume of residuals will be reduced by the incorporation of backwash recovery tanks into the process train.

Disinfection is likely to be through a gaseous chlorination process unless the water quality dictates that specific alternative processes might be needed (eg Ozone). However, this latter option is unlikely to be needed.

Whilst the DWA requirements for minimum contact time is 6% of a day, or 1.5 hours, it is proposed that a total contact tank volume equivalent to 3 hours contact time be provided, with the contact tank split into two compartments so that the minimum contact time of 1.5 hrs can still be achieved with one tank off-line for servicing. This will also provide some flexibility of operation by providing more balancing capacity for the plant through flow rate, and for the treated water pumps.

It is also recommended that the treated water pumping station is integrated into, or close to, the contact tank at the WTW, at an elevation such that the suction of these pumps are continuously drowned.

5.7 WASTE WATER TREATMENT WORKS

Wastewater treatment plants will be required to treat effluents produced by the Ntabelanga as well as the Lalini Dam operations centre and housing. This will be appropriately sized for this purpose and it is probable that this requirement could be met by using a screening and pre-treatment process followed by a reed bed system.

It is not recommended that such a wastewater treatment plant be designed or used to treat the effluent from the construction activities, as this would be oversized and would have to deal with industrial pollutants as well as domestic effluents. The contractors themselves must be made responsible for the safe and environmentally sensitive disposal of all of their effluents and waste products, leaving only domestic effluents for the permanent wastewater treatment plant to deal with.

The treatment plants will consist of a small activated sludge WWTW with reinforced concrete septic tank, pre-treatment, aerobic reactor and settling tank. This is followed by a constructed reedbed which is lined with a Geosynthetic Clay Liner. The effluent from the reedbed is disinfected with gaseous chlorine (assuming this is what will be used at the Water treatment plant). Sludge would be wasted to the septic tank which would be desludged every 6 months to taken to a larger WWTW for processing.

The plants would be designed to treat to the standards as set out in the General Authorisation published in Government Notice No. 665 of 6 September 2013.

5.8 HYDROPOWER PLANTS

The conjunctive use hydropower scheme (i.e. Ntabelanga Dam in conjunction with the Laleni Dam and hydropower scheme), is expected to produce approximately 35 000 kVA on a continuous basis, and this means that the conjunctive scheme will not only be "self-sufficient" in its energy usage for potable and irrigation water supply needs, but will also supply surplus energy into the local grid at the rate of 22 000 kVA continuously

The proposed infrastructure configuration to generate hydropower is the development of a storage structure at the identified Lalini dam site; and the development of an approximately seven kilometre long tunnel to drop and discharge the releases approximately 330m into the Tsitsa River gorge downstream of the Tsitsa Falls.

The temperature of the water released from the Lalini hydropower plant will be controlled by the conditions in the proposed Lalini Dam near the intake. Downstream, the temperature is
modified by ambient conditions and the inflow of the Ngcolora tributary. The increase in temperature from the outlet will be negligible.

In South African dams the thermo cline (the change from warm surface water to cold bottom water) occurs at about 8 m below surface. Both dams are deeper than this and especially during summer water released from the bottom of the dam will be colder than water that occurred in the river before the dam was constructed. This will only affect the reach of river between the dams and the confluence of the Tsitsa River and Koi River.

Benthic macro-invertebrates are sensitive to temperature and will move within the stream to find areas where their specific optimal temperature is obtained. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die. For fish, there are two kinds of limiting temperatures:

1. Changes temperature for short exposures; and
2. A weekly average temperature that varies according to the time of year; and the life cycle stage of the fish species. Reproductive stages (spawning and embryo development) are the most sensitive stages.

Due to the low fish community diversity and sensitivity in the Tsitsa River, the significance of impacts by the proposed dams on altered temperature regimes, affecting fish ecology is considered limited. Although a diverse and sensitive aquatic macro-invertebrate community occurs in the system the impact of altered temperature regimes in the system is considered limited as invertebrates will relocate to adapt to the changes in temperature. However it must be noted that aquatic communities are more sensitive to rapid changes in temperature than the absolute change within reason. Therefore management should strive to ensure that releases from the dame lead to a gradual change in temperature and avoid creation of a temperature change shock.

5.9 FLOW GAUGING WEIRS

Five new flow measuring weirs will be required in order to measure the flow that is entering and released from the dams. These flow gauging points will be important for monitoring the implementation of the Reserve and for operation of the dams.

Each weir will take about three months to construct and will be a low concrete structure with erosion control measures on both banks to prevent out-flanking. It is envisaged that construction of the weirs will form part of the dam construction contract.

Sedimentation will occur upstream behind the weir structures. Although this is unavoidable, no mitigation is required as this will not impact on the water quality downstream of the weir and the extent of habitat alteration will be very limited.

6. IMPACT ASSESSMENT FOR DAMS AND ASSOCIATED WATER INFRASTRUCTURE

This Chapter presents the findings of the environmental impact assessment for the dams and associated activities (DEA Ref no. 14/12/16/3/3/2/677).

The activities assessed under this chapter are listed below:

- The Ntabelanga and Lalini Dams;
- Five flow gauging weirs;
- Primary and secondary bulk potable water infrastructure:
    - Primary infrastructure: main water treatment works, including four major treated water pumping stations and three minor treated water pumping stations, main bulk treated water rising mains, and eight Command Reservoirs that will supply the whole region;
    - Secondary distribution lines: conveying bulk treated water from Command Reservoirs to existing and new District Reservoirs;
- Bulk raw water conveyance infrastructure (abstraction, pipelines, one raw water pumping station, one reservoir and two booster pumps) for irrigated agriculture (raw water supply up to field edge);
- Impact of commercial agriculture in earmarked irrigation areas;
- WWTWs at the Ntabelanga and Lalini Dam sites;
- Accommodation for operational staff at the Ntabelanga and Lalini Dam sites;
- Eight construction materials quarries and borrow pits;
- River intake structures and associated works;
- Information centres at the two dam sites; and
- Miscellaneous construction camps, lay down areas, and storage sites.

6.1 CONSTRUCTION AND DECOMMISSIONING PHASES

The following key impacts on water quality have been identified for the construction, first filling and decommissioning phases.

6.1.1 Impact on river water quality: Contamination of river water by construction materials and the discharge of waste from the construction site.

Lalini and Ntabelanga Dams and associated infrastructure

Some impacts on water quality may occur during the construction and decommissioning phases. These have to do with possible contamination of the river by construction materials, as well as the discharge of waste from the construction site. During construction some increases in sedimentation of the Tsitsa River system and ultimately the Mzimvubu River system is deemed likely. The significance of these impacts is however considered limited as the duration of the impact will be limited to relatively short periods of time. These occurrences are governed by the National Water Act, and as long as this is adhered to, the effect will be minimal. This applies at both sites, namely the proposed Ntabelanga dam and the proposed Lalini dam.

Recommended mitigation:

As long as the construction site and the construction activities are managed properly in accordance with accepted practice, incidences of contamination should only occur under extraordinary circumstances.

Table 24: Assessment of Water Quality Impacts during the construction and decommissioning phases

Impact on river water quality: Contamination by construction materials	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Ntabelanga Dam and associated infrastructure							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium -Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 1 (preferred) and associated infrastructure							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium -Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 2 (alternative) and associated infrastructure							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium -Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 3 (alternative) and associated infrastructure							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium -Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

6.1.2 Impacts during first filling of the dam: The creation of anoxic conditions due to decomposition of organic material.

Lalini and Ntabelanga Dams and associated infrastructure

A potential problem that could occur is that any vegetation that is left in the dam basin will begin to decompose once the dam basin is filled with water. This will create anoxic conditions that may persist for a considerable period of time, and will pose a risk to downstream aquatic life, will render the dam basin itself unfit to support aquatic life, and will cause problems at the water treatment plant. The anoxic zone may exist as close as two meters from the surface.

Factors that should be considered when determining if de-bushing is required include:

- the depth of the water in storage;
- the size of the surface area;
- MAR;
- current and expected future water quality;
- land cover; and
- planned future use of the water surface.

The following general principles regarding dam basin clearing are recommended:

The Developer should generally not de-bush the dam basin except for a 300 m stretch upstream of the entire dam wall (in order to prevent blocking of the outlet works and safety boom). Exceptions (i.e. basins that should be selectively de-bushed up to a predetermined level below the FSL depending on the nature of the dam) should be identified on a case by case basis and could include:

- Cases where commercial fish harvesting is viable;
- Cases where current or future water quality indicate that potential negative impacts could be caused by rotting vegetation;
- Cases where the recreational use of the dam is envisaged and requires the removal of potential dangerous obstacles and
- If cleared strips are required for silt surveys in the future.

This does not address the issues of community collection of plant material or plant rescue for bio-diversity conservation purposes.

The proposed Ntabelanga Dam and Lalini Dam sites both have a very small woody component with the area dominated by grass. Bush removal is recommended, but the amount of biomass is too little to cause serious oxygen depletion even over the short term.

Recommended mitigation:
In the cases where clearing is recommended the following principles should apply:

- Vegetation clearing should generally be understood to include trees and bushes, and to exclude grass. Identified very large trees may be left.
- The roots of plants should not be removed, but plants should rather be cut down close to ground level with a chain-saw.
- Topsoil should not be disturbed.
- The material that is removed will first be made available to the communities in the area.
- Non-commercial material to be removed should be burned in a hot fire in order to minimise air quality impacts. This can be achieved by stacking the material in rows and burning on a windy day.

- The areas of the basin that are cleared/ not cleared should be marked on a map for future use.

Table 25: Water Quality Impacts during first impoundment of the dam

Creation of anoxic conditions	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Ntabelanga Dam and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Low	Medium	Very low
Lalini Dam size 1 (preferred) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 2 (alternative) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 3 (alternative) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

6.2 OPERATIONAL PHASE

The following key impacts on water quality downstream of the dams and associated infrastructure have been identified for the operation phase.

6.2.1 Water Quality (Downstream effects): Temperature and Oxygen

Lalini and Ntabelanga Dams and associated infrastructure

The storage of a large quantity of water in the proposed dams could lead to eutrophic conditions and an increase in salinity due to the concentrating effect of evaporation losses. These problems tend to be accentuated during periods of prolonged low inflow.

The release of cold and anaerobic bottom water during periods when the dams become stratified could impact on water quality.

Recommended mitigation:

- The installation of multiple level outlets and proper operation will completely mitigate the effect of water quality changes downstream of the proposed dam.

Table 26: Water Quality Impacts (Downstream effects): Temperature and Oxygen

Water Quality (Downstream Effects): Temperature and Oxygen	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Ntabelanga Dam and associated infrastructure							
Without Mitigation	Regional	Long term	Medium	High	High	High	Medium-high
With Mitigation	Site	Short term	Negligible	Low	Improbable	High	Very Low
Lalini Dam size 1 (preferred) and associated infrastructure							
Without Mitigation	Regional	Long term	Medium	High	High	High	Medium-high
With Mitigation	Site	Short term	Negligible	Low	Improbable	High	Very Low
Lalini Dam size 2 (alternative) and associated infrastructure							
Without Mitigation	Regional	Long term	Medium	High	High	High	Medium-high
With Mitigation	Site	Short term	Negligible	Low	Improbable	High	Very Low
Lalini Dam size 3 (alternative) and associated infrastructure							
Without Mitigation	Regional	Long term	Medium	High	High	High	Medium-high
With Mitigation	Site	Short term	Negligible	Low	Improbable	High	Very Low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

6.2.2 Impact on water quality: Sediment balance

Lalini and Ntabelanga Dams and associated infrastructure

The sediment balance of the Mzimvubu River and associated estuary will be slightly altered during the life cycle of the project. During the operational phase of the two dams there will be reduced sediment input to areas below the dams. Although the reduced sediment load may lead to increased erosion and armouring of the river downstream of the dams this impact is not considered highly significant. The aquatic macro-invertebrate community of the Tsitsa River relies on fast flowing water and a substrate free of sediments on the rocky substrate. The reduced sediment load downstream of the dams therefore has the potential to improve the aquatic ecology in these sections of the system.

The Mzimvubu catchment is severely impacted by the erosion of soils due to the highly erodible nature of the soils in the catchment as well as the topography in the catchment and the associated agricultural practices in the catchment. The reduced sediment input that will occur from the Tsitsa River into the Mzimvubu River system is unlikely to lead to negative impacts on the Mzimvubu River and the associated estuary and some improvements in the overall sediment balance of the system is considered possible.

Recommended mitigation:

- There are not many options available to minimise impacts of altered sedimentation downstream of the impoundments however if any areas downstream of the two proposed dams are observed where excessive erosion are occurring, these areas should be rehabilitated immediately. Such measures should be included into the operation management program of the dams.
- In order to minimise the impacts on sedimentation within the dam a sediment management program should be implemented as part of the catchment management plan for the dam catchments and should include awareness training on sustainable agricultural practices.

Table 27: Water Quality impacted by sedimentation

Water Quality (Downstream Effects) : Sediment balance	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Ntabelanga Dam and associated infrastructure							
Without Mitigation	Regional	Long term	Low	Medium	High	High	Medium Low
With Mitigation	Regional	Long term	Negligible	Low	Medium	High	Low
Lalini Dam size 1 (preferred) and associated infrastructure							
Without Mitigation	Regional	Long term	Low	Medium	High	High	Medium Low
With Mitigation	Regional	Long term	Negligible	Low	Medium	High	Low
Lalini Dam size 2 (alternative) and associated infrastructure							
Without Mitigation	Regional	Long term	Low	Medium	High	High	Medium Low
With Mitigation	Regional	Long term	Negligible	Low	Medium	High	Low
Lalini Dam size 3 (alternative) and associated infrastructure							
Without Mitigation	Regional	Long term	Low	Medium	High	High	Medium Low
With Mitigation	Regional	Long term	Negligible	Low	Medium	High	Low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

Flow Gauging Weirs

Sedimentation will occur upstream behind the weir structures. Although this is unavoidable, no mitigation is required as this will not impact on the water quality downstream of the weir and the extent of habitat alteration will be very limited.

Recommended mitigation:

No mitigation required.

Table 28: Water Quality Impacts: Sedimentation upstream of weirs

Sedimentation upstream of weirs	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Ntabelanga Dam and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Low	Medium	Very low
Lalini Dam size 1 (preferred) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 2 (alternative) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 3 (alternative) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

6.2.3 Impact on water quality: Salinity

The impact on water quality by fertilizers contained in the runoff from irrigated areas was determined by calculating the potential salinity level in the dam. There will be a slight increase in the conductivity and phosphorous levels in the dam. Although this is relevant, it is not significant and the water quality still falls within the ideal range.

Recommended mitigation:

No mitigation is recommended as the water quality falls within the ideal range.

Table 29: Water Quality Impacts: Salinity

Salinity	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Ntabelanga Dam and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Low	Medium	Very low
Lalini Dam size 1 (preferred) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 2 (alternative) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Lalini Dam size 3 (alternative) and associated infrastructure							
Without Mitigation	Local	Short term	Low	Low	Low	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

6.2.4 Impact assessment for electricity generation and distribution infrastructure

This Chapter presents the findings of the environmental impact assessment for the electricity generation and distribution related activities (DEA Ref no. 14/12/16/3/3/2/678).

The activities assessed under this chapter are listed below:

- Pipeline and tunnel (including tunnel alternatives) at the proposed Lalini Dam;
- Generation of hydro power and feeding of this power into the existing grid; and
- 18.5km power line from the Lalini Dam tunnel.

6.3 CONSTRUCTION AND DECOMMISSIONING PHASES

The following key impacts on water quality have been identified for the construction and decommissioning phases:

6.3.1 Impacts during the construction of the electricity generation and distribution infrastructure

Some impacts on water quality may occur during the construction and decommissioning phases. These have to do with possible contamination of the river by construction materials. These occurrences are governed by the National Water Act, and as long as this is adhered to, the effect will be minimal. This applies to the proposed Lalini Dam site.

Table 30: Water Quality Impacts during the construction of the electricity generation and distribution infrastructure

Contamination by construction materials	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Peak power generation with hydropower tunnel and power line alternative 1							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Peak power generation with hydropower tunnel and power line alternative 2							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Peak power generation with hydropower tunnel and power line alternative 3							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Base-load power generation and with hydropower tunnel and power line alternative 1							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Base-load power generation with hydropower tunnel and power line alternative 2							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Base-load power generation with hydropower tunnel and power line alternative 3							
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

6.4 OPERATIONAL PHASE

The following key impacts on water quality have been identified for the operational phase.

6.4.1 Water Quality (Downstream effects)

Water quality changes (temperature) in the river downstream of the proposed hydropower plant outlet.

Table 31: Water Quality Impacts during the operation of the electricity generation and distribution infrastructure

Water quality changes (Temperature)	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Peak power generation with hydropower tunnel and power line alternative 1							
Without Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Peak power generation with hydropower tunnel and power line alternative 2							
Without Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Peak power generation with hydropower tunnel and power line alternative 3							
Without Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Base-load power generation and with hydropower tunnel and power line alternative 1							
Without Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Base-load power generation with hydropower tunnel and power line alternative 2							
Without Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Base-load power generation with hydropower tunnel and power line alternative 3							
Without Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *The increase in water temperature from the outlet is negligible and does not require any mitigation.*							

7. IMPACT ASSESSMENT FOR ROADS INFRASTRUCTURE

This Chapter presents the findings of the environmental impact assessment for the road infrastructure (DEA Ref no. 14/12/16/3/3/1/1169).

The activities included under this chapter are listed below:

- Upgrading and relocation of roads and bridges;
- Construction of new access roads around the Lalini Dam site.

7.1 CONSTRUCTION AND DECOMMISSIONING PHASES

The following key impacts on water quality have been identified for the construction and decommissioning phases:

7.1.1 Impacts during the construction of the road infrastructure

Some impacts on water quality may occur during the construction and decommissioning phases. These have to do with possible contamination of the river by construction materials. These occurrences are governed by the National Water Act, and as long as this is adhered to, the effect will be minimal. This applies to the proposed upgrading, realignment and construction of access roads.

Table 32: Water Quality Impacts during the construction of the road infrastructure

Contamination by construction materials	Extent	Duration	Intensity	Potential for irreplaceable loss of resources	Probability	Confidence	Significance
Without Mitigation	Regional	Medium term	Medium	Medium	High	Medium	Medium - Low
With Mitigation	Site	Short term	Negligible	Low	Improbable	Medium	Very low
Cumulative Impact – *Additional loss of in stream and riparian habitat may occur downstream of the two dams.*							

7.2 OPERATIONAL PHASE

There will be no impacts on water quality of the Tsitsa River during the operation of the access roads.

8. IMPACT ASSESSMENT FOR THE NO PROJECT ALTERNATIVE

From the impacts assessed in the previous sections, it is clear that sedimentation and stratification are of main concern. The impacts of these conditions will be relevant but insignificant. From a water quality perspective, the no project alternative will best ensure maintenance of the existing water quality in the system.

9. RECOMMENDED MITIGATION MEASURES

9.1 WATER QUALITY FROM THE PROPOSED DAM

No water quality problems are expected, and no mitigation is required.

9.2 WATER QUALITY EFFECTS DOWNSTREAM OF THE DAM

Some effects as a result of stratification, namely the release of cold and anaerobic water, can be expected. This can effectively mitigated by the installation of a multiple level outlet structure. It is recommended that the outlets be positioned at intervals of up to 6.5 m, starting 7 m below full supply level.

9.3 IMPACTS DURING CONSTRUCTION

9.3.1 Baseline water quality monitoring

The objective of the baseline water quality monitoring is to provide a background record against which the performance of the environmental management plan can be assessed. As such two conditions have to be considered, namely the construction phase and the operational phase. During the construction phase the impact is from the discharge of waste and waste water from the various construction activities, while during the operational phase the impact will be from storing water in the proposed dam, and the transfer of water from one catchment to another.

Construction Phase

Any waste water and/or storm water that is discharged during the construction phase will have to comply with the requirements of the National Water Act, specifically with the conditions set by the General Standard (Regulation 9225, Government Gazette, 18 May 1984) unless a licence is issued that sets specific standards for selected variables.

It is recommended that samples for a comprehensive analysis are collected at the recommended sites for baseline monitoring, in order to establish a more exact relationship between the variables that are measured as part of the National Water Quality Monitoring Network and the additional variables that are required for the baseline study. This can then be used for the purposes of correlation, should this be required.

Variables

The baseline monitoring should consider those variables that describe the fitness for use of all possible downstream users. This can only be done if guidelines are available, as without guidelines it is not possible to assess the impact. For this reason the variables that are considered in the South African Water Quality Guidelines should be used. The variables for which guidelines are available are shown in the table below (an **X** indicates that guidelines are available, shaded variables denote General Standard variables). Only four user groups were considered, as the variables that apply for human consumption also apply to livestock watering (the guideline values are different), and the same applies for aquaculture and the aquatic ecosystem.

Table 33: Water quality variables for which guidelines are available

Variable	User Group			
	Domestic	**Irrigation**	**Ecosystem**	**Recreation**
Aluminium	X	X	X	
Ammonia	X		X	
Arsenic	X	X	X	
Asbestos	X			
Atrazine	X		X	
Beryllium		X		
Boron		X		
Cadmium	X	X	X	
Calcium	X			
Chloride	X	X		
Chlorine			X	
Chromium	X	X	X	
Cobalt		X		
Coliforms (F)		X		
Colour	X			
Copper	X	X	X	
Corrosion	X	X		
Cyanide			X	
Dissolved Organic Carbon	X			
Dissolved Oxygen			X	
Endosulfan			X	
Fluoride	X	X	X	
Indicator Organisms	X			X
Iron	X	X	X	
Lead	X	X	X	

Variable	User Group			
	Domestic	Irrigation	Ecosystem	Recreation
Lithium		X		
Magnesium	X			
Manganese	X	X	X	
Mercury	X		X	
Molybdenum		X		
Nickel		X		
Nitrate	X			
Nitrogen (Inorganic)		X	X	
Odour	X			X
pH	X	X	X	X
Phenols	X		X	
orus (Inorganic)			X	
Potassium	X			
Radioactivity	X			
Selenium	X	X	X	
Settleable Matter (Susp Solids)	X	X	X	
Sodium	X	X		
Sodium Adsorption Ratio		X		
Sulphate	X			
Trihalomethanes	X			
Temperature			X	
TotalDissolved Solids (Cond)	X	X	X	
Total Hardness	X	X		
Turbidity	X			X
Uranium		X		
Vanadium	X	X		
Zinc	X	X	X	

The proposed development will not affect all of the variables, nor are all of the variables relevant in the affected catchments (Uranium and radioactivity are examples of this), while other variables are not practical to measure (odour). Some variables are calculated from the concentrations of measured variables (Sodium Adsorption Ratio, Total Hardness, Corrosivity). The approach is therefore to use primarily those variables that are listed as part of the General Standard, and also those variables that were identified as variables of concern during the water quality study.

The variables that should be measured in terms of the General Standard are:

- Colour (Cobalt-Platinum Units)
- pH (pH Units @ 25 °C)
- Dissolved Oxygen (mg/l O2) (To be measured in situ)
- Faecal Coli (CFU/100ml)
- Temperature (°C) (To be measured in situ)
- Chemical Oxygen Demand (mg/l)
- Oxygen Absorbed (mg/l)
- Conductivity (mS/m @ 25 °C)
- Suspended Solids (mg/l)
- Sodium (mg/l Na)
- Soap, oil, grease (mg/l)
- Residual chlorine (mg/l Cl)
- Free and saline ammonia (mg/l N)
- Arsenic (mg/l As)
- Boron (mg/l B)
- Hexavalent chromium (mg/l Cr)
- Total chromium (mg/l Cr)
- Copper (mg/l Cu)
- Phenolic compounds (mg/l phenol)
- Lead (mg/l Pb)
- Cyanides (mg/l Cn)
- Sulphides (mg/l S)
- Fluoride (mg/l F)
- Zinc (mg/l Zn)
- Manganese (mg/l Mn)
- Cadmium (mg/l Cd)
- Mercury (mg/l Hg)
- Selenium (mg/l Se)

Some of these variables can be expected to be absent, or if present, occur in trace concentrations. However, confirming this will represent information that otherwise could be held in doubt.

- Calcium (mg/l Ca)
- Magnesium (mg/l Mg)
- Sulphate (mg/l SO_4)
- Fluoride (mg/l F)
- Chloride (mg/l Cl)
- Nitrate/Nitrite (mg/l NO_3 / NO_2)
- Potassium (mg/l K)
- Aluminium (mg/l Al)
- Phosphate (mg/l PO_4)
- Total Alkalinity (mg/l $CaCO_3$)

Sampling Frequency

Construction is scheduled to start in July 2015, and therefore less than one year of sampling is available to establish baseline conditions. However, site establishment will take some time, and it can be accepted that more time is available before any serious disturbance to the river occurs.

In order to determine accurate statistic parameters for the baseline condition, monitoring should be conducted over at least one year in order to detect seasonal variations. At the same time a total of at least 19 measurements are required in order to determine the 95th percentile value. Water quality data is under normal conditions highly correlated, and collecting samples at too short an interval will generate data that are not statistically independent. A sampling interval of at least two weeks is recommended in order to ensure the statistical independence of the measurements. A fortnightly sampling programme over one year will yield 27 results, which will be adequate to calculate statistical parameters at a reasonable confidence (± 10%).

A sampling interval of two weeks is therefore recommended.

A one year sampling programme is not sufficient to detect trends, but the historic data from the DWS can be used for this purpose.

Sampling Protocol

The sampling protocol as prescribed by the laboratory that will perform the analyses must be followed. In the absence of a clear sampling protocol, the guidelines presented in Water Research Commission Report No: TT 117/99 must be followed.

Sample Analyses

Measurements and analytical processes must conform to the appropriate SANS, or to the Standard Methods if no SANS method is applicable.

Sampling Sites

For the purposes of compliance monitoring, upstream and downstream samples should be collected during the construction period. For the purposes of establishing the baseline conditions, four sampling sites are recommended, one upstream of the Ntabelanga Dam, one downstream of the Ntabelanga Dam, one downstream of the Lalini Dam and one downstream of the Ngcolora tributary. The sites should be chosen such that they will not be directly affected by construction activities, or inundated after completion of the proposed dam.

Operational Phase

During the feasibility study and the subsequent EIA, no variables of concern were identified that do not form part of the list proposed above. There is therefore no need to expand the programme in terms of variables.

9.3.2 Water Management

General

The Contractor shall submit a Water Management Method Statement (WMMS), including measures for water conservation, for approval to the Engineer prior to the commencement of works.

The WMMS should include an indication of how water and wastewater/effluent will be managed at/with respect to (i) camps and associated facilities, including batching/mixing plants; (ii) excavations, (iii) pumping operations, (iv) cleaning and washing bays, (v) site drainage (silt and erosion control), (vi) storm water, and (vii) river/wetland and erosion gulley crossings.

The Contractor shall take all necessary precautions and properly deal with and dispose of all water, in accordance with the specification to ensure that:

- the Works are kept sufficiently dry at all times for their proper and safe execution;
- there is no deleterious impact on the environment and adjacent properties; and
- damage, inconvenience or interference arising from flood waters is prevented.

Such operations shall continue for the duration of the Contract and shall at all times be subject to the agreement of the Engineer with regard to the sufficiency of measures and the degree of environmental protection achieved.

The Contractor shall minimise the use of water and shall immediately attend to any wastage. Natural water sources (e.g. springs, streams, open water bodies) shall not be used as a source of water by the Contractor without the Engineer’s approval.

On completion of the Works, all temporary diversions, protective works and dewatering systems shall be removed by the Contractor. Affected areas shall be rehabilitated according to the specifications.

Quality and quantity monitoring

The Contractor must appoint a suitably qualified water quality specialist for approval by the Engineer to implement a water quality monitoring programme for monitoring the water quality in the Tsitsa River only.

The Water Management Method Statement must include monitoring and reporting mechanisms that cover all water abstractions from the river or any other water source, waste discharge, soil erosion and water quality aspects.

The Water Management Method Statement must include measures to prevent the pollution of any river, stream or wetland with grease, hydrocarbons, suspended solids or other contaminants emanating from construction activities, these measures shall include a site plan, approved by the Engineer, on which is shown monitoring points of all treated or un-treated discharges to a public stream (considered to be industrial wastewater for this purpose) where monitoring of flow rate and quality will be undertaken in accordance with the requirements of Schedule 3 of Government Notice 665 published in Government Gazette No 36820 dated 6 September 2013.

The flow rate and quality of all potential discharges of treated and un-treated waste water from the construction site, at points marked on a site plan in the WMMS for approval by the Engineer, will be monitored in accordance with the requirements of Schedule 3 of Government Notice 399 published in Government Notice 665 published in Government Gazette No 36820 dated 6 September 2013.

Water sampling must follow a clear protocol specified by the laboratory that will perform the analyses. Measurements and analytical procedures must conform to the relevant SANS.

All discharges from settlement ponds, sewage treatment works, batching plants, washing areas and any other areas must be sampled and tested at points approved by the Engineer. The quality of point discharges shall comply with the criteria given in **Table 34**. Water quality monitoring reports must be submitted to the Engineer within 10 days of taking the sample.

Table 34: List of Water Quality Variables to be Sampled at the Discharge Point

VARIABLE	REQUIRED EFFLUENT STANDARD
Arsenic (as As)	Not to exceed 0.1 mg/ ℓ
Boron (as B)	Not to exceed 0.5 mg/ ℓ
Cadmium (as Cd)	Not to exceed 0.05 mg/ ℓ
COD	Not to exceed 5 mg/ ℓ
Colour, odour, taste	Free of any substance in a concentration capable of producing any colour, odour or taste
Conductivity	Not to exceed 250 mS/m
Copper (as Cu)	Not to exceed 0.02 mg/ ℓ
Cyanide (as Cn)	Not to exceed 0.5 mg/ ℓ

VARIABLE	REQUIRED EFFLUENT STANDARD
Dissolved oxygen	At least 75% saturation
Faecal coliforms Thermotolerant (faecal) coliform bacteria	No *E. coli* (0/100 m ℓ) or No Thermotolerant (faecal) coliform bacteria (0/100 m ℓ)
Fluoride (as F)	Not to exceed 1.0 mg/ ℓ
Free & saline ammonia (as N)	Not to exceed 1.0 mg/ ℓ
Lead (as Pb)	Not to exceed 0.1 mg/ ℓ
Manganese (as Mn)	Not to exceed 0.1 mg/ ℓ
Mercury (as Hg)	Not to exceed 0.02 mg/ ℓ
Nitrate (as $N0_3$)	Not to exceed 1.5 mg/ ℓ
Nitrite	Not to exceed 1.0 mg/ ℓ
pH	Between 5,5 and 7,5
Phenolic compound (as phenol)	Not to exceed 0.01 mg/ ℓ
Phosphate (as $P0_4$)	Not to exceed 1.0 mg/ ℓ
Residual Chlorine (as Cl)	Non residual chlorine
Selenium (as Se)	Not to exceed 0.05 mg/ ℓ
Soap, oil, grease	No soap, oil or grease
Sodium	Not to be increased by more than 50 mg/ℓ above influent
Sulphides (as S)	Not to exceed 0.05 mg/ ℓ
Suspended solids	Not to exceed 10 mg/ℓ
Temperature	Maximum of 25°C. In addition the effect of water discharged into watercourses shall not raise the water within the watercourse at a point 500 m downstream of the point of discharge by more than 2°C above the temperature of the water 500 m upstream of the Works
Total Chromium (as Cr)	Not to exceed 0.05 mg/ℓ
Zinc (as Zn)	Not to exceed 0.03 mg/ℓ

<u>Watercourses</u>

The Contractor shall take all necessary measures when working within rivers to ensure that the water quality of these systems is not adversely impacted by the construction activities.

Up and downstream monitoring is required (sites to be determined by specific context and up/downstream land-use/impacts). Pre-construction (baseline) samples must be collected. The final monitoring sample must take place after rehabilitation is complete.

The following variables must be monitored:

- Temperature
- pH
- Electrical conductivity
- Dissolved oxygen
- Suspended solids.

The Engineer may require more detailed testing where there is evidence of contamination.

Water quality sampling at the upstream and downstream monitoring sites will be made at the same time –around noon - each day. The maximum “allowable limit of change” in any water quality parameter at the downstream monitoring point should not be greater than 10 % above the value for the respective water quality parameter measured at the upstream monitoring point. Careful records shall be kept of all occasions when the water quality at a downstream monitoring point has exceeded the limits of allowable change.

Should the values of any of these key indicator variables at the downstream site vary by 10 per cent or more relative to measurements of the same variables taken at approximately the same time at the upstream site, it could indicate that associated changes have occurred in some of the other water quality variables. Immediate mitigation action will be required on the site and water samples should be collected as soon as possible and sent to the accredited analytical laboratory for analysis of the full list of river and wetland variables (**Table 35**). The laboratory should be requested to provide the results of these samples within 14 working.

Table 35: Full list of Water Quality Monitoring variables for rivers and wetlands

Parameters and Variable	Testing Frequency	Test Responsibility
COD (mg/l)	Every 2 days when flow is present	Collect sample on site analyse in laboratory
Nitrate and Nitrite (mg/l)	Every 2 days when flow is present	Sample on site & laboratory analysis
Orthophosphates (mg/l)	Every 2 days when flow is present	Sample on site & laboratory analysis
Suspended Solids (TSS) (mg/l)	Every 2 days when flow is present	Sample on site & laboratory analysis
Soaps, oil and grease (mg/l)	Every 2 days when flow is present	Sample on site & laboratory analysis
Free & Saline ammonia (mg/l)	Every 2 days when flow is present	Sample on site & laboratory analysis
Faecal Coliform bacteria (per 100ml)	Every 2 days when flow is present	Sample on site & laboratory analysis
Conductivity (mS/m)	Daily when flow is present	Measure on site using hand-held meter
Dissolved oxygen (% saturation)	Daily when flow is present	Measure on site using hand-held meter
pH	Daily when flow is present	Measure on site using hand-held meter
Temperature	Daily when flow is present	Measure on site using hand-held meter when any one of the key variables deviates by more than 10% from the upstream value at the construction site
Turbidity (NTU)	Daily when flow is present	Measure on site using hand-held meter when any one of the key variables deviates by more than 10% from the upstream value at the construction site

Note: Concentrations of the above variables measured 50m downstream of the works in a water resource system must not differ by more than 10% of concentrations of the same variables measured 300 m upstream of the works.

As soon as practically possible, each incident of water contamination shall be investigated, the contamination source(s) located and mitigatory measures implemented to prevent further contamination. A set of confirmatory measurements shall be taken after the implementation of remedial/mitigatory actions to demonstrate that the problem has been dealt with successfully.

<u>On-site management</u>

Storm water and site drainage

Storm water drainage lines shall be constructed by the Contractor to divert runoff water around the construction site to prevent contamination of the water and collection of water in excavations.

All storm water drainage lines shall contain water flow arrestors to prevent erosive action on the sides of the drainage lines.

The Contractor shall not alter or damage existing drainage lines, levees or dams or modify the course or channel of water courses without the prior approval of the Engineer. The Contractor must ensure that all storm water lines are reinstated or rehabilitated on completion of construction activities.

The Contractor must submit a storm water management method statement to the Engineer for approval before the start of construction. The method statement must take into account relevant sections of the specifications.

Settlement ponds

The Contractor shall obtain the Engineer's approval for all settlement pond designs. Temporary settlement ponds must be constructed and maintained by the Contractor for the settling out of suspended solids. Each pond must be of sufficient capacity to allow for the steady through flow of waste water without threat of this water contaminating natural water courses. The ingress of water from natural water courses into settling ponds must be prevented.

Flocculants may need to be used if the settling ponds do not achieve the desired reduction in the concentration of suspended solids. The disposal of flocculated sludge will conform to the specifications for waste disposal.

Crossing of aquifers

A method statement shall be required to be submitted to the Engineer for approval before commencement of any works.

Where the aquifer is directly affected by the Works (i.e. the excavation will be through permeable / water-bearing strata), the methodology employed must ensure that contamination of the aquifer is prevented. Therefore, appropriate measures must be used to prevent the possible migration of pollutants or contaminated water from entering the aquifer.

Disposal of water into the receiving environment from dewatering operations will not proceed in areas overlying known aquifers. All contaminated water must be removed and dealt with outside a buffer zone 50 m around the aquifer.

Working in rivers and wetlands

The Contractor will ensure that adequate measures are in place to prevent contamination of natural water bodies. These measures will include coffer dams or pumping water from the point of source to be treated before release back into the system.

No impediment to the natural water flow other than approved erosion control works and Engineer approved river and wetland crossings shall be permitted. In addition, such crossings shall be performed according to the Engineer approved methodology for construction.

The Contractor must ensure substratum restoration during the rehabilitation phase of the contract. Impermeable clay layers must be recreated / restored to reinstate the sub-surface hydrology and to ensure that perched water tables sustaining wetland habitats are kept intact. Any impermeable layers encountered within the wetland, shall be recorded, and their depths and types noted. These layers will need to be recreated during rehabilitation. The Contractor shall submit to the Engineer for approval, a method statement that deals specifically with the restoration of impermeable substratum layers prior to the commencement of works.

Trench excavations and dewatering

The ingress of water into the trench excavation must be prevented with the placement of suitably constructed berms or drainage lines on either side of the trench. Topsoil or other excavated material shall be prevented from being washed away or allowed to contaminate the storm water.

Trenches shall be re-filled to the same level and state of compaction as the surrounding land surface to minimise erosion. Excess soil shall be stockpiled in accordance with the specifications.

Water that has entered the trench or found naturally underground must be removed from the working area in order to complete the safe and effective laying of the pipeline. Such water may not be pumped to or be allowed to drain directly into a water course, drainage line or wetland. Water removed from trenches during dewatering operations must be pumped at low pressures into suitable settling ponds for treatment (where necessary) to attain compliance to the water quality concentration limits (**Table 36**) prior to release from site. The water may not be used to irrigate a landowner's crops.

The Contractor shall prevent hydrocarbon spillage within the trench. All visible hydrocarbon spillages shall be skimmed off or removed by suitable methods before dewatering and shall be disposed of in terms of the specifications for waste management.

Pump attendants must be designated and trained to manage pumps in a responsible manner, ensuring no environmental degradation occurs whilst maintaining the pumps efficacy. All pumps must be fitted with drip trays and be securely placed to prevent the pumps from accidentally falling into the trench. Should pumps leak any hydrocarbons, the pumps will immediately be switched off and receive the appropriate off-site maintenance. All pumps will be operated and maintained in a good working condition at all times.

<u>Cleaning and Washing</u>
Washing of tools and/or equipment shall take place at dedicated washing facilities within the construction camps. Suitable wash facilities must be provided at all construction camps and all wastewater must be treated before discharge into any natural watercourse.

No surface run-off of oils, cement, litter, paints etc. which could pollute or alter current water quality are to be deposited into the river system or nearby streams and rivers. Any abstraction of water for construction purposes must be approved by DWS. Prevention and mitigation measures must be implemented to ensure water quality is not adversely affected by such abstraction.

<u>Silt and erosion control</u>
The Contractor shall implement measures to prevent, reduce and mitigate water contamination, including prevention of contamination by suspended sediments. The Contractor shall provide proper storm water drainage plans that shall not concentrate water on downstream receiving streams or water courses. Storm water shall be diverted to lessen its erosive impact upon the surrounding environment. All material and soil stockpiles will be managed to prevent erosion in accordance with the specifications.

Any runnels or erosion channels that develop during the construction period or during the vegetation establishment period shall be backfilled and compacted, and the areas restored by the Contractor in accordance with the specifications for rehabilitation.

<u>Oil interceptor</u>
Oily waters and contaminated waters arising from vehicle refueling yards, vehicle-washing facilities and vehicle maintenance yards will be directed to an impermeable oil/water interceptor. Separation tanks and oil interceptors will be inspected on a weekly basis. Hydrocarbons collected from the oil interceptor will be collected and pumped to a storage tanker for disposal or recycling at an appropriate facility. The Contractor shall set up a waste register and log the volumes of all contaminated water removed from site for

disposal. The Contractor shall obtain a waste disposal certificate from the registered general/hazardous waste landfill site or recycling company.

Oil separators will be installed in the drainage systems of diesel and oil storage facilities, and will be connected to a discharge system. A sketch of the discharge system comprising relevant data (depth, dimensions, etc.) must be provided by the Contractor on site for any required intervention or maintenance operation. These facilities will be inspected regularly by the Environmental Officer to ensure they are functioning correctly.

Construction waste water

The Contractor shall prevent discharge of any pollutants, such as cements, concrete, lime, chemicals and fuels into any water sources. Water from kitchens, showers, sinks, workshops, etc. shall be discharged into the prescribed waste water treatment works. Runoff from fuel storage areas / workshops / vehicle washing areas and concrete swills shall be directed via an oil separator into a settlement pond and this will be disposed of at a site approved by the Engineer. Appropriate measures to prevent water pollution at/from batching plants must be implemented.

Water not disposed of as above, must comply with the other environmental requirements if it is to be recycled or re-used.

Recycling water

Water derived from or generated through construction related activities that becomes contaminated must be treated to ensure compliance with Water Quality Monitoring Specifications before being released back into the environment. The Contractor shall re-use or recycle as much of this water as possible. Water whose quality meets these standards and is approved by the Engineer may be used for the irrigation of rehabilitated areas. Irrigation of agricultural lands shall not be permitted with water impacted by Construction activities.

9.4 IMPACTS DURING FIRST IMPOUNDMENT OF THE DAM

The water quality could be affected by decomposing vegetation once the dam starts to fill. Seeing that both the Ntabelanga Dam and Lalini Dam have a very small woody component with the area dominated by grass, bush removal is recommended, but the amount of biomass is too little to cause serious oxygen depletion even over the short term

9.5 IMPACTS DURING THE OPERATION OF THE DAM

If any areas downstream of the two proposed dams are observed where excessive erosion is occurring, these areas should be rehabilitated immediately. Such measures should be included into the operation management program of the dams.

In order to minimise the impacts on sedimentation within the dam a sediment management program should be implemented as part of the catchment management plan for the dam catchments and should include awareness training on sustainable agricultural practices.

10. CONSULATION PROCESS

10.1 CONSULTATION PROCESS FOLLOWED

PUBLIC PARTICIPATION

Engagement with Interested and Affected Parties (I&APs) forms an integral component of the EIA process. I&APs have an opportunity at various stages throughout the EIA process to gain more knowledge about the proposed project, to provide input into the process and to verify that their issues and concerns have been addressed.

The proposed project was announced in April 2014 to elicit comment from and register I&APs from as broad a spectrum of public as possible. The announcement was done by the following means:

- The distribution of Background Information Documents (BIDs) in English and IsiXhosa;
- Placement of site notices in the project area and Municipal offices (Tsolo and Qumbu);
- Placement of advertisements in one regional (The Herald) and two local (Daily Dispatch and the Mthatha Fever) newspapers; and
- Publication of all available information on the DWS web site (www.dwa.gov.za/mzimvubu).

The Draft Scoping Report (DSR) was made available for a 30 day public comment period in May 2014. All documents were uploaded to the web, notification letters were sent out, the summary of the DSR was translated into isiXhosa, distributed to all registered stakeholders and hardcopies of the full report and translated summary report were available at public places. Additionally, three public meetings were held in the affected areas, Siqhungqwini, Tsolo and Lalini respectively. An Authorities Forum Meeting with all relevant authorities was held in the Eastern Cape on the 28 May 2014. This was to assist the authorities with commenting on the relevant documentation.

Comments received from stakeholders were captured in the Issues and Response Report (IRR) which formed part of the Final Scoping Report (FSR). The FSR was made available to the public for a 21 day comment period on 13 June 2014 and was submitted to the Department of Environmental Affairs (DEA). Comments received during the Final Scoping public comment period were compiled and an updated IRR was submitted to DEA on 8 July 204 and uploaded to the website. The FSR was accepted by DEA with certain conditions on 15 July 2014. Following this, a newsletter was compiled and translated to isiXhosa, explaining everything that has happened to date as well as what is to come. Both the English and isiXhosa versions were electronically distributed to all registered stakeholders and hardcopies were distributed by the local facilitators in the affected areas.

The Draft Environmental Impact Assessment Report (DEIR), its summary (translated into isiXhosa), the various specialist studies, the Environmental Management Programmes (one for the construction and operation of the project, and one for the borrow areas and quarries) as well as the Water Use Licence Application will be made available for a period of thirty (30 days) for stakeholders to comment. Hardcopies will be made available at the same venues as the DSR and all documents will be uploaded to the website. The availability of these documents as well as the announcement of the upcoming public meetings in Siqhungqwini, Tsolo and Lalini will be advertised on the Eastern Cape SABC radio station, Umhlobo Wenene FM, which has a listenership of over 4 million people. Another Authorities Forum Meeting is scheduled for September 2014.

Stakeholder comments will be taken into consideration with the preparation of the final documents. The availability of the final documents will be announced prior to submission to the decision-making authority. Once a decision has been made by the DEA, all stakeholders will again be notified.

The following issues were sourced from the Issue and Response Report (Final Version 1) as submitted to the Department of Environmental Affairs with the Final Scoping Report.

10.2 SUMMARY OF COMMENTS RECEIVED

The following issues were sourced from the Issue and Response Report as submitted to the Department of Environmental Affairs with the Scoping Report.

Table 36: Issues Related to water quality

Issue	Person submitted by	When received	Response
An enquiry was made about the areas close to the dam that have been earmarked for irrigated agriculture. Will the EIA consider potential pollution from those areas (e.g. from the use of fertilisers) into the river?	John Geeringh (Eskom)	28.05.2014 AFM	The impact on water quality by fertilizers contained in the runoff from irrigated areas was determined by calculating the potential salinity level in the dam. The results show that the conductivity in the dam will increase by 2%. The contribution from phosphorus will occur in the same ratio as conductivity and will thus also increase by 2%. Although this increase is relevant it is not significant and the water quality still falls within the ideal range.

Issue	Person submitted by	When received	Response
The trees that are surrounding the Tsitsa River that will be inundated may at some point pollute the water. Before the dam is flooded the trees need to be removed.	Sivuyise Mange (Resident)	09.06.2014 via fax	The Ntabelanga Dam and Lalini Dam have a very small woody component with the area dominated by grass. Bush removal is recommended, but the amount of biomass is too little to cause serious oxygen depletion even over the short term
The dams will impact the water quality downstream through nutritional pollution and sedimentation. Has this been considered / investigated?	Isa Thompson	PSC Meeting 28 August 2014	Sedimentation allowance volumes for the Ntabelanga dam catchment and incremental Lalini dam catchment were determined. Initially the sediment load in the river downstream will reduce significantly. This is unavoidable. Coarse sediment will settle at the inlet to the dam and finer suspended material will be carried through. This will have a very limited impact the Tsitsa river and a negligible impact on the Mzimvubu River system and the reduced sediment inputs can potentially be a positive change to the system. A catchment management plan should be developed and should address sediment generation and control in the catchment and any areas of significant erosion downstream of the dams should be rehabilitated.

11. OTHER INFORMATION REQUESTED BY THE AUTHORITY

No other information was requested by the Authority.

12. IMPACT STATEMENT

A summary of the findings of this report is listed below:

- Water quality was assessed in terms of electrical conductivity, pH, nitrate/nitrite and phosphorous. Water quality data was assessed according to a fitness for use range (water quality criteria), which was based on the Department of Water Sanitation’s water quality guidelines.
- A non-parametric statistic analysis was used to calculate the variability in water quality data from the river flow station. For the purposes of this study the 90th percentile was included as it provides an indication of variability and can be used to assess the frequency of excursions into higher and possibly unacceptable water quality conditions.
- The surface water quality is fit for all users and is such that no water quality problems are expected to occur.
- The dam will be able to provide water of an acceptable quality to all users.
- The release of cold and anaerobic bottom water during periods when the dam becomes stratified could impact on the water quality. This can effectively be mitigated by the installation and correct operation of multiple level outlets.
- There is some risk of contamination from construction material and waste discharge during construction. This can be mitigated by the implementation of proper construction methods and effective waste management.
- The sediment balance of the Mzimvubu River and associated estuary will be slightly altered during the life cycle of the project. Sedimentation is unlikely to lead to negative impacts on the Mzimvubu River and the associated estuary and some improvements in the overall sediment balance of the system are considered possible.
- The impact on water quality by fertilizers contained in the runoff from irrigated areas was determined by calculating the potential salinity level in the dam. There will be a slight increase in the conductivity and phosphorous levels in the dam. Although this is relevant, it is not significant and the water quality still falls within the ideal range.
- In terms of water quality there is therefore no significant effect on the environment from the construction of the proposed new dams.

13. CONCLUSION AND RECOMMENDATIONS

The water quality in the Tsitsa system, both with reference to the Tsitsa River is considered to be good. The majority of water quality parameters and element concentrations comply with guidelines consulted.

In terms of “fitness for use” classification, the selected water quality parameters are classified as “ideal” for use.

Given the good water quality any disturbances pertaining to the proposed development, especially during the construction phase, are like to negatively affect water quality status. Mitigation measures should thus be implemented to restrict negative impact on the system.

14. REFERENCES

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