water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

REPORT NO.: P 02/B810/00/0608/02 Annexure H1

GROOT LETABA RIVER WATER DEVELOPMENT PROJECT (GLeWaP)

Environmental Impact Assessment

(DEAT Ref No 12/12/20/978)

ANNEXURE H1: AQUATIC ECOLOGY SPECIALIST STUDY

MARCH 2010

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DECLARATION OF CONSULTANTS' INDEPENDENCE

Peter Kimberg and Cameron von Bratt, ecological consultants of Golder Associates (Pty) Ltd., are independent consultants to ILISO Consulting (Pty) Ltd (for the Department of Water Affairs and Forestry), i.e. they have no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of these specialists performing such work.

REPORT DETAILS PAGE

Project name:	***Groot Letaba River Development Project***
Report Title:	***Environmental Impact Assessment Annexure H: Aquatic Ecology Specialist Study***
Author:	***Golder Associates Africa (Pty) Ltd.***
DWAF report reference no.:	***P 02/B810/00/0708/Volume 2 Annexure H***
Golder Associates Africa (Pty) Ltd. Reference no.:	***10647-10478-1-W***
Status of report:	***Final***
First issue:	***November 2008***
Final issue:	***March 2009***

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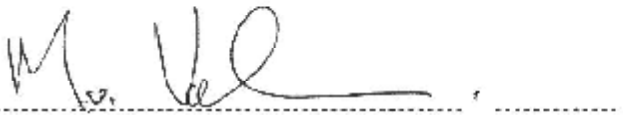

Dr Martin van Veelen
Project Director

EXECUTIVE SUMMARY

The Department of Water Affairs and Forestry (DWAF) is currently undertaking an Environmental Impact Assessment (EIA) to investigate the environmental feasibility of raising the Tzaneen Dam, the construction of a storage dam in the Groot Letaba River and associated bulk water infrastructure (BWI) (water treatment, pipelines, pump stations, off-takes and reservoirs) in the Limpopo province. The EIA is being undertaken according to the EIA Regulations under Section 24 (5) of the National Environmental Management Act (NEMA), (Act No 107 of 1998) as amended in Government Notice R385, 386, 387 – Government Gazette No. 28753 of 21 April 2006.

ILISO Consulting appointed Golder Associates Africa (Pty) Ltd. to undertake the Aquatic Environment Impact Report (EIR) as part of the EIA.

The scope of work as per the submitted and approved Golder proposal (PRO11418) and additional aspects from the original Terms of Reference (ToR) were assessed in terms of the impacts associated with the raising the dam wall of Tzaneen Dam, the construction and operation of the proposed Nwamitwa Dam, the proposed flow gauging weir as well as the BWI on the associated aquatic ecosystems of the Groot Letaba River and its associated tributaries.

The following conclusions were reached based on the results of the baseline assessment:

- *During the November 2007 survey the Present Ecological States (PES) at sites NWA02 and NWA03 in the Nwanedzi River were below the recommended Ecospecs. This could most likely be attributed to the non-perennial nature of the Nwanedzi River and likely represents an under estimation of the actual level of biotic integrity in the river. The presence of the aggressively invasive introduced fish species M. salmoides, may be contributing to the low FAII scores recorded in the Nwanedzi River.*

- *The PES recorded at site LET01 during the November 2007 survey exceeded the recommended Ecospecs for the reach. This is considered to be of importance in the context of this EIA and the existing Reserve Determination Study (RDS).*

- *Oreochromis mossambicus (Mozambique Tilapia) is a Near Threatened (NT) fish species that was recorded at all of the sampling sites during the November 2007 survey.*

O.mossambicus is threatened by hybridization with Oreochromis Niloticus (Nile Tilapia); a North African species introduced for aquaculture purposes. O.mossambicus is generally regarded as a hardy species which is likely to thrive in the Nwamitwa Dam.

- *Based on the FAII assessment biotic integrity within reach EWR3 complied with the recommended Ecospec of C (moderately modified). It should be noted that the November 2007 FAII results were based on a single survey and likely represent an under estimation of the actual level of biotic integrity within the reach.*

The significance of potential impacts on aquatic ecosystems within the dam basin was rated as high prior to mitigation, for construction and operational phases. The riverine habitat that fall within the full supply level of the proposed dam will be unavoidably and irrevocably lost due to inundation, siltation, change in flow regime loss of riparian vegetation and the formation of a largely anaerobic epilimnion (bottom layer of water). It is likely that at least 6 of the 17 fish species currently inhabiting reach EWR3 will permanently disappear from the dam basin due to the loss of specific habitat types. In terms of the 2006 RDS the loss of 6 species will have a negative impact on the PES and may make the Recommended Ecological Class (REC) unattainable. The level of significance after implementation of recommended mitigation decreased to medium, for both phases. Key mitigation measures include:

- *Implementation of a suitable management action plan, based on analysis of monthly water quality and bi-annual biological monitoring data collected at sites upstream, downstream and within the Nwamitwa Dam;*
- *Maintaining natural features such as trees around the proposed dam margin, so as to provide habitats for colonising aquatic biota and perches for aquatic birds;*
- *Preventing further introductions, or the proliferation of introduced fish species such as M. salmoides (Largemouth Bass) within the dam basin;*
- *Maintaining connectivity between fish assemblages and remaining riverine habitats upstream and downstream of the dam by means of a fishway;*
- *Preventing the encroachment of invasive aquatic vegetation such as Water hyacinth (Eichornia crassipes) or Kariba weed (Salvinia molesta);*

The potential significance of impacts on aquatic ecosystems downstream of the dam was rated as medium for both the construction and operational phases. Shifts can be expected in

the natural macroinvertebrate assemblages downstream of the dam due to the changes in the physical and chemical characteristics as well as the modified flows and habitats. This may reduce or eliminate certain taxa thus, while other species, such as Simuliidae sp. (Blackflies) may proliferate. The potential decrease in abundances of 14 fish species and loss or proliferation of certain species within the remaining reach (EWR3) will have a negative impact on the PES and it is uncertain whether the REC and Ecospecs set out in the 2006 RDS will be attainable. The level of significance after implementation of mitigation was rated as low for both phases. Key mitigation measures would include:

- *Ensuring adequate stabilisation of the downstream river bed and banks;*
- *Maintaining connectivity between fish assemblages and remaining riverine habitats upstream and downstream of the dam wall by means of a fishway;*
- *A properly managed timing and release strategy that will ensure that presently existing or naturally seasonal variability in flows are released and or maintained within the downstream Groot Letaba River. This will enable specific ecosystem functions such as migration queues, seasonal floodplain inundation and temperature variations to be maintained.*

The potential significance of an additional migration barrier on migratory fish species in the Groot Letaba River was rated as high for both the construction and operational phases. Sixteen of the 17 indigenous fish species currently occurring within reach EWR3 are likely to be impacted upon in terms of migration potential. The level of significance after implementation of mitigation was rated as medium for both phases. Key mitigation measures include:

- *Identifying remaining riverine habitats upstream and downstream of the Nwamitwa Dam and affording these habitats special conservation significance;*
- *Maintaining connectivity between fish assemblages and upstream and downstream riverine habitats by means of a fishway.*

As a final conclusion, the construction of the GLeWaP, in particular, the construction of the proposed Nwamitwa Dam can proceed, provided that the recommended mitigation measures as set out in this report are implemented. The mitigation measures provide the means to

reduce or even eliminate certain impacts and are therefore considered to be able to ensure continued ecosystem functioning.

With regard to the gaps in knowledge as expressed in this report, the following are required:

- *A genetic assessment of specific fish species upstream and downstream of the proposed Nwamitwa Dam site. This will provide further scientific evidence as to the transfer of genetic material between populations upstream and downstream of the Nwamitwa Dam site and thus provide information as to the connectivity and genetic importance of the reach and give further support to the need to maintain this connectivity at the dam by means of a fishway/fish ladder or not;*

- *A habitat suitability and accessibility study of the area both upstream and downstream of the Nwamitwa Dam site. This will give further scientific evidence of the availability and accessibility of suitable breeding/critical life-stage habitats required by specific fish species. This would enable required habitat areas not impacted by the GLeWaP to be identified, assessed in terms of suitability and accessibility for ecosystem functioning and conserved as a mitigation option; and*

- *A full flow regime maintenance and release management strategy for the proposed Nwamitwa Dam.*

Without these three abovementioned assessments, the level of impact on the migratory fish populations within this river reach (EWR3) is uncertain. In addition, the impact of the ability of any remaining fish species be able to find and access suitable habitats that are required for all the life stages of the species is also uncertain due to the limitations in habitat assessment. The construction of a fish ladder into the dam wall is the immediate solution to the problem of the Nwamitwa Dam as a barrier to fish migration. The option not to put a fish ladder however, will depend on the two additional studies needed (genetics and habitat).

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ABBREVIATIONS

ASPT	Average Score per Taxa
BAP	Biodiversity Action Plan
BWI	Bulk Water Infrastructure
DEAT	Department of Environmental Affairs and Tourism
DO	Dissolved Oxygen
DWAF	Department of Water Affairs and Forestry
COD	Chemical Oxygen Demand
EC	Ecological Category / Electrical Conductivity (Context-dependant)
ECA	Environmental Conservation Act
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMP	Environmental Management Programme
EWR	Ecological Water Requirement
FAII	Fish Assemblage Integrity Index
FROC	Frequency of Occurrence
GLeWaP	Groot Letaba River Water Development Project
GSM	Gravel, Sand and Mud
IHAS	Invertebrate Habitat Assessment System (Version 2)
IUCN	International Union for the Conservation of Nature
KNP	Kruger National Park
LC	Least Concern
NBA	National Biodiversity Act
NEMA	National Environmental Management Act
NT	Near Threatened

NWA	National Water Act
OA	Options Analysis
PCMT	Project Co-ordination and Management Team
PES	Present Ecological State
pH	Percentage Hydrogen
POP	Persistent Organic Pollutants
PSP	Professional Service Provider
RDM	Reserve Determination Methodology
RDS	Reserve Determination Study
RU	Resource Unit
SASS5	South African Scoring System, Version 5
SCI	Stream Condition Index
SIC	Stones In Current
SOC	Stones Out of Current
TDS	Total Dissolved Solids

1. INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

The Department of Water Affairs and Forestry (DWAF) is currently undertaking an Environmental Impact Assessment (EIA) to investigate the environmental feasibility of raising the Tzaneen Dam, the construction of a storage dam in the Groot Letaba River and associated bulk water infrastructure (water treatment, pipelines, pump stations, off-takes and reservoirs) in the Limpopo Province. The EIA is being undertaken by ILISO Consulting with Zitholele Consulting providing the public participation support. The EIA is being undertaken according to the EIA Regulations under Section 24 (5) of the National Environmental Management Act (NEMA), (Act No 107 of 1998) as amended in Government Notice R385, 386, 387 – Government Gazette No. 28753 of 21 April 2006.

ILISO Consulting appointed Golder Associates Africa (Pty) Ltd. to undertake the Aquatic Ecology Specialist Study as part of the EIA.

1.2 STRUCTURE OF THE REPORT

This specialist study will be undertaken in compliance with regulation 33(2) of GN 385. (**Table 1.1**) indicates how Regulation 33 of GN385 has been fulfilled in this report.

Table 1.1: Indication of compliance with Regulation 33 in this report

REGULATORY REQUIREMENTS	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 2
(B) A declaration that the person is independent	Page I
(C) An indication of the scope of, and the purpose for which, the report was prepared	Chapter 3
(D) A description of the methodology adopted in preparing the report or carrying out the specialised process	Chapter 4
(E) A description of any assumptions made and any uncertainties or gaps in knowledge	Chapter 5
(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	Chapter 6
(G) Recommendations in respect of any mitigation measures that should be considered by the applicant and the competent authority	Chapter 7
(H) A description of any consultation process that was undertaken during the course of carrying out the study	Chapter 8
(I) A summary and copies of any comments that were received during any consultation process	Chapter 9
(J) Any other information requested by the competent authority.	Chapter 10

2. PROJECT TEAM

Peter Kimberg of Golder Associates (Pty) Ltd. undertook the Project Management and Project Review of the Environmental Impact Report (EIR) and the Environmental Management Programme Report (EMP) for the aquatic ecosystem components. He has an Honours Degree in Aquatic Health from the University of Johannesburg (UJ) and has worked as a fulltime aquatic specialist since 2003. He has extensive experience in aquatic biomonitoring, baseline assessments of aquatic ecosystems, Environmental Impact Assessment Reports (EIA's) and biodiversity assessments. Over the last four years he has worked on projects throughout sub-Saharan Africa, including: Mali, Central African Republic, Democratic Republic of the Congo, Zambia, Mozambique, Madagascar, Lesotho, Botswana, Namibia and South Africa. He is SASS5 accredited.

Cameron von Bratt of Golder Associates Africa (Pty) Ltd. undertook the Environmental Impact Report (EIR) and the Environmental Management Programme Report (EMP) for the Aquatic Ecosystem components. He has a Masters degree in Zoology (Aquatic Health). His field focuses on aquatic ecosystem functioning, habitat, flow and biotic responses. He has specialised in Aquatic Baseline Assessments, Biomonitoring and Ecosystem functioning and health and has completed numerous Aquatic Baseline Assessments, Biomonitoring Assessments and specialist Environmental Impact Reports in river systems throughout South Africa. He has worked as a guest lecturer for Aquatic Ecosystem components (in particular EcoHydraulics, EcoGeomorphology and EcoHydrology) at the University of Johannesburg (Department of Zoology) and has lectured post-graduate (B.Sc. Honours) classes on specialist Field Assessment components. He is SASS5 accredited and an executive committee member of the Vaal River Catchment Organisation (VAALCO).

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3. PURPOSE OF REPORT AND SCOPE OF WORK

The scope of work set out by ILISO Consulting (Pty) Ltd according to the submitted and approved Golder proposal (PRO11418) included the following:

- To assess the significance of the potential impact of a proposed dam on aquatic ecosystems within the dam basin and in the Groot Letaba River downstream of the dam basin;

- To assess the significance of the potential impact of a potential migration barrier on fish assemblages within the Groot Letaba River; and

- To compile an Environmental Management Plan (EMP) with relevance to the aquatic ecosystems associated with the development.

The information provided by the 2006 Letaba Catchment Reserve Determination Study (DWAF, 2006), together with the survey data collected in November 2007 was used to assess the above mentioned scope of work.

In addition, after the peer review process, the following items were assessed according to the original Terms of Reference (ToR), which were not included in the scope of work as set out in the submitted and approved Golder proposal (PRO11418):

- Assess the significance of the potential impact of raising the dam wall of Tzaneen Dam on the aquatic ecosystems both upstream and downstream of the dam wall;

- Assess the significance of the potential impact of the proposed flow gauging weir downstream of the proposed Nwamitwa Dam on the aquatic ecosystems upstream and downstream of the proposed weir;

- Assess the significance of the potential impact of the proposed Bulk Water Infrastructure (BWI) associated with the GLeWaP on the associated aquatic ecosystems.

This report presents the results of the aquatic baseline assessment conducted in November 2007 as well as an Environmental Impact Report (EIR) of the potential impacts associated with the raising the dam wall of Tzaneen Dam, the construction

and operation of the proposed Nwamitwa Dam, the proposed flow gauging weir as well as the GLeWaP BWI on the associated aquatic ecosystems of the Groot Letaba River and its associated tributaries. The EMP Report is included as a separate attachment to this report (Appendix F), and has been incorporated into the GLeWaP EMPs.

4. METHODOLOGY

The methodology of the Environmental Impact Report (EIR) and Environmental Management Plan (EMP) was conducted according to the following:

- Literature review;
- Aquatic baseline assessment site selection;
- Aquatic baseline assessment methodology;
  - *In situ* water quality;
  - Intermediate Habitat Assessment System;
  - Aquatic macroinvertebrates; and
  - Ichthyofauna.
- Assessment of Potential Impacts.

4.1 LITERATURE REVIEW

Information from the GLeWaP Specialist Scoping Phase Report (Scoping Phase Report, 2007), the DWAF Draft Scoping Phase Report (DWAF GLeWaP, 2007a), the DWAF Final Scoping Phase Report (DWAF GLeWaP, 2007b), the 2008 River Health Programme (RHP) Rivers Database and the 2006 Letaba Catchment Reserve Determination Study (RDS) (DWAF, 2006), was used as reference material in the literature review.

During the 2006 RDS, seven Ecological Water Requirement (EWR) sites were selected, each representing a critical site within the relevant river section (DWAF, 2006 and Scoping Phase Report, 2007). Site EWR3 situated between Junction Weir (B8H009) and Prieska Weir (B8H017) is the nearest EWR site to the current project study area (DWAF, 2006 and Scoping Phase Report, 2007).

The study area was thus defined as the river reaches of the Groot Letaba River below the Tzaneen Dam wall and Prieska Weir (B8H017) including the Nwanedzi River. A map of this study area is shown in **Figure 4.1**.

For the purposes of this project, this reach was henceforth referred to as EWR3.

Reach EWR3 is approximately 75 km long. Anthropogenic impacts affecting this reach include agricultural activities and water abstraction (DWAF, 2006).

The aquatic baseline assessment focused on reach EWR3 as the majority of the impacts by the GLeWaP including the raising of the Tzaneen Dam wall, the proposed Nwamitwa Dam, the flow gauging weir and the BWI, would occur within this reach.

Within reach EWR3 the major proposed change associated with this development will be the construction of the Nwamitwa Dam. An indication of the proposed inundation of this dam according to the DWAF Draft Scoping Phase Report (DWAF GLeWaP, 2007a), is provided in (**Figure 4.1**) The proposed dam wall will be approximately 30 to 35 m high and comprise a concrete structure in the river section, accommodating a spillway and outlet works, with earth embankments on both flanks. The storage capacity of the new dam will be 144 million m³ (DWAF GLeWaP, 2008).

The river reach directly downstream of the proposed Nwamitwa Dam extends from the Nwanedzi River confluence to Prieska Weir (B8H017) (**Figure 4.1**). The Resource Unit (RU) defined by the Reserve Determination Study (RDS) for this reach is GL6 (DWAF, 2006). One Ecoregion was defined within this Resource Unit, 3.03. Anthropogenic impacts affecting this Resource Unit include agricultural activities, water abstraction and flow modification due to five in-stream weirs (DWAF, 2006).

During the Letaba River Reserve Determination Study the Present Ecological State (PES) classes were determined for each of the EWR sites based on the main ecological drivers (hydrology, geomorphology and water quality) and ecological responses (riparian vegetation, aquatic macroinvertebrates and fish) (DWAF, 2006). These PES classes were integrated into an overall EcoStatus. The PES results for site EWR3 (representing the entire reach) are summarized in **Table 4.1**. Based on the overall EcoStatus results is it can be concluded that reach EWR3 has high Ecological Importance and significance with a current PES of a C/D. Maintenance and management of this PES Ecological Category (EC) is required (DWAF, 2006).

The results in **Table 4.1** will form the basis and reference data of the EIR for the GLeWaP (DWAF, 2006 and Scoping Phase Report, 2007).

In order to meet, maintain and manage the current PES and recommended ECs as set out in the 2006 RDS for this reach (EWR3) of the Groot Letaba River, the 2006 RDS specialist results (DWAF, 2006) were considered throughout the aquatic baseline assessment and in the assessment of the potential impacts.

Table 4.1: PES results for the site EWR3 (adapted from DWAF, 2006)

Site	Hydrology	Physico-chemical	Geomorphology	Fish	Invertebrates	Riparian vegetation
EWR3	D	C	C	C	D	D
Present Ecological Status: C/D						
Ecological Importance and Significance: High						
Recommended Ecological Category: C/D						

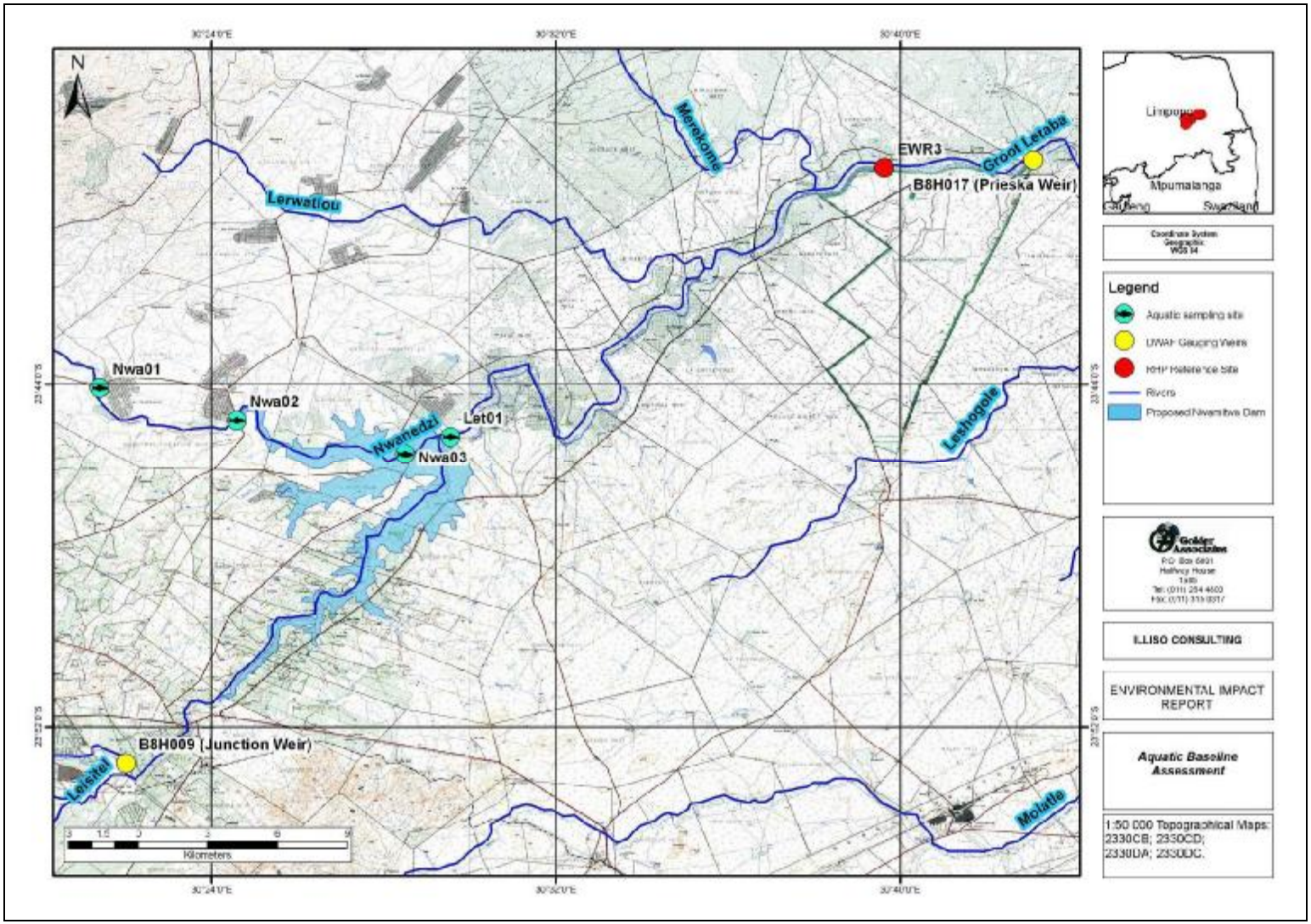

Figure 4.1: 1:50 000 Topographical map of the study area, rivers, DWAF weirs, RHP reference site and the aquatic sampling sites.

4.2 STUDY AREA

The study area of the Nwamitwa Dam falls within the Luvulvhu-Letaba Water Management Area (WMA) and the lower Lowveld Ecoregion (Level 1 Ecoregion 3) (Kleynhans *et al*., 2005a and Dallas, 2007). The Nwanedzi River is a non-perennial tributary of the Groot Letaba River which confluences with the Groot Letaba River just upstream of the proposed dam wall site.

One site was sampled in the Groot Letaba River downstream of the confluence with the Nwanedzi River (LET01) (**Figure 4.1**). Three sites were sampled in the Nwanedzi River (NWA01 – NWA03) (**Figure 4.1**). GPS coordinates of the samplings sites are provided in **Table 4.2**. Photographs of the sampling sites are provided in **Appendix A**.

Table 4.2: GPS coordinates and descriptions of the aquatic sampling sites

SITE	DESCRIPTION	CO-ORDINATES*
NWA01	**Most upstream site on the Nwanedzi River, near Ruwanda village**	**S 23.73475** **E 30.35652**
NWA02	**Middle section of the Nwanedzi River**	**S 23.74742** **E 30.40978**
NWA03	**Most downstream site on the Nwanedzi River just upstream of the confluence with the Great Letaba**	**S 23.76055** **E 30.47495**
LET01	**Groot Letaba River in the vicinity of the proposed dam wall site. Site is situated at two low water crossings.**	**S 23.75388** **E 30.49255**

* WGS_84 datum GPS coordinate system

4.3 IN SITU WATER QUALITY

During the field survey the following variables were measured on site with lightweight, compact field instruments:

- pH (Corning CheckMate 90: pH probe)
- Electrical Conductivity (EC) (Corning CheckMate 90: EC/TDS probe)
- Total Dissolved Salts (TDS) (Corning CheckMate 90: EC/TDS probe)
- Dissolved Oxygen (DO) (Corning CheckMate 90: DO probe)
- Temperature (Corning CheckMate 90: pH probe)

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a "snapshot", they provide valuable insight into the *in situ* characteristics of a specific sample site.

Comparison with water quality results, findings and PES obtained in the 2006 RDS were used to place this assessment within context when assessing the impacts of the proposed Nwamitwa Dam. This along with the water quality specialist study (GLeWaP, 2008a) was used in the impact assessment.

4.4 INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS , VERSION 2)

Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al.,* 1996). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.

The Invertebrate Habitat Assessment System (IHAS, version 2) was applied at suitable sampling sites in order to assess the availability of habitat biotopes for aquatic macroinvertebrates. The IHAS was developed specifically for use with the SASS5 index in South Africa (McMillan, 1998). IHAS evaluates the availability of the macroinvertebrate habitats at each site and expresses the availability and suitability as a percentage, where 100% represents "ideal" habitat availability. It is presently

thought that a total score of over 65% represents good habitat conditions, and over 55% indicates adequate habitat conditions (McMillan, 2002).

Comparison with habitat results, findings and PES obtained in the 2006 RDS were used to place this assessment within context when assessing the impacts of the proposed Nwamitwa Dam. This along with the sediment specialist study (GLeWaP, 2008b) was used in the impact assessment.

4.5 AQUATIC MACROINVERTEBRATES

The monitoring of benthic macroinvertebrates forms an integral part of the monitoring of the health of an aquatic ecosystem as they are relatively sedentary and enable the detection of localized disturbances. Their relatively long life histories (±1 year) allow for the integration of pollution effects over time. Field sampling is easy and since the communities are heterogeneous and several phyla are usually represented, response to environmental impacts is normally detectable in terms of the community as a whole (Hellawell, 1977).

The South African Scoring System, Version 5 (SASS5) index was designed specifically for the evaluation of perennial streams and rivers and is not suitable for assessment of impoundments, isolated pools, wetlands or pans (Dickens & Graham, 2002). For the assessment of the sites, the standard SASS5 sampling methodology was applied. Stones-In-Current (SIC), Aquatic Vegetation (marginal and aquatic macrophytes), and Gravel, Sand and Mud (GSM) habitats were sampled. This was done using the standard SASS net, whereby aquatic macroinvertebrates are physically dislodged from aquatic vegetation, collected from the water column, removed from the surfaces substrate and caught in the fine mesh size of the net. Thereafter, these organisms were placed into a white tray and identified to family level (Thirion *et al*., 1995; Davies & Day, 1998; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

The endpoint of any biological or ecosystem assessment is a value expressed either in the form of measurements (data collected) or in a more meaningful format by summarising these measurements into one or several index values (Cyrus *et al*., 2000) The endpoints used for this study were, total SASS score and average score per taxa (ASPT).

SASS5 Data Interpretation Guidelines (Dallas, 2007) were used to evaluate the SASS5 results. A summary of the Ecological Categories used for the interpretation of the SASS5 data is shown in **Table 4.3**.

Table 4.3: Ecological Categories for the interpretation of SASS5 data (adapted from Dallas, 2007 and Kleynhans *et al*., 2005b)

ECOLOGICAL CATEGORY (EC)	EC NAME	DESCRIPTION
A	NATURAL	UNMODIFIED NATURAL; COMMUNITY STRUCTURES AND FUNCTIONS COMPARABLE TO THE BEST SITUATION TO BE EXPECTED. OPTIMUM COMMUNITY STRUCTURE FOR STREAM SIZE AND HABITAT QUALITY.
B	GOOD	LARGELY NATURAL WITH FEW MODIFICATIONS; A SMALL CHANGE IN COMMUNITY STRUCTURE MAY HAVE TAKEN PLACE BUT ECOSYSTEM FUNCTIONS ARE ESSENTIALLY UNCHANGED
C	FAIR	MODERATELY MODIFIED; COMMUNITY STRUCTURE AND FUNCTION LESS THAN THE REFERENCE CONDITION. COMMUNITY COMPOSITION LOWER THAN EXPECTED DUE TO LOSS OF SOME SENSITIVE FORMS. BASIC ECOSYSTEM FUNCTIONS ARE STILL PREDOMINANTLY UNCHANGED.
D	POOR	LARGELY MODIFIED; FEWER FAMILIES PRESENT THEN EXPECTED, DUE TO LOSS OF MOST INTOLERANT FORMS. AN EXTENSIVE LOSS OF BASIC ECOSYSTEM FUNCTION HAS OCCURRED.
E	SERIOUSLY MODIFIED	SERIOUSLY MODIFIED; FEW AQUATIC FAMILIES PRESENT, DUE TO LOSS OF MOST INTOLERANT FORMS.
F	CRITICALLY MODIFIED	CRITICALLY OR EXTREMELY MODIFIED; AN EXTENSIVE LOSS OF BASIC ECOSYSTEM FUNCTION HAS OCCURRED.

The November 2007 SASS5 results were compared to the 2006 RDS.results in order to illustrate possible trends in aquatic macroinvertebrate assemblage integrity.

4.6 ICHTHYOFFAUNA

Whereas invertebrate communities are good indicators of localised conditions in a river over the short-term, fish are:

- relatively long-lived and mobile;

- good indicators of long-term influences;
- good indicators of general habitat conditions;
- organisms that integrate effects of lower trophic levels; and are
- consumed by humans (Uys et al., 1996)

The available habitat types are important when sampling fish, and involve an assessment of both flow-depth types and cover types. For each of these, fish species give preference depending on their specific life cycle requirements (food sources, reproduction, prey evasion, hunting, foraging, migration, diurnal/nocturnal cycles, etc.).

Electrofishing is the use of electricity to catch fish. The electricity is generated by a system whereby a high voltage potential is applied between two electrodes that are placed in the water (USGS, 2004). The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance, electrotaxis (forced swimming), electrotetanus (muscle contraction), Electricalarcosis (muscle relaxation or stunning) and death (USGS, 2004). Electrofishing was conducted by means of a portable battery driven electrofishing device (DC 12V pulsating). Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin *et al.,* 1989). Additional gill netting and seine netting was conducted at site NWA03 due to the abundance of deep, slow flowing habitats at the site.

All fish were identified in the field and released at the point of capture. Fish species were identified using the guide Freshwater Fishes of Southern Africa (Skelton, 2001).

The November 2007 fish survey results were compared to the 2006 RDS results in order to detect possible trends in fish assemblage integrity.

4.6.1 Expected fish assemblage

Based on a survey of available literature a shortlist of expected species was compiled for reach EWR3 (**Table 4.4**) (Skelton, 2001; Kleynhans *et al.*, 2007; and DWAF, 2006).

Table 4.4: Expected fish assemblage for study reach (EWR3), based on a survey of available literature (Skelton, 2001; Kleynhans *et al*., 2007; DWAF, 2006)

Species	Common Name	Habitat Preference	IUCN Status
Family Amphiliidae			
Amphilius uranoscopus	Stargazer Mountain Catfish	Clear and flowing water in rocky habitats	Unlisted
Family Anguillidae			
Anguilla mamorata	Giant Mottled Eel	Wide variety of habitats due to migration. Favours pools	Unlisted
Anguilla mossambica	Longfin Eel	Wide variety of habitats due to migration. Favours pools	Unlisted
Family Characidae			
Brycinus imberi	Imberi	Wide variety of habitats due to migration.	Unlisted
Micralestes acutidens	Silver Robber	In clear and open waters	Unlisted
Family Cichlidae			
Oreochromis mossambicus	Mozambique Tilapia	Wide range of habitats except fast flowing water	NT
Pseudocrenilabrus philander	Southern Mouthbrooder	Wide variety of habitats from flowing waters to lakes, usually favours vegetated zones.	Unlisted
Tilapia rendalli	Redbreast Tilapia	Quiet and well vegetated waters	Unlisted
Tilapia sparrmanii	Banded Tilapia	Tolerant of a wide range of habitats but prefers quiet or standing waters with submerged or emergent vegetation	Unlisted
Family Clariidae			
Clarias gariepinus	Sharptooth Catfish	Occurs in a wide variety of habitats but favours floodplains, large sluggish rivers, lakes and dams	Unlisted
Family Cyprinidae			
Barbus eutaenia	Orangefin Barb	Clear, flowing and rocky rivers	Unlisted
Barbus linomaculatus	Line-spotted Barb	Wide range of habitats	Unlisted
Barbus neefi	Sidespot Barb	Wide variety of habitats	Unlisted
Barbus paludinosus	Straightfin Barb	Slow flowing and vegetated habitats	Unlisted
Barbus radiatus	Beira Barb	Marginal vegetation of streams	Unlisted
Barbus toppini	East Coast Barb	Shallow and well vegetated streams	Unlisted
Barbus trimaculatus	Threespot Barb	Wide variety of habitats	Unlisted

Barbus unitaeniatus	Longbeard Barb	Wide variety of habitats	LC
Barbus viviparus	Bowstripe Barb	Vegetated pools with submerged roots	LC
Labeo cylindricus	Redeye Labeo	Clear running water in rocky habitats	LC
Labeo molybdinus	Leaden Labeo	Deep pools and rapids	LC
Labeo rosae	Rednose Labeo	Sandy stretches of large rivers	LC
Labeo ruddi	Silver Labeo	Quiet or standing waters of large rivers	LC
Labeobarbus marequensis	Lowveld Largescale Yellowfish	Flowing water	LC
Mesobola brevianalis	River Sardine	Well aerated, open water of flowing rivers	LC
Opsaridium peringueyi	Southern Barred Minnow	Shallow, clear and flowing waters. Favours sand and gravel	LC
Family Gobiidae			
Glossogobius callidus	River Goby	Cobble pools with vegetation	LC
Glossogobius giuris	Tank Goby	Quiet sandy zones of rivers	Unlisted
Family Mochokidae			
Chiloglanis paratus	Sawfin Suckermouth	Rocky riffles and rapids	LC
Chiloglanis pretoriae	Shortspine Suckermouth	Rocky riffles and rapids	LC
Synodontis zambezensis	Brown Squeaker	Pools and slow flowing reaches	Unlisted
Family Mormyridae			
Marcusenius macrolepidotus	Bulldog	Well-vegetated and muddy bottomed rivers	Unlisted
Petrocephalus wesselsi	Southern Churchill	Quiet reaches	LC
Family Schilbeidae			
Schilbe intermedius	Silver Catfish	Slow-flowing and open water with vegetation	Unlisted

NT – Near threatened; and LC – Least Concern

Based on this assessment a total of thirty three fish species would historically have occurred within reach EWR3. The expected frequency of occurrences (FROC) of the expected species was obtained from Kleynhans *et al*. (2007).

4.6.2 Presence of Red Data Species

In order to assess the IUCN status of fish species occurring in the sample area, the 2007 IUCN Red List of Threatened Species (IUCN, 2007) was consulted:

Based on the 2007 IUCN list, it was shown that of the total 33 expected fish species for the study area:

- Thirteen species are currently listed as Least Concern (LC) (**Table 4.4**). A species in this category is widespread and abundant (IUCN, 2001);
- One species: *Oreochromis mossambicus* (Mozambique Tilapia) is currently listed as Near Threatened (NT) (**Table 4.4**). A species is classified as Near Threatened when it likely to qualify for a threatened category in the near future (IUCN, 2001); and
- The remaining 20 fish species are currently unlisted.

Oreochromis mossambicus is threatened by hybridization with the rapidly spreading *O. niloticus* (Nile Tilapia) (IUCN, 2007). Hybridization has already been documented throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River system (IUCN, 2007). Conservation measures stipulate that river systems not yet invaded by *O. niloticus* must be protected from deliberate and accidental introductions of that species (IUCN, 2007).

4.6.3 Fish Health Assessment

For the purpose of this study the fish health assessment was based on an external examination of the skin and fins, eyes, gills, opercula and the presence of ectoparasites. This approach ensured the minimization of stress due to handling and allowed the fish to be released unharmed.

4.6.4 Biotic integrity based on the Fish Assemblage Integrity Index (FAII)

The Fish Assemblage Integrity Index (FAII) is an index which assesses the biological integrity of a river based on attributes of the indigenous fish assemblages (Kleynhans, 1999). Alien species (introduced indigenous and exotic species) are not included as metrics in the FAII (Kleynhans, 1999). Their presence and distribution are noted but interpreted as possible causes for a decline in the FAII score. Calculation of the

relative FAII score consists of the calculation of an expected score, which serves as the reference, the calculation of an observed score and the comparison of the expected and observed scores (Kleynhans, 1999).

A summary of the Ecological Categories used for the interpretation of the FAII data is shown in **Table 4.5**.

Table 4.5: Ecological Categories for the interpretation of FAII data (adapted from Kleynhans *et al*., 2005b)

ECOLOGICAL CATEGORY (EC)	EC NAME	DESCRIPTION
A	NATURAL	UNMODIFIED NATURAL; COMMUNITY STRUCTURES AND FUNCTIONS COMPARABLE TO THE BEST SITUATION TO BE EXPECTED. OPTIMUM COMMUNITY STRUCTURE FOR STREAM SIZE AND HABITAT QUALITY.
B	GOOD	LARGELY NATURAL WITH FEW MODIFICATIONS; A SMALL CHANGE IN COMMUNITY CHARACTERISTICS MAY HAVE TAKEN PLACE BUT SPECIES RICHNESS AND PRESENCE OF INTOLERANT SPECIES INDICATE LITTLE MODIFICATION.
C	FAIR	MODERATELY MODIFIED; A LOWER THAN EXPECTED SPECIES RICHNESS AND PRESENCE OF MOST INTOLERANT SPECIES. SOME IMPAIRMENT OF HEALTH MAY BE EVIDENT AT THE LOWER LIMIT OF THIS CLASS.
D	POOR	LARGELY MODIFIED; A CLEARLY LOWER THAN EXPECTED SPECIES RICHNESS AND PRESENCE OF MOST INTOLERANT SPECIES. SOME IMPAIRMENT OF HEALTH MAY BE EVIDENT AT THE LOWER LIMIT OF THIS CLASS.
E	SERIOUSLY MODIFIED	SERIOUSLY MODIFIED; A STRIKINGLY LOWER THAN EXPECTED SPECIES RICHNESS AND GENERAL ABSENCE OF INTOLERANT AND MODERATELY INTOLERANT SPECIES. IMPAIRMENT OF HEALTH MAY BECOME EVIDENT.
F	CRITICALLY MODIFIED	CRITICALLY OR EXTREMELY MODIFIED; EXTREMELY LOWERED SPECIES RICHNESS AND AN ABSENCE OF INTOLERANT AND MODERATELY INTOLERANT SPECIES. ONLY TOLERANT SPECIES MAY BE PRESENT WITH A COMPLETE LOSS OF SPECIES AT THE LOWER LIMIT OF THE CLASS. IMPAIRMENT OF HEALTH GENERALLY VERY EVIDENT.

4.7 ASSESSMENT OF POTENTIAL IMPACTS

The key issues identified during the Scoping Phase informed the terms of references 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 and 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.

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:

4.7.1 Nature

The nature of the impact will be classified as positive or negative, and direct or indirect.

4.7.2 Extent and location

Magnitude of the impact and is classified as:

- **Local**: the impacted area is only at the site – the actual extent of the activity
- **Regional**: the impacted area extends to the surrounding, the immediate and the neighbouring properties.
- **National**: the impact can be considered to be of national importance.

4.7.3 Duration

This measures the lifetime of the impact, and is classified as:

- **Short term**: the impact will be for 0 – 3 years, or only last for the period of construction.
- **Medium term**: three to ten years.

- **Long term**: longer than 10 years or the impact will continue for the entire operational lifetime of the project.
- **Permanent**: this applies to the impact that will remain after the operational lifetime of the project.

4.7.4 Intensity

This is the degree to which the project affects or changes the environment, and is classified as:

- **Low**: the change is slight and often not noticeable, and the natural functioning of the environment is not affected.
- **Medium**: The environment is remarkably altered, but still functions in a modified way.
- **High**: Functioning of the affected environment is disturbed and can cease.

4.7.5 Probability

This is the likelihood or the chances that the impact will occur, and is classified as:

- **Low**: during the normal operation of the project, no impacts are expected.
- **Medium**: the impact is likely to occur if extra care is not taken to mitigate them.
- **High**: the environment will be affected irrespectively; in some cases such impact can be reduced.

4.7.6 Confidence

This is the level knowledge/information, the environmental impact practitioner or a specialist had in his/her judgement, and is rated as:

- **Low**: the judgement is based on intuition and not on knowledge or information.
- **Medium**: common sense and general knowledge informs the decision.

- **High**: Scientific and or proven information has been used to give such a judgement.

4.7.7 Significance

Based on the above criteria the significance of issues will be determined. This is the importance of the impact in terms of physical extent and time scale, and is rated as:

- **Low**: the impacts are less important, but may require some mitigation action.
- **Medium**: the impacts are important and require attention; mitigation is required to reduce the negative impacts
- **High**: the impacts are of great importance. Mitigation is therefore crucial.

4.7.8 Cumulative Impacts

The possible cumulative impacts will also be considered.

4.7.9 Mitigation

Mitigation for significant issues will be incorporated into the EMP for construction.

5. ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

Certain gaps in knowledge arose during the aquatic baseline assessment that were not included in this EIR, but were recommended in the original ToR. These are considered to be of important value for the scientific analysis of the impacts outlined in this EIR. These are:

- A genetic assessment of specific fish species upstream and downstream of the proposed Nwamitwa Dam site. This will provide further scientific evidence as to the transfer of genetic material between populations upstream and downstream of the Nwamitwa Dam site and thus provide information as to the connectivity and genetic importance of the reach and give further support to the need to maintain this connectivity at the dam by means of a fishway/fish ladder or not;

- A habitat suitability and accessibility study of the area both upstream and downstream of the Nwamitwa Dam site. This will give further scientific evidence of the availability and accessibility of suitable breeding/critical life-stage habitats required by specific fish species. This would enable required habitat areas not impacted by the GLeWaP to be identified, assessed in terms of suitability and accessibility for ecosystem functioning and conserved as a mitigation option; and

- A full flow regime maintenance and release management strategy for the proposed Nwamitwa Dam.

Without these three above mentioned assessments, the level of impact on the migratory fish populations within this river reach (EWR3) is uncertain. In addition, the impact of the ability of any remaining fish species be able to find and access suitable habitats that are required for all the life stages of the species is also uncertain due to the limitations in habitat assessment.

6. RESULTS AND FINDINGS

Site conditions recorded at the sites during the survey indicated that high flows within the Great Letaba and Nwanedzi Rivers. This was evident by the excessive amount of suspended silt in the water column and inundated vegetation present at the sites. At site NWA02, very shallow depths of approximately 20 to 50 mm were recorded with little to no variation in substrate (only sand present).

6.1 *IN SITU* WATER QUALITY

In situ water quality was measured in the field with lightweight compact field instruments and the results presented in **Table 6.1**. These results are important in assisting with the interpretation of biological results because of the direct influence water quality has on aquatic life forms. It should however be noted that these values represent a single moment in time, and cannot be interpreted as representative of overall water quality conditions of the sites.

Table 6.1: *In situ* water quality parameters recorded during the November 2007 baseline assessment

Site	Time	pH	EC[1] (mS/m)	TDS[2] (mg/l)	DO[3] (mg/l)	Temp (˚C)
NWA01	16h00	7.9	112.6	732	5.4	34.9
NWA02	14h00	8.4	138.5	900	8.7	38.2
NWA03	07h55	8.3	163.1	1060	9.1	23.6
LET01	09h10	8.0	122.9	799	5.6	26.8

[1] EC – Electrical Conductivity; [2] TDS – Total Dissolved Salts; and [3] DO – Dissolved Oxygen

Water quality information provided by the 2006 RDS (DWAF 2006) was used to compare the baseline assessment data to in terms of variables and the recommended Ecospecs. Where variables such as: Electrical conductivity (EC) and TDS, were not assessed in the 2006 RDS, the South African Water Quality Guidelines for Aquatic Ecosystems and Domestic Use were applied (DWAF, 1996).

6.1.1 pH

The pH of natural waters is determined by both geological and atmospheric influences, as well as by biological activities. Most fresh waters are usually relatively well buffered with a pH range from 6 to 8, and most are slightly alkaline due to the presence of bicarbonates of the alkali and alkaline earth metals (DWAF, 1996). The pH target for fish health is presented as ranging between 6.5 and 9.0, as most species will tolerate and reproduce successfully within this pH range (Alabaster and Lloyd, 1982). According to the 2006 RDS (DWAF, 2006), pH within this reach (EWR3) is in an A category and therefore the Quality Ecospecs for pH should range from 6.5 – 8.

During the November 2007 baseline assessment survey pH levels in the Nwanedzi River ranged from 7.9 at site NWA01 to 8.4 at site NWA02 (**Table 6.1**). A pH value of 8.0 was measured at site LET01 in the Groot Letaba River (**Table 6.1**). Within this range, according to the pH target for fish, this should not have had limiting effect on aquatic biota in the sample area (**Table 6.1**) at the time of the survey. According to the Qualtity Ecospecs of the RDS, sites NWA02 and NWA03 were above the target range, but according to results obtained during the RDS, this range may be higher as pH values of 8.36 were obtained (DWAF, 2006). According to the water quality specialist study for this project (GLeWaP, 2008a), there has been a slight decreasing trend in the pH values due to processes in the catchment that are causing changes in water quality.

Within the context of the RDS, pH values from this baseline assessment were similar and within the Quality Ecospecs. Within this range pH values are not expected to have a limiting effect on aquatic biota.

6.1.2 Electrical Conductivity (EC)

Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current (DWAF, 1996). This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge (DWAF, 1996).

Electrical Conductivity (EC) values ranged from 112.6 mS/m at site NWA01 to 163.1 mS/m at site NWA03 (Table 6.1). No guideline values are available for EC levels within aquatic ecosystems. According to the water quality specialist study for this project (GLeWaP, 2008a), there has been a slight increasing trend in Electrical Conductivity (EC) values ascribed to processes in the catchment that are causing changes in water quality. The changes in water quality are however small, and not significant in terms of fitness for use. Even at the 95th percentile value, the water quality still falls mostly in the ideal range in the upper reaches.

6.1.3 Total Dissolved Solids (TDS)

Concentrations of Total Dissolved Solids (TDS) in water vary owing to different mineral solubilities in different geological regions. The TDS concentrations are generally in the range of 200 - 1 100 mg/l in water in contact with Paleozoic and Mesozoic sedimentary rock formations (DWAF, 1996), because of the presence of carbonates, chlorides, calcium, magnesium and sulphates (Health Canada, 2008).

The geology of the proposed Nwamitwa Dam site consists of Goudplaas Gneiss from the Swazian age (GLeWaP, 2007b) and includes both feldspar and quartzite aggregates. Underlying this is granite gneiss. The remainder of the Great Letaba catchment consists of granites that allow shallow weathering (less than 10 m) and the soils formed are expected to be more sandy. The soils present are mainly Hutton and Shortlands types. The geology of the study area therefore consists of soils and formations associated with Paleozoic and Mesozoic formations.

No TDS concentration guidelines were provided in the 2006 RDS (DWAF, 2006), however, the sum of the Inorganic Salt Quality Ecospecs is 621 mg/l, which is within the abovementioned guideline range. Therefore, a general guideline range of 200 – 1100 mg/l was used as a guideline range for this assessment.

In the Nwanedzi River, TDS concentrations increased in a downstream direction from 732 mg/l at site NWA01 to 1060 mg/l at site NWA03 just before the confluence with the Groot Letaba River (**Table 6.1**). A TDS concentration of 799 mg/l was measured at site LET01 in the Groot Letaba River (**Table 6.1**). Within this TDS range, TDS concentrations should not have a limiting effect on aquatic biota.

According to the water quality specialist study for this project (GLeWaP, 2008a), there is an increasing trend in salinity ascribed to processes in the catchment causing changes in water quality. The changes in water quality are however small, and not significant in terms of fitness for use. Even at the 95th percentile value, the water quality still falls mostly in the ideal range in the upper reaches.

Within the context of the 2006 RDS, the TDS concentrations obtained during the baseline assessment were above the Total Inorganic Salt Quality Ecospecs.

6.1.4 Dissolved Oxygen (DO)

The maintenance of adequate dissolved oxygen (DO) is critical for the survival and functioning of the aquatic biota because it is required for the respiration of all aerobic organisms. Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWAF, 1996). The median guideline for DO for the protection of aquatic biota is > 5 mg/l (Kempster *et al*., 1980). According to the 2006 RDS (DWAF, 2006), DO within reach EWR3 is in a category A and the Quality Ecospecs for DO should range from 6 – 7 mg/l.

During the November 2007 baseline assessment survey, DO concentrations were adequate (> 5 mg/l) at all the sites and should not have a limiting effect on aquatic biota (**Table 6.1**). The lower oxygen level of 5.6 mg/l recorded at site LET01 was considered to be due to the increase turbidity observed at the site and may possibly be as a result of increased Chemical Oxygen Demand (COD).

Within the context of the 2006 RDS, the DO concentrations obtained during the baseline assessment were above the Quality Ecospecs at sites NWA02 and NWA03 and below at sites NWA01 and LET01. As discussed, the increase may have been due to the high temperatures and shallow water levels present at the two sites. The decreases at sites NWA01 and LET01 were slight and could possibly be attributed to the high turbidity and siltation present. These deviations were thus considered to be temporary.

6.1.5 Temperature

Water temperature plays an important role in aquatic ecosystems by affecting the rates of chemical reactions and therefore also the metabolic rates of organisms (DWAF, 1996). Temperature affects the rate of development, reproductive periods and emergence time of organisms (Davies & Day, 1998). Temperature varies with season and the life cycles of many aquatic macroinvertebrates are cued to temperature. According to the 2006 RDS (DWAF, 2006), temperature within this reach (EWR3) caters for moderate changes and therefore the Quality Ecospecs for temperature stipulate that temperature values should vary by no more than 2 ºC.

During the November 2007 survey water temperatures in the Nwanedzi River ranged from 23.6 ˚C at site NWA03 to 38.2 ˚C at site NWA02 (**Table 6.1**). High temperatures recorded at sites NWA01 and NWA02 can be attributed to the shallow water depths (< 10 cm) observed at these sites. A water temperature of 26.8 ˚C was measured at site LET01 in the Groot Letaba River (**Table 6.1**).

Within the context of the 2006 RDS, temperatures at sites NWA02 and NWA01 are expected to fluctuate greatly within a 24 hour period due to the shallow water levels at the sites. It should however be noted that the Nwanedzi River is naturally non-perennial and that the biota are adapted to the fluctuating conditions in the river.

6.2 INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS , VERSION2)

The availability of the instream and riparian habitat influences the structure and function of the aquatic community in a stream; therefore evaluation of habitat availability is critical to any assessment of aquatic biota. The results of the Invertebrate Habitat Assessment System (IHAS, *Version 2*) are presented in **Table 6.2**.

Table 6.2: IHAS scores recorded during the November 2007 baseline assessment

Site	November 2007	
	IHAS Score	Description
NWA01	62	Adequate

NWA02	41	Poor
NWA03	52	Adequate
LET01	76	Good

Based on the IHAS results, adequate habitat availability exists at sites NWA01 and NWA03 (**Table 6.2**). Habitat availability at site NWA02 was poor (**Table 6.2**). This can be attributed to the low flow conditions at the site, the absence of the Stones-In-Current (SIC) habitat and of the limited availability of marginal vegetation. Therefore, habitat availability can be considered a limiting factor of SASS5 scores at site NWA02. Based on the IHAS score, habitat availability at site LET01 was good (**Table 6.2**).

6.3 AQUATIC MACROINVERTEBRATES

A list of aquatic macroinvertebrates collected during the November 2007 baseline assessment survey is provided in Appendix B. A summary of the SASS5 results is provided in **Table 6.3**.

Table 6.3: SASS5 Scores, ASPT* Scores and Number of taxa recorded during the November 2007 survey

Site	SASS5 scores	Number of taxa	ASPT*
NWA01	78	16	4.9
NWA02	40	8	5.0
NWA03	56	15	3.7
LET01	161	27	6.0

* Average Score per Taxa

In the Nwanedzi River, SASS5 scores ranged from 40 at site NWA02 to 78 at site NWA01 (**Table 6.3**). The number of taxa ranged from 8 at site NWA02 to 16 at site NWA01 (**Table 6.3**) The ASPT scores, which represent the average sensitivity of the aquatic macroinvertebrate sample, ranged from 3.7 at site NWA03 to 5.0 at site NWA02 indicating that the aquatic macroinvertebrate assemblage in the Nwanedzi River is characterised by tolerant taxa (Intolerance Rating < 5) (**Table 6.3**).

In the Groot Letaba River, a SASS5 score of 161 was recorded at site LET01 (**Table 6.3**). Twenty seven aquatic macroinvertebrate taxa were recorded at site LET01 (**Table 6.3**). An ASPT score of 6.0 was recorded at site LET01 indicating that the aquatic macroinvertebrate assemblage at the site is characterised by moderately sensitive taxa (Intolerance Rating 5 - 10) (**Table 6.3**).

6.3.1 Biotic Integrity based on SASS5 Results

The SASS and ASPT results were used to evaluate the biotic integrity of the sites using the SASS Data Interpretation Guidelines (Dallas, 2007). The biotic integrity of the various sites based on the SASS5 results is provided in **Table 6.4**.

Table 6.4: Biotic Integrity of sites in the Nwanedzi and Groot Letaba Rivers based on SASS5 data collected during the November 2007 survey

Site	Integrity Class	Class Description
NWA01	D/E	Largely/seriously impaired
NWA02	E	Seriously impaired
NWA03	F	Critically impaired
LET01	B	Minimally impaired

Based on the SASS results, biotic integrity in the Nwanedzi River ranged from largely/seriously impaired (Integrity Class D/E) in the upper reaches (Site NWA01), to critically impaired at site NWA03 (**Table 6.4**). **It should be noted that the Nwanedzi River is non-perennial and therefore SASS results obtained from this river should be interpreted with caution. The low level of biotic integrity recorded at site NWA02 can be attributed in part to the limited habitat availability at the site.**

Based on the SASS results, biotic integrity at site LET01 was minimally impaired (Integrity Class B) (**Table 6.4**). A small change in aquatic macroinvertebrate community structure is associated with this level of impairment but basic ecosystem function remains intact.

Within the context of the 2006 RDS (DWAF, 2006), the aquatic macroinvertebrates within this reach (EWR3) had a PES of D, indicating seriously modified conditions.

This was attributed to upstream abstraction which had resulted in a reduction of flow velocities, habitat availability, flushing flows and dilution of pollutants. This was determined to be a neutral trend and that the aquatic macroinvertebrate was stable and had adjusted to the present flow regime. The recommended Ecospecs for this reach is D (DWAF, 2006). During the November 2007 survey the PES at sites NWA02 and NWA03 were below the recommended Ecospecs. As discussed, this was most likely due to the non-perennial nature and limited habitat availability in the Nwanedzi River.

The PES recorded at site LET01 during the November 2007 survey was above the recommended Ecospecs. This is considered to be of importance in the context of this EIA and the existing RDS.

6.4 ICHTHYOFFAUNA

6.4.1 Observed Fish Assemblage

Of the 33 expected indigenous fish species expected to occur within reach EWR3, a total of 15 indigenous and one introduced fish species were recorded during the November 2007 survey (**Table 6.5**)

Table 6.5: Number of fish individuals, species and families recorded during the November 2007 baseline assessment

Species	Common Name	IUCN Status	NWA01	NWA02	NWA03	LET01
Family Characidae						
Micralestes acutidens	Silver Robber	Unlisted				8
Family Cichlidae						
Oreochromis mmossambicus	Mozambique Tilapia	NT	9	5	3	16
Pseudocrenilabrus philander	Southern Mouthbrooder	Unlisted	25	1	2	28
Tilapia sparrmanii	Banded Tilapia	Unlisted		7	1	
Family Clariidae						
Clarias gariepinus	Sharptooth Catfish	Unlisted	1		3	2
Family Cyprinidae						
Barbus toppini	East Coast Barb	Unlisted	4		1	12

Barbus trimaculatus	Threespot Barb	Unlisted	10	10	4	1
Barbus unitaeniatus	Longbeard Barb	LC	1		7	
Barbus viviparus	Bowstripe Barb	LC	11	1	13	11
Labeo cylindricus	Redeye Labeo	LC	5			4
Labeo molybdinus	Leaden Labeo	LC	1			7
Labeo rosae	Rednose Labeo	LC			1	
Labeobarbus marequensis	Lowveld Largescale Yellowfish	LC				16
Mesobola brevianalis	River Sardine	LC				7
Family Mochokidae						
Chiloglanis pretoriae	Shortspine Suckermouth	LC				24
Family Centrarchidae						
*Micropterus salmoides**	Largemouth Bass	Unlisted			1	
Total number of individuals			**67**	**24**	**36**	**136**
Total number of species			**9**	**5**	**10**	**12**

* Introduced species

6.4.2 Nwanedzi River

Twelve fish species were recorded in the Nwanedzi River (**Table 6.5**). The most abundant fish species in the Nwanedzi River was *Pseudocrenilabrus philander* (Southern Mouthbrooder) which was collected at all of the sites and comprised 22.0% of the total catch (**Table 6.5**). Four fish species that were recorded in the Nwanedzi River were not recorded in the Groot Letaba River namely: *Barbus unitaeniatus* (Longbeard Barb), *Tilapia sparrmanii* (Banded Tilapia), *Labeo rosae* (Rednose Labeo) and *Micropterus salmoides (*Largemouth Bass) (**Table 6.5**).

The presence of the aggressively invasive alien fish species *M.salmoides* in the reach is cause for concern (**Table 6.5**). *M. salmoides* (Largemouth Bass) was introduced into South African waters from North America between 1928 and 1938 and quickly became established in natural waters (Skelton, 2001). Although this species is primarily piscivorous, it is a voracious predator that will take virtually any animal food it encounters including crabs, frogs, snakes and even small mammals. In the long term it can be expected that this species will cause extensive damage to indigenous fish populations (Skelton, 2001).

Limited availability of flowing habitat types may have a limiting effect on fish assemblages in the Nwanedzi River. Two fish species that were recorded at site NWA03 during the November 2007 survey were not recorded within reach EWR3 during the 2006 RDS namely *Labeo rosae* (Rednose Labeo) and *M. salmoides* (Largemouth Bass).

6.4.3 Groot Letaba River

Twelve of the 33 expected indigenous fish species were at site LET01 during the November 2007 survey (**Table 6.5**). The most abundant fish species was *P.philander* (Southern Mouthbrooder). Fish species collected in the Groot Letaba River that were not recorded in the Nwanedzi River included: *Chiloglanis pretoriae* (Shortspine Suckermouth), *Labeobarbus marequensis* (Lowveld Largescale Yellowfish), *Micralestes acutidens* (Slender Robber) and *Mesobola brevianalis* (River Sardine) (**Table 6.5**).

Sixteen of the 33 expected species were recorded in reach EWR3 during the 2006 RDS (DWAF, 2006). Two fish species namely *C. paratus* (Sawfin Suckermouth) and *T. rendalii* (Redbreast Tilapia) that were recorded in reach EWR3 during the 2006 RDS were not recorded during the November 2007 survey (DWAF, 2006). Based on the combined results of the 2006 RDS and the November 2007 survey it can be concluded that at least 17 indigenous and 1 exotic fish species remain within reach EWR3.

6.4.4 Presence of Red Data Species

Oreochromis mossambicus was recorded at all four sites (**Table 6.5**) and is currently listed as Near Threatened (NT) on the IUCN red data list (IUCN, 2007).

Oreochromis mossambicus is threatened by hybridization with the rapidly spreading *O. niloticus* (Nile Tilapia) (IUCN, 2007). Hybridization is already been documented throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River system (IUCN, 2007). Conservation measures stipulate that river systems not yet invaded by *O. niloticus* must be protected from deliberate and accidental introductions of that species (IUCN, 2007). No evidence of *O. niloticus* was recorded within reach EWR3 during the November 2007 survey although it should be

noted that the expression of the characteristic hybrid traits would depend on the degree of hybridization and can only be verified by means of a genetic analysis.

***O. mossambicus* is generally regarded as a hardy species that inhabits a wide variety of habitats including estuaries and the sea and thrives in impoundments (Skelton, 2001). It is likely that a thriving population of *O. mossambicus* will become established in Nwanedzi Dam.**

6.4.5 Fish Health Assessment

After thorough external examination, it was determined that all individuals were free of apparent diseases, parasites and body injuries.

6.4.6 Biotic Integrity based on FAII Results

The fish assemblages at all the sites were evaluated in terms of habitats, flows present as well as expected fish habitat, flow and cover preferences.

Relative FAII scores were calculated by taking the observed FAII score as a percentage of the expected FAII score. The relative FAII scores recorded during the November 2007 survey are presented in **Table 6.6**.

Table 6.6: Relative FAII Scores recorded in the sample area during the November 2007 baseline assessment

Site	Relative FAII Score (% of expected)	Class Rating	Description
NWA01	50	D	Poor –largely modified
NWA02	41	D	Poor – largely modified
NWA03	41	D	Poor – largely modified
LET01	70	C	Fair – moderately modified

Based on the November 2007 FAII results, biotic integrity in the Nwanedzi River (sites NWA01 – NWA03) was poor (Class D) at all three sampling sites (**Table 6.6**). This can most likely attributed to the non-perennial nature of the Nwanedzi River, the naturally low flow conditions and limited habitat availability. Due to the non-perennial

nature of the Nwanedzi River the relative FAII scores likely represents an under estimation of the actual level of biotic integrity in the river. The presence of the aggressively invasive introduced fish species *M. salmoides*, may also be contributing to the low FAII scores recorded in the Nwanedzi River.

The highest FAII score in the sample area was recorded at site LET01 in the Groot Letaba River (**Table 6.6**). Based on the FAII assessment, biotic integrity at site LET01 is moderately modified (Class C) (**Table 6.6**). It should be noted that these FAII results are based on the results from a single survey. It is unlikely that all the fish species present within the reach would be recorded during a single survey. Based on this assumption it can be deduced that the results of the November 2007 survey represents an under estimation of the actual level of integrity within the reach. Anthropogenic impacts such as flow regulation, water abstraction and water quality impairment due to surrounding agricultural activities may have a limiting effect on fish assemblages with the reach.

The results of the November 2007 survey were similar to those of the 2006 RDS, with a total of 17 of the 33 expected fish recorded within the Resource Unit (RU) (EWR3). The PES for fish within reach EWR3 is set as a C (Moderately modified) with a recommended Ecospec of C.

It is likely that some of the expected fish species may no longer occur within the reach. The continued presence of two expected migratory eel species (*A. marmorata* and *A. mossambica*) within the reach is unlikely due to Massangir Dam in Mozambique. *Barbus eutaenia* is a highly sensitive flow dependant species which may be lost from the RU due to high degree of flow modification and water abstraction in the Groot Letaba River (DWAF, 2006). Abundances of all species within this RU are known to be declining (DWAF, 2006). The 16 expected fish species that have not been sampled in recent years are considered to be lost within this reach (DWAF, 2006).

The source of these losses and decreases in fish species populations may be attributed to fragmentation of the system and regulation of flows by the numerous dams and weirs upstream and downstream of the RU and which have had a limiting effect on fish recruitment and distribution (DWAF, 2006). The trend was determined to be stable and it is believed that the remaining species have adapted and are surviving

under current conditions. It was also suggest by the 2006 RDS that suitable breeding areas are still available within this RU (DWAF, 2006).

6.5 CONCLUSIONS

The following conclusions were reached based on the results of the November 2007 baseline assessment:

- The Present Ecological States (PES) at sites NWA02 and NWA03 in the Nwanedzi River were below the recommended Ecospecs. This could most likely due to the non-perennial nature of the Nwanedzi River and likely represents an under estimation of the actual level of biotic integrity in the river. The presence of the aggressively invasive introduced fish species *M. salmoides*, may be contributing to the low FAII scores recorded in the Nwanedzi River.

- The PES recorded at site LET01 exceeded the recommended Ecospecs. This is considered to be of importance in the context of this EIA and the existing RDS.

- *Oreochromis mossambicus* (Mozambique Tilapia) is a Near Threatened (NT) fish species that was recorded at all of the sampling sites during the November 2007 survey. *O.mossambicus* is threatened by hybridization with *Oreochromis niloticus* (Nile Tilapia); a North African species introduced for aquaculture purposes. *O.mossambicus* is generally regarded as a hardy species which is likely to thrive in the Nwamitwa Dam.

- Based on the FAII assessment, biotic integrity within reach EWR3 complied with the recommended Ecospec of C (moderately modified). It should be noted that these November 2007 FAII results are based on a single survey and likely represent an under estimation of the actual level of biotic integrity within the reach.

6.6 ASSESSMENT OF POTENTIAL IMAPACTS

Any development in a natural system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT, 2002). Dams are the main reason that 20% of the world's freshwater fish species are endangered (Davies & Day, 1998).

Alterations of the natural variation of flow by river regulation through decreasing or increasing the flows can only have a profound influence upon almost every aspect of river ecological functioning (Davies *et al*., 1993).

Mitigation options should first comply with the 2006 RDS requirements.

6.6.1 Existing legislation with regards to in-stream migration barriers

Environmental legislation has recently been promulgated in South Africa that adequately protects riverine ecosystems from man-induced impacts. If correctly and strictly applied, this new legislation should ensure that appropriate mitigation (e.g. fishway provision) is taken when in-stream barriers to fish migration are constructed (Bok *et al*., 2007). This legislation includes:

The Environment Conservation Act, 1989 (No. 73 of 1989)

In terms of Regulations (Section 21, Schedule 1, No.1 (j) published in Government Gazette No. 18261, 5 September 1997, in terms of the Environment Conservation Act, 1989 (ECA), appropriate environmental investigations (EIA's) are mandatory before approval for the “construction or upgrading of dams, levees or weirs affecting the flow of a river” will be given by the relevant authority (Bok *et al*., 2007).

The National Environmental Management Act (Act 107 of 1998)

The National Environmental Management Act (Act 107 of 1998), in terms of Regulation 386, Activity 1 (m) gazetted in terms of Section 24, a basic assessment is required to be conducted before approval for any in-stream barrier construction is granted (Bok *et al*., 2007).

National Water Act, 1998 (Act No. 36 of 1998)

In the National Water Act (NWA), use of water is no longer limited to consumptive use, such as the abstraction of water, but includes non-consumptive activities that may have an impact on the resource quality (Bok *et al*., 2007). These “water uses”, which require authorization (usually in the form of a license) are given in Section 21 of the NWA, and include:

- Section 21 (a): storing water;
- Section 21 (c): impeding or diverting the flow of water in a watercourse;
- Section 21 (i): altering the bed, banks, course or characteristics of a watercourse.

6.6.2 Potential impacts of raising the dam wall of Tzaneen Dam on the aquatic ecosystems upstream and downstream of the dam wall

(a) Potential impacts on physical and chemical water conditions

As was indicated by the water quality specialist report (GLeWaP, 2008a), the raising of the Tzaneen Dam will have no water quality effects with respect to the current situation. It is expected that already existing impacts will only be compounded.

(b) Potential impacts on the physical habitat conditions

As was indicated by the sediment impact specialist report, the raising of Tzaneen Dam will not significantly alter the sediment trapping efficiency of the dam and most of the incoming sediment load will be trapped in the reservoir. Sediment deposition in the live storage will however occur further upstream than before. Storage capacity will increase, which could attenuate small and medium floods more. Large floods will not be attenuated significantly more than in the current condition (GLeWaP, 2008b).

River morphology downstream of the dam is not expected to change significantly. Small floods will be attenuated more and it is expected that the main channel width downstream of the dam to the first main tributary could decrease by less than 5 % of the current width (GLeWaP, 2008a).

(c) Potential impacts on the aquatic biota

As indicated by the impacts on the physical and chemical water conditions and on the physical habitat conditions, the raising of the Tzaneen Dam will is not expected to impact on the aquatic biota significantly with respect to the current situation. It is expected that already existing impacts will only be compounded. A further decrease in aquatic macroinvertebrate abundances and fish Frequency of Occurrences (FROCs) is expected.

(d) Potential impacts on the migration potential of fish species

No fish can currently migrate upstream in the Groot Letaba River beyond the base of Tzaneen Dam.

In terms of the 2006 RDS, the potential impacts of raising the Tzaneen Dam wall on the aquatic ecosystem ecosystems both upstream and downstream of the dam wall

may result in a decrease in PES over the short to medium term. This decrease should not compromise the Recommended Ecological Category (REC) significantly over the long term.

Mitigation measures include:

- The compilation of a management action plan whereby information from monthly water monitoring and bi-annual biomonitoring can be used to implement management actions should a significant decrease in PES (C/D EC) be noted.

The level of significance of this impact was rated as low, for the construction phase and medium for the operational phase, prior to the implementation of mitigation measures (**Table 6.7**). The level of significance remained low, for the construction phase and decreased to low for the operational phase, after implementation of recommended mitigation (**Table 6.7**).

Table 6.7: Significance of the potential impacts of raising the dam wall of Tzaneen Dam on the aquatic ecosystems upstream and downstream of the dam wall

Description of potential impact	**Raising the dam wall of Tzaneen Dam on the aquatic ecosystems both upstream and downstream of the dam wall**	
Nature of impact	Negative and direct	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative and direct	Negative and direct
Extent of impact	Regional	Regional
Duration of impact	Short term	Long term
Intensity	Medium	Medium
Probability of occurrence	High	High
Confidence of assessment	High	High
Level of significance before mitigation	Low	Medium
Mitigation measures (EMP requirements)	Implementation of a suitable management action plan based on monthly water quality and two biological monitoring surveys	Implementation of a suitable management action plan based on bi-annual water quality and biological monitoring data
Level of significance after mitigation	Low	Low
Cumulative Impacts	As discussed in Section 6.6.2 and include biotic and abiotic impacts	As discussed in Section 6.6.2 and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.2		

6.6.3 Potential impacts on the aquatic ecosystems within the proposed Nwamitwa Dam basin

(a) Potential impacts on physical and chemical water conditions

The water quality specialist report indicates that the impacts on physical and chemical water conditions are considered to be limited to the predicted phosphate concentration in the dam which will put the Nwamitwa Dam in the range of eutrophic. This means that nuisance conditions with respect to algal blooms will occur, but for less than 20% of the time (GLeWaP, 2008a). Mitigation of this is limited to identifying and reducing the source of this phosphate.

Concern over the amount of toxicants, especially Persistent Organic Pollutants (POPs) in the soils from years of crop spraying with fungicides, insecticides, may become suspended when the Nwamitwa Dam basin is inundated. As the presence or extent of these pollutants is not known, mitigation of this impact is limited to annual bioaccumulation studies of plant, macroinvertebrate and fish material from within the Nwamitwa Dam basin during the operation of the dam.

It is expected that water quality in the dam will represent a significant improvement in the water quality that is currently available, especially for domestic users that are currently dependent on borehole water (GLeWaP, 2008a).

Stratification is predicted to occur in the proposed Nwamitwa Dam (GLeWaP, 2008a). Physical and chemical conditions may fluctuate greatly for some time, depending on how long the dam takes to fill, the prevailing water temperature, the quantities of nutrients made available from the inundated fauna and flora and soils and finally, the rate at which these are released into the water. Pollution from chemicals, sediments and nutrient loads (e.g. Phosphates) from upstream sources are also trapped in the dam and will impact on the physical and chemical characteristics of the water (Davies & Day, 1998). It is likely that a warm epilimnion of 18 to 24 ºC and cool lower hypolimnion of 14 to 18 ºC will develop (van Veelen *pers. comm.*, 2008). No mitigation required.

In terms of the 2006 RDS, the potential impacts on the aquatic ecosystems within the dam basin, in terms of the impacts on physical and chemical water conditions will most probably result in a large decrease in PES over the short to medium term. This decrease will compromise the Recommended Ecological Category (REC) over the

long term. Fluctuations in pH, Electrical Conductivity (EC), TDS, DO, and temperature will occur in the inundated areas as well as in the upstream river reach during flood events. These will most likely stabilize over the long term, but will differ from the PES.

Potential mitigation measures are limited due to permanent inundation of all existing riverine habitats within the dam basin. Potential mitigation should include the compilation of a management action plan whereby information from monthly water monitoring can be used to implement management actions should a significant decrease in Quality Ecospecs be noted:

- Monthly water quality monitoring should be conducted within the dam basin in order to detect trends in water quality. Suitable mitigation measures can then be implemented should it become clear that water quality is deteriorating beyond the recommended Water Quality Ecospecs.

The level of significance of this impact was rated as high during the construction and operation phases. After mitigation the significance of the impact decreased to medium for both phases (**Table 6.8**).

Table 6.8: Significance of the potential impacts on physical and chemical water conditions within the proposed Nwamitwa Dam basin

Description of potential impact	**Physical and chemical water conditions within the proposed Nwamitwa Dam basin**	
Nature of impact	Negative, direct and indirect	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Local
Duration of impact	Short term	Permanent
Intensity	Medium	Medium
Probability of occurrence	High	High
Confidence of assessment	High	High
Level of significance before mitigation	High	High
Mitigation measures (EMP requirements)	• Bioaccumulation assessments of plant and biotic tissue • Implementation of a suitable management action plan based on monthly water quality assessment and bi-annual biological monitoring surveys	• Implementation of a suitable management action plan based on monthly water quality assessment and bi-annual biological monitoring surveys
Level of significance after mitigation	Medium	Medium
Cumulative Impacts	As discussed in Section 6.6.3 (a) and include biotic and abiotic impacts	As discussed in Section 6.6.3 (a) and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.3 (a)		

(b) Potential impacts on riverine habitats within the dam basin

Sediment transport capacity is likely to decrease within the dam basin due to the decreased flows and siltation of the substrate begins. Flowing habitats are likely to be lost within the proposed Nwamitwa Dam basin. Although the sediment deposition volume in proposed Nwamitwa Dam is expected to be small over a 50 year period, deposition above full supply level will result in elevated flood levels in the river upstream of the reservoir which should be considered when floodlines are determined during the design of the dam (GLeWaP, 2008b). Mitigation is limited to accurate floodline calculation.

Surveys should be undertaken to identify red data or rare riparian plants species that may have to be removed from any of the construction sites or from the proposed inundated areas of the Nwamitwa Dam basin. Mitigation measures may include translocation of such riparian plant species to alternative areas.

The alteration of aquatic ecosystems from a lotic to a lentic ecosystem creates opportunities for exotic faunal and floral invasions (Davies & Day, 1998). Potential mitigations measures include:

- The prevention of exotic vegetation encroachment during the pre-construction and construction phases as well as bi-annual identification and removal of exotic vegetation within the Nwamitwa Dam basin during the operational phase;

- Natural features such as trees should not be removed from the proposed dam margin, so as to provide underwater habitats for colonising aquatic biota.

- The introduction of invasive alien fish species such as Carp (*Cyprinus carpio*) and bass (Centrarchidae sp.) should be prevented.

The species that make up the various animal and plant communities are altered: specialised river-adapted species will decrease or be lost and lake-tolerant species will flourish (Davies & Day, 1998). At regulated or impeded sites, the numbers of macroinvertebrates and fish are significantly lower than at unregulated sites and suggests that altered local flow hydraulics, flow depths and flow velocities have a significant effect on aquatic organisms (Jordonova *et al.*, 2004). It is expected that all fast velocity flowing habitats will be lost within the proposed Nwamitwa Dam basin

and will have resulting impacts on the aquatic organisms in terms of community structure and functioning.

Due to the currently fragmented state of reach EWR3 (DWAF, 2006), mitigation of this loss of habitat is limited to Identifying and assessing the suitability and accessibility of remaining habitats upstream for specific biota (i.e. macroinvertebrates and fish) that may migrate upstream in search of specific habitat requirements (i.e. flowing water, cobbles, cooler water temperature, etc.). Identified areas, if any, should be made conservation areas during the operational phases of the Nwamitwa Dam, thus ensuring sustainability of the aquatic biodiversity.

A management action plan should be set up; whereby information from bi-annual biomonitoring can be used to implement management actions should a significant decrease in the PES (C/D EC) (DWAF, 2006) within the reach be noted:

- Biomonitoring of selected sites within the Nwamitwa Dam basin and upstream reaches should be conducted bi-annually. This will allow trends in biotic integrity to be identified and compared to the results and recommendations of the 2006 RDS and November 2007 survey. A suitable management action plan which includes potential corrective procedures should be formulated.

The level of significance of this impact prior to mitigation was rated as high, for construction and operational phases (**Table 6.9**). The level of significance after implementation of recommended mitigation decreased to medium, for both phases (**Table 6.9**).

Table 6.9: Significance of the potential impacts on aquatic habitats within the proposed Nwamitwa Dam basin

Description of potential impact	Aquatic habitats within the proposed Nwamitwa Dam basin	
Nature of impact	Negative, direct and indirect	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Regional
Duration of impact	Short term	Permanent
Intensity	Medium	Medium
Probability of occurrence	High	High
Confidence of assessment	High	High
Level of significance before	High	High

mitigation		
Mitigation measures (EMP requirements)	• Phased removal of vegetation, limiting the amount of exposed areas and confining the majority of disturbance to the dry season • Translocation of red data or rare riparian plant species to alternative locations • Accurate floodline calculation • Planting larger, more developed rooted trees along the margin of the dam • Prevention of exotic vegetation encroachment • Identifying and assessing the suitability and accessibility of remaining habitats upstream for specific biota (i.e. fish) that may migrate upstream in search of specific habitat requirements • Implementation of a suitable management action plan based on bi-annual biological monitoring surveys	• Bi-annual identification and removal of exotic vegetation within the Nwamitwa Dam basin • Identified habitat areas, if any, should be made conservation areas during the operational phases of the Nwamitwa Dam. This will ensure the sustainability of the upstream aquatic biodiversity. • Implementation of a suitable management action plan based on bi-annual biological monitoring data
Level of significance after mitigation	Medium	Medium
Cumulative Impacts	As discussed in Section 6.6.3 (b) and include biotic and abiotic impacts	As discussed in Section 6.6.3 (b) and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.3 (b)		

(c) Potential Impacts on aquatic biota

Aquatic Macroinvertebrates

Thirty nine aquatic macroinvertebrate taxa were recorded in the sample area during the November 2007 baseline assessment. The potential impact of the proposed Nwamitwa Dam on aquatic macroinvertebrate assemblages within reach EWR3 was assessed in terms of flow and habitat preferences of the recorded taxa.

Flow and habitat preferences were based on the Macroinvertebrate Response Assessment Index (MIRAI) (Kleynhans *et al*., 2005b). A taxon with a high preference to a particular flow category or biotope type is rated between 3 and 5. Only taxa with a high preference rating to each flow category were assessed. These taxa are listed in Appendix C, according to their flow, biotope and water quality sensitivity preference types.

Four taxa currently occurring within the dam basin have a high preference rating for fast flow velocities > 0.6 m/s. These taxa all have high preference for cobble biotopes, and are usually associated with riffles and rapids (Gerber & Gabriel, 2002).

Of the eight taxa with high preferences for fast flow velocities of 0.3 – 0.6 m/s, five have high preferences for cobbles. Two of these five taxa are sensitive to impacts on water quality.

Two taxa with high flow preferences for slow velocities of 0.1 – 0.3 m/s (Corbiculidae and Sphaeridae) and are usually associated with gravel beds with/in slow riffles (Gerber & Gabriel, 2002).

It is likely that velocities between 0.1 and > 0.6 m/s and riffles, rapid as well as cobble and gravel biotopes will be eliminated from the proposed dam basin. Therefore, taxa that are dependant on these velocities and habitats/biotopes will be reduced in abundance or will completely disappear from the inundated areas of the basin. This accounts for 11 of the 39 aquatic macroinvertebrate taxa recorded during the November 2007 survey and is regarded as a significant loss in biodiversity in terms of maintaining the recommended Ecospecs (DWAF, 2006).

Due to the predicted increases in depth and inundation, taxa that have high preferences for slow flow velocities < 0.1 m/s and high biotope preferences to vegetation, sand or mud biotopes are most likely to be favoured. These taxa will increase in abundances and presence within the basin. Thus, a change will occur in the aquatic macroinvertebrate communities within the Nwamitwa Dam basin.

An additional cause for concern is the potential increase in the prevalence of Malaria (*Plasmodium sp*) infections due to the likely increase in the transmitter macroinvertebrate taxa Culicidae. Potential mitigation measures include creating community awareness on the preventative measures that can be take to avoid infections.

In terms of the 2006 RDS (DWAF, 2006), this change in aquatic macroinvertebrate community structure and loss of biodiversity will have a negative impact on the PES within the dam basin.

Recommended mitigation measures include:

- Natural features such as trees should not be removed from the proposed dam margin, so as to provide underwater habitats and cover for colonising aquatic biota.

- Identifying and assessing the suitability and accessibility of remaining habitats upstream of the dam. Identified areas, if any, should be made conservation areas so as to ensure the remaining viability of riverine flowing habitat types.

Ichthyofauna

Thirty three fish species are expected to occur within the study area, including one Near Threatened (NT) species: *O. mossambicus* (**Table 4.4**). According to the results of the 2006 RDS (DWAF, 2006) and the November 2007 baseline assessment, 17 indigenous and 1 exotic species are expected to remain within reach EWR3. The remaining 16 species have not been recorded in the reach for several years and are considered locally extinct due to existing impacts. Additional surveys may reveal that small isolated populations of some species remain in isolated sections of the reach.

The potential impact of the dam was assessed in terms of velocity depth, flow intolerance and migration potential preferences. The assessment was based on the Fish Response Assessment Index (FRAI) ratings (Kleynhans *et al*., 2005b). The specific species preferences for the remaining 18 species are provided in Appendix D. Species with a high preference for faster velocities, intolerance to flow modifications and high migration potential are expected to be negatively impacted upon by the construction of the dam.

Based on this assessment, six of the remaining species are likely to be negatively upon due to the construction of the dam. These species include: *Chiloglanis paratus* (Sawfin Suckermouth), *Chiloglanis pretoriae* (Shortspine Suckermouth), *Labeobarbus marequensis* (Lowveld Largescale Yellowfish), *Labeo cylindricus* (Redeye Labeo), *Labeo molybdinus* (Leaden Labeo) and *Micralestes acutidens* (Silver Robber). Of these six species, five were recorded during the baseline assessment. *C. paratus* (Sawfin Suckermouth) was not recorded during the November 2007 baseline assessment, but was recorded recorded during the 2006 RDS (DWAF, 2006) and is therefore known to remain within the reach.

It is likely that these six species will disappear from the proposed Nwamitwa Dam basin due to the change of habitat.

In terms of the 2006 RDS, the loss of these six species from reach EWR3 will have a negative impact on the PES and may have a negative implication on meeting the REC.

Mitigation includes identifying and assessing the suitability of remaining riverine habitats within reach EWR3. Remaining sections of river should be afforded special

conservation significance if there is so be any hope of maintaining the already impoverished fish diversity within the Groot Letaba River catchment.

The remaining 12 species including the aggressively invasive species: *M. salmoides* (Largemouth Bass) and the Near Threatened (NT) species *O.mossambicus* are likely to survive within the inundated waters of the proposed Nwamitwa Dam basin, some species may even flourish.

This impact is seen as negative in terms of the potential loss of six additional species from the local fish assemblage and negative in terms of the potential increase in abundance of *M. salmoides* within the dam basin. Over the long-term the increase in abundance of this exotic species will have a significant impact on the remaining indigenous fish species within the proposed Nwamitwa Dam basin.

Mitigation of this impact includes:

- Natural features such as trees should not be removed from the proposed dam margin, so as to provide underwater habitats and cover for colonising aquatic biota.

- The prevention of further introductions of *M. salmoides* into the proposed Nwamitwa Dam basin and upstream reaches;

- Control of fishing activities within the proposed Nwamitwa Dam. The role of recreational fishermen in the spread of invasive fish species should not be underestimated. The presence of introduced species within the dam basin should be monitored and the removal of any exotic fish that are caught should be encouraged.

- Setup of a management action plan based on monitoring of the population levels of *M.salmoides*. The purpose of monitoring activities should be to assess abundances of the exotic species and develop population control measures should large populations increase;

In addition, the following recommendations require further investigation:

- A genetic assessment of specific fish species upstream and downstream of the proposed Nwamitwa Dam site. This will provide further scientific evidence as to

the genetic status of fish populations upstream and downstream of the Nwamitwa Dam site and therefore provide insight on the importance of maintaining connectivity between fish populations by means of a fishway/fish ladder.

- A survey of habitat suitability for flow dependant fish species upstream and downstream of the Nwamitwa Dam. Remaining sections of riverine habitat should be afforded special conservation significance if the presence of flow dependant fish species is to be maintained.

Other aquatic-dependant fauna

Impacts on other aquatic-dependant fauna within the proposed Nwamitwa Dam basin may include impacts on the following fauna known to occur within the study area:

- Hippopotami (*Hippopotamus amphibious*) – this large mammal can adapt to dams (Stuart & Stuart, 1988 and Carruthers (Ed), 1997). This species can also migrate large distances overland if necessary to find suitable habitat or food. Therefore no mitigation is required, although the dangerous nature of the animal may require further restricted access to areas near the shoreline of the dam or alternatively the translocation of groups and individuals of this species to other locations.

- Water mongoose (*Atilax paludinosus*) – this small rodent-like mammal can adapt to large inundated waters associated with dams (Stuart & Stuart, 1988 and Carruthers (Ed), 1997). The species can also migrate large distances overland if necessary to find suitable habitat or food. Therefore no mitigation is required.

- Cape clawless otter (*Aonyx capensis*) and Spotted-necked otter (*Lutra maculicollis*) – these large rodent-like mammals can adapt to large inundated waters associated with dams (Stuart & Stuart, 1988 and Carruthers (Ed), 1997). These two species can also migrate large distances overland if necessary to find suitable habitat or food. Therefore no mitigation is required.

- Reptiles associated with aquatic ecosystems include snakes, terrapins (*Pelusios* sp.), water monitors (*Veranus niloticus*) and Nile crocodiles (*Crocodylus niloticus*). These reptiles can adapt to large inundated waters associated with dams (Carruthers (Ed), 1997). They can all migrate large distances if necessary

to find suitable habitats or food. No mitigation is required, although the dangerous nature of the Nile crocodile may require further restricted access to areas near the shoreline of the dam or alternatively the translocation of groups and individuals of this species to other locations.

- Amphibians (frogs) – are generally adaptable to large inundated waters associated with dams (Carruthers (Ed), 1997). They can move over land if necessary to find suitable habitats or food. No mitigation is required, certain species may require flowing habitats for critical life stages (i.e. tadpoles, however data is this regard is limited).

- Avifauna (birds) – various bird species are associated with aquatic ecosystems including: Reed cormorant (*Phalacrocorax africanus*), White-breasted cormorant (*P. carbo*), Darter (*Anhinga melonogaster*), Greenbacked heron (*Butorides rufiventris*), Squacco heron (*Ardeola ralloides*), Grey heron (*Ardea cinerea*), Blackheaded heron (*A. melanocephala*), Goliath heron (*A. goliath*), Hammerkop (*Scopus umbetta*), African fish eagle (*Haliaeetus vocifer*) and various Kingfisher species including the Giant kingfisher (*Ceryle maxima*), Pied kingfisher (*C. rudis*) and Brownhooded kingfisher (*Halcyon albiventris*). These species are all adaptable to dams (Carruthers (Ed), 1997). They can also fly large distances if necessary to find suitable habitats or food. No mitigation is required.

The results of the Impact Assessment are provided in **Table 6.10**. Prior to implementation of recommended mitigation measures the significance level of this impact was rated as medium for both the construction and operational phases (**Table 6.10**). The level of significance after implementation of mitigation was rated as low (**Table 6.10**).

Table 6.10: Significance of the potential impacts on aquatic biota within the proposed Nwamitwa Dam basin

Description of potential impact	Aquatic biota within the proposed Nwamitwa Dam basin	
Nature of impact	Negative, direct and indirect	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Could be international depending on environmental flows and % MAR contribution)
Duration of impact	Short term	Long term
Intensity	High	Medium
Probability of occurrence	High	High
Confidence of assessment	High	High
Level of significance before mitigation	Medium	Medium
Mitigation measures (EMP requirements)	• Limit the amount of disturbances to local construction site only • Maintain natural features such as large trees around the margin of the dam basin so as to provide underwater habitats, cover and refuge for aquatic biota. • Identifying and assessing the suitability of remaining habitats for flow dependant aquatic biota. Sections of remaining riverine habitat should be afforded special conservation significance of flow dependant species are to survive within the Groot Letaba catchment. • Implementation of a suitable management action plan based on two biological monitoring survey.	• Prevent any introductions *of M. salmoides* (Largemouth Bass) • Control access to fishing activities within, the proposed Nwamitwa Dam basin • Identified habitat areas, if any, should be made conservation areas during the operational phases of the Nwamitwa Dam. This will ensure the sustainability of the upstream aquatic biodiversity. • Setup a management action plan based on bi-annual monitoring of the population levels of *M. salmoides*. • Assess the genetic status of the *O.mossambicus* population within the project area. • Biotic compensation through the setup of an ecoregion (a wildlife park, or eco-reserve) around the dam
Level of significance after mitigation	Low	Low
Cumulative Impacts	As discussed in Section 6.6.3 (c) and include biotic and abiotic impacts	As discussed in Section 6.6.3 (c) and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.3 (c)		

6.6.4 Potential impacts on the aquatic ecosystems of the Groot Letaba River, downstream of the proposed Nwamitwa Dam

(a) Potential impacts on physical and chemical water conditions

The natural seasonality of South African rivers influences the physical and chemical characteristics of the water. Temperatures, oxygen concentrations, silt loads and nutrient concentrations are some of the main seasonal variants in natural rivers to which biota have specifically adapted (Davies & Day, 1998).

Temperature

The potential impact on water temperature in the downstream receiving ecosystem is primarily considered to be from water released from either the hypolimnion or epilimnion waters within the dam. These usually differ from the receiving river water temperatures and may have a detrimental effect on the aquatic life up to a distance of about 15 km downstream of the dam wall (GLeWaP, 2008a). The impacts on aquatic biota may include:

- Accelerated or reduced growth rates;
- Accelerated or reduced metabolisms and digestion of food;
- Increased or decreased food availability;
- Premature or delayed emergence of aquatic macroinvertebrates;
- Retardation of or mistimed life cycles;
- Reduced diversity due to elimination of taxa with preferences for warm or cold water; and
- Temperature shock often resulting in aquatic macroinvertebrate and fish kills.

Any change from the natural pattern may result in the disruption of riverine food chains and life cycles (Davies & Day, 1998).

Mitigation of this impact includes:

Oxygen

Water is usually turbulently discharged from dams thus allowing rapid absorption of oxygen by the water. No mitigation is needed.

Silt load

As the water releases from the dam has lost most of its particulate load, water discharged from the dam has less silt than the natural receiving river water (Davies and Day, 1998). According to the sediment impact report (GLeWaP, 2008b), a decrease in sediment supply and an increase in sediment transport can be expected

downstream of the Nwamitwa Dam. This may have indirect impacts on aquatic ecosystems in terms of changes in water chemistry and biological processes and direct impacts on aquatic biota due to abrasion of gills, changes in predator-prey dynamics etc.

Large flood events may overcome this impact and reset the downstream aquatic ecosystems in terms of providing adequate silt loads. Mitigation includes the compilation of a suitable management action plan based on water quality monitored at downstream sites. This will allow the identification and characterisation of trends in water quality and biotic integrity. The potential for large flood events to reset the downstream aquatic ecosystems should be assessed.

Nutrient concentrations

Changes in may occur in terms of nutrient concentrations due to stratification of water within the Nwamitwa Dam.

The above mentioned impacts on temperature, oxygen, silt load and nutrients from the release strategy of the proposed Nwamitwa Dam are most likely to occur downstream of the Nwamitwa Dam for some length within the receiving waters of the Groot Letaba River.

The impacts of changes to water quality will have a negative impact on the PES (C/D EC) and may have a negative implication on meeting the REC (C/D EC) within reach EWR3 (DWAF, 2006).

Proper release management during the operational phase may act as a 'reset' measure for the water quality continuing to downstream reaches and improve water quality within the Groot Letaba River. Monthly monitoring of water quality and bi-annual monitoring of aquatic ecosystems should measure the effects of this release strategy.

The results of the Impact Assessment are provided in **Table 6.11**. Prior to implementation of recommended mitigation measures the significance of this impact was rated as medium for both the construction and operational phases (**Table 6.11**). The level of significance after implementation of mitigation was rated as low for (**Table 6.11**).

Table 6.11: Significance of the potential impacts on physical and chemical water conditions on the aquatic ecosystems of the Groot Letaba River, downstream of the proposed Nwamitwa Dam

Description of potential impact	Physical and chemical water conditions downstream of the proposed Nwamitwa Dam	
Nature of impact	Negative, direct and indirect	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Regional
Duration of impact	Short term	Long term
Intensity	Low	Medium
Probability of occurrence	Medium	High
Confidence of assessment	Medium	High
Level of significance before mitigation	Medium	Medium
Mitigation measures (EMP requirements)	• Limit disturbances to the development footprint only • Implementation of a suitable management action plan based on monthly water monitoring at selected downstream sites	• Proper release management • Setup a Management action plan based on monthly monitoring of the water quality and bi-annual biomonitoring of aquatic ecosystems at selected downstream sites
Level of significance after mitigation	Low	Low
Cumulative Impacts	As discussed in Section 6.6.4 (a) and include biotic and abiotic impacts	As discussed in Section 6.6.4 (a) and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.4 (a)		

(b) Potential impacts on aquatic habitats

Most South African rivers are naturally seasonal systems with specific high and low flow regimes as well as high variability in these regimes. Dam releases seldom follow these regimes and remove natural variability from the system. Discharges from the dam may result in increased erosion of river banks and incising of the river channel downstream of the dam (DWAF, 1999b). Downstream river habitats of the Groot Letaba River are likely to be directly altered in terms of habitat loss or modification as well as in riparian vegetation changes (Davies & Day, 1998).

The sediment impact report indicates that sediment transport will increase downstream of the proposed Nwamitwa Dam, this will result in increased scouring of the substrates and channel (GLeWaP, 2008b). Near the dam wall, the model indicated bed degradation of at least 2 m. The level of degradation depends on the number and size of large floods released from the dam into the downstream river. A

new equilibrium is typically established seven to ten years after completion of the dam.

The report also indicated that the post-dam river (Groot Letaba River downstream of the proposed Nwamitwa Dam) will become narrower due to flood attenuation (GLeWaP, 2008b). Near the dam wall, the main channel width could decrease by 19 % (resulting in a 22 m reduction on the existing 116 m channel width). The report further indicated that the river bed of the Groot Letaba River between the proposed Nwamitwa Dam and the Klein Letaba River confluence will become coarser due to sediment trapping within the dam.

Some form of channel degradation will occur despite mitigation. Construction of the dam wall and downstream stabilisation measures should provide some mitigation.

The presence of the dam is likely to cause an increase in the duration of low flow seasons and a reduction in the availability of certain habitat types (marginal vegetation, water column cover, undercut roots and banks, fast-velocity flow decreases, etc.) (DWAF,1999). A reduction in the abundance or availability of marginal habitat types due to the expected reduction in channel width will have potentially serious biological consequences, especially for macroinvertebrates and small fish (Hughes & Münster, 2000). It is expected that riffle-rapid and pool sequences will decrease for some length downstream of the dam and that during periods of no release, only reduced pools will remain.

Based on the 2006 RDS (DWAF, 2006), the state of existing geomorphology, hydraulics and hydrology of Resource Unit EWR3 was low due to prior channel, flow and sediment transport modifications. This resulted in a PES of C/D and a RECs of C/D. The impacts on the remaining reach downstream of the proposed Nwamitwa Dam will result in a decreased PES and thus it is uncertain whether the REC and Ecospecs set out in the 2006 RDS will be attainable (DWAF, 2006).

Mitigations measures include:

- A properly managed timing and release strategy that will ensure that presently existing or naturally seasonal variability in flows are released and or maintained within the downstream Groot Letaba River. This will enable specific ecosystems functions to be maintained (migration queues, seasonal floodplain inundation, temperature variations, etc.) within the downstream river; and

- The setup of a management action plan based on bi-annual habitat integrity monitoring during both the construction and operational phases at selected sites downstream of the Nwamitwa Dam. Any major decreases in habitat integrity can thus be measured and suitable management options can thus be implemented.

The results of the Impact Assessment are provided in **Table 6.12**. Prior to implementation of recommended mitigation measures the significance was rated as high for both the construction and operational phases (**Table 6.12**). The level of significance after implementation of mitigation was rated as low for both phases (**Table 6.12**).

Table 6.12: Significance of the potential impacts on the aquatic habitats of the Groot Letaba River, downstream of the proposed Nwamitwa Dam

Description of potential impact	**Aquatic habitats downstream of the proposed Nwamitwa Dam**	
Nature of impact	Negative, direct and indirect	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Regional
Duration of impact	Short term	Long term
Intensity	Medium	High
Probability of occurrence	Medium	High
Confidence of assessment	High	High
Level of significance before mitigation	High	High
Mitigation measures (EMP requirements)	• Limit the amount of disturbances to local construction site only • Stabilisation of downstream river bed and banks • Implementation of a suitable management action plan based on bi-annual habitat integrity monitoring at selected downstream sites	• Proper release management from the multi-level outlets • Setup a Management action plan based on bi-annual habitat integrity monitoring at selected downstream sites
Level of significance after mitigation	Low	Low
Cumulative Impacts	As discussed in Section 6.6.4 (b) and include biotic and abiotic impacts	As discussed in Section 6.6.4 (b) and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.4 (b)		

(c) Potential impacts on aquatic biota

Aquatic Macroinvertebrates

The impact of the proposed Nwamitwa Dam on aquatic macroinvertebrate assemblage downstream of the dam basin was assessed in terms of flow and habitat preferences of the recorded taxa (Appendix C). Based on this assessment it can be

concluded that most of the taxa will have fluctuating abundances and diversities depending on the variability in timing, rate and frequency of release from the dam.

Shifts can be expected in the natural macroinvertebrate assemblages downstream of the dam due to the changes in the physical and chemical characteristics as well as the modified flows and habitats. This may reduce or eliminate certain taxa thus, while other species, such as *Simuliidae sp*. may proliferate. Outbreaks of Simuliidae and Bilharzia (from increased snail vectors) are associated with the changes to the downstream river ecosystems below large dams (Davies & Day, 1998). It is expected that most taxa with a preference to vegetation (especially marginal vegetation) will be lost due to the expected reduction in the channel width. A reduction in taxa with a preference to fine sand and mud is also expected due to the coarsening of the substrate due to expected sediment transport increases.

In terms of the 2006 RDS (DWAF, 2006), the change in aquatic macroinvertebrate community structure and loss of some taxa will have a negative impact on the PES for the downstream section of reach EWR3 and it is uncertain whether the REC and Ecospecs set out in the 2006 RDS will be attainable (DWAF, 2006).

Mitigations measures include:

- A properly managed timing and release strategy to ensure that presently existing or naturally seasonal variability in flows are maintained within the downstream Groot Letaba River. This will enable specific ecosystems functions to be maintained (migration ques, seasonal floodplain inundation, temperature variations, etc.) within the downstream river and will prevent large scale changes in the aquatic macroinvertebrate community structure;

- Identifying and assessing the suitability and accessibility of remaining habitats downstream for specific taxa that may migrate downstream in search of specific habitat requirements (i.e. marginal vegetation, flowing water, cobbles, sand, cooler water temperatures, etc.). Identified areas should be afforded special conservation significance if existing levels of biotic integrity are to be maintained.

- The setup of a management action plan based on bi-annual biomonitoring during both the construction and operational phases at selected sites downstream of the Nwamitwa Dam. A downward trend in macroinvertebrate diversity and

abundances can thus be measured and suitable management options can be implemented.

Ichthyofauna

It can be expected that a shift in the existing fish assemblage is likely to occur downstream of the proposed Nwamitwa Dam, due to the changes in the physical and chemical characteristics as well as the modified flows and habitats.

The impact of the Nwamitwa Dam on downstream habitats will reduce the abundances of at least 14 of the 18 fish species and may even eliminate certain species downstream of the dam. Species such as *M. salmoides* (Largemouth Bass), *C. gariepinus* (Sharptooth catfish) and *O. mossambicus* (Mozambique Tilapia) may proliferate. The shift in species assemblage, decrease in abundances and possible elimination and proliferation of certain species will however depend on the variability in timing, rate and frequency of release from the dam.

The potential decrease in abundances of 14 species and loss or proliferation of certain species within the remaining reach (EWR3) will have a negative impact on the PES and thus it is uncertain whether the REC and Ecospecs set out in the 2006 RDS will be attainable (DWAF, 2006).

Mitigation measures include:

- Maintenance of lateral connectivity between fish assemblages situated upstream and downstream of the proposed dam this is typically achieved by means of a fishway.

- Maintenance of connectivity between remaining riverine habitats upstream and downstream of the dam. This can be achieved by means of a fishway.

- A habitat suitability and accessibility study of the area both upstream and downstream of the Nwamitwa Dam site. Suitable habitat areas not impacted by the GLeWaP should be identified and afforded special conservation significance.

Other aquatic-dependant fauna

It is expected that these species will migrate further downstream to more suitable habitats or perhaps even migrate upstream into the areas surrounding the dam basin. No mitigation is therefore required.

The results of the Impact Assessment are provided in **Table 6.13.** Prior to implementation of recommended mitigation measures the significance level of this impact was rated as high for both the construction and operational phases (**Table 6.13**). The level of significance after implementation of mitigation was rated as low for both phases (**Table 6.13**).

Table 6.13: Significance of the potential impacts on the aquatic biota of the Groot Letaba River, downstream of the proposed Nwamitwa Dam

Description of potential impact	**Aquatic biota downstream of the proposed Nwamitwa Dam**	
Nature of impact	Negative and direct	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Regional and international
Duration of impact	Short term	Long term
Intensity	Medium	High
Probability of occurrence	Medium	High
Confidence of assessment	High	High
Level of significance before mitigation	High	High
Mitigation measures (EMP requirements)	• Limit the amount of disturbances to local construction site only • Identifying and assessing the suitability and accessibility of remaining habitats upstream for specific biota (aquatic macroinvertebrates and fish) that may migrate upstream in search of specific habitat requirements • Maintain connectivity between fish assemblages upstream and downstream of the proposed dam wall by means of a fishway. • Maintain access for downstream fish assemblages to remaining sections of riverine habitats upstream of the dam by means of a fishway.	• Comply with the 2006 RDS requirements • Prevent any new introductions *of M. salmoides* (Largemouth Bass) • Identified habitat areas should be made conservation areas during the operational phases of the Nwamitwa Dam. This will ensure the sustainability of the upstream aquatic biodiversity. • Setup a management action plan based on bi-annual monitoring of the population levels of *M. salmoides*. • Proper release management • Well managed operational procedures • Implementation of a suitable management action plan based on bi-annual biological monitoring data • Maintain connectivity between fish assemblages upstream and downstream of the proposed dam wall by means of a fishway. • Maintain access for downstream fish assemblages to remaining sections of riverine habitats upstream of the dam by means of a fishway.

Level of significance after mitigation	Low	Low
Cumulative Impacts	As discussed in Section 6.6.4 (c) and include biotic and abiotic impacts	As discussed in Section 6.6.4 (c) and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.4 (c)		

6.6.5 Potential impacts of the proposed Nwamitwa Dam as a migration barrier on fish assemblages in the Groot Letaba River

The presence of barriers to migration in rivers (weirs, dams, road bridges, causeways, etc) is considered to be a major factor responsible for the reduction in numbers and range of many migratory fish and invertebrate species throughout South Africa (Bok *et al*., 2007). Most indigenous fish species carry out annual migrations within river systems in order to optimize feeding, promote dispersal, to avoid unfavourable conditions and to enhance reproductive success.

Impassable constructed barriers to migration are partly responsible for the threatened status of a number of Red Data species in southern Africa (Bok *et al*., 2007).

The presence of migratory aquatic species within reach EWR3 is therefore critical to the assessment of this impact.

Migratory fish species

The majority of freshwater fish species undertake migrations for feeding, spawning, dispersion and recolonisation after droughts. Many of these species (e.g. *Labeobarbus sp., Barbus sp. and Clarias sp.*) are well known for undertaking spectacular spawning migrations after the 1st summer rains. However evidence exists that many fish species migrate various distances upstream and downstream into more favourable habitats, as both adults and juveniles, at various times of the year, and for a variety of reasons (Bok *et al*., 2007).

According to the 2006 RDS, (DWAF, 2006), the abundances of most of the fish species in the study area (EWR3) is declining. The main factor was attributed to fragmentation of the river reach. It is likely that some of the expected fish species may no longer occur within the reach. The continued presence of two expected migratory eel species (*A. marmorata* and *A. mossambica*) within the reach is unlikely due to Massangir Dam in Mozambique. *Barbus eutaenia* is a sensitive flow dependant species capable of extended migrations which may be lost from the RU due to high

degree of flow modification and water abstraction in the Groot Letaba River (DWAF, 2006).

The remaining 17 indigenous fish species (*M. salmoides* was excluded from this assessment) believed to remain within reach EWR3 were assessed in terms of their migration potential according to Kleynhans *et al*. (2005b)(Appendix E). Only species with a high migration potential (rating 3-5) were considered to be negatively impacted by the construction of the dam. Based on the results of this assessment, it can be concluded that of the 17 indigenous fish species expected to remain and occur within this reach (EWR3):

- 16 fish species have migration potential of 3.0 and thus migrate between reaches; and

- One species *(P.philander*) has a migration potential of 1, indicating that it only migrates within the reach.

Therefore, 16 of the 17 indigenous fish species occurring within reach EWR3 are likely to be impacted in terms of migration potential.

Based on this it can be concluded that construction of an additional migration barrier will impact the PES and will likely make the REC for this reach unattainable.

The level of impact may include loss of genetic diversity, reproduction decreases, population isolation and fish kills above or below the dam wall during migration periods. These impacts may result in the loss or reduction of species upstream and downstream of the Nwamitwa Dam.

Mitigation measures include:

- Identifying and assessing the suitability and accessibility of remaining habitats upstream and downstream of the Nwamitwa Dam. This assessment should be undertaken prior to the construction phase;

- Areas of remaining riverine habitats between impoundments should be afforded special conservation significance. This will ensure that biotic integrity is maintained within the remaining river reaches.

- Maintain connectivity between upstream and downstream riverine habitats by means of a fishway.

The results of the Impact Assessment are provided in **Table 6.14**. Prior to implementation of recommended mitigation measures the significance level of this impact was rated as high for both the construction and operational phases (**Table 6.14**). The level of significance after implementation of mitigation was rated as medium for both phases (**Table 6.14**).

Table 6.14: Significance of the potential impacts of the proposed Nwamitwa Dam as a migration barrier on fish assemblages in the Groot Letaba River

Description of potential impact	Migration barrier on fish assemblages in the Groot Letaba River	
Nature of impact	Negative and direct	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative and direct	Negative and direct
Extent of impact	Local	Regional
Duration of impact	Short term	Long term
Intensity	Medium	High
Probability of occurrence	Medium	High
Confidence of assessment	High	High
Level of significance before mitigation	High	High
Mitigation measures (EMP requirements)	• Identifying and assessing the suitability and accessibility of remaining habitats both upstream and downstream for specific biota (aquatic macroinvertebrates and fish) that may migrate in search of specific habitat requirements • Maintain connectivity between upstream and downstream riverine habitats by means of a fishway.	• Remaining segments of riverine habitat between impoundments should be identified and afforded special conservation significance. This will ensure that some habitat remains intact for flow dependant fish species and some semblance of the predevelopment fish assemblage is maintained. • Maintain connectivity between upstream and downstream riverine habitats by means of a fishway.
Level of significance after mitigation	Medium	Medium
Cumulative Impacts	As discussed in Section 6.6.5 and include biotic and abiotic impacts	As discussed in Section 6.6.5 and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.5		

6.6.6 Potential impacts of the proposed Bulk Water Infrastructure (BWI) associated with the GLeWaP on the associated aquatic ecosystems

(a) Potential impacts on physical and chemical water conditions

Water quality changes due to metal and sediment contamination, changes in pH, COD, TDS, etc. and nutrient increases from sewage contamination may occur. These may arise from underground seepage, runoff or direct discharge from the proposed BWI, sewage treatment facilities, and infrastructure associated with the GLeWaP. These changes will have negative impacts on the receiving aquatic ecosystems. Major construction activities may have a negative impact on sediment load in the rivers due to run off.

Mitigation of these impacts is limited to:

- Prevent underground seepage, runoff or direct discharge from any of the activities from entering the aquatic and wetland ecosystems through effective construction engineering;
- Prevent waste return flows from entering the river systems;
- Incorporate preventative measures into the design process to minimize the mobilization of sediments;
- Establish and maintain buffer zones;
- Limit the amount of disturbances to local construction site only and confine most major construction to the dry season;
- Implement an adequate water, sediment and biological monitoring programme together in the form of a management action plan; and
- Design and implement a Biodiversity Action Plan (BAP) to facilitate planning and zonation of human activities.

(b) Potential impacts on the physical habitat conditions

Alterations in the water flow, channel structure and riparian vegetation and may be as a result of the planned construction of the infrastructure associated with the BWI (power lines, roads, pipes, sewage treatment plants, etc.).

Mitigation measures are limited to:

- Comply with the 2006 RDS requirements;
- The use of existing impacts such as roads, bridges and servitudes;
- Maintain natural water flow through effective construction engineering;
- Keep habitat alteration to a minimum by limiting the foot print of construction activities and the spatial extent of infrastructure; and
- Implement rehabilitation where construction site footprint impacts occur.

(c) Potential impacts on the aquatic biota

As indicated by the impacts on the physical and chemical water conditions and on the physical habitat conditions, impacts on the aquatic biota may occur.

Mitigation measures are limited to a Management action plan that should be set up, whereby information from bi-annual water monitoring and biomonitoring at selected sites of potential impact can be used to implement management actions should a significant decrease in PES (C/D EC) at these selected sites occur.

In terms of the 2006 RDS, the potential impacts of this proposed BWI on the associated aquatic ecosystems may result in a slight decrease in PES within the reach (EWR3) over the short to medium term. This decrease should not compromise the recommended Ecological Category (REC) or decrease from the current Ecospecs significantly over the long term.

The level of significance of this impact was rated as medium, for construction and operational phases, prior to the implementation of mitigation measures (**Table 6.15**). The level of significance was reduced to low, for both phases, after implementation of recommended mitigation (**Table 6.15**).

Table 6.15: Significance of the potential impacts of the proposed Bulk Water Infrastructure (BWI) associated with the GLeWaP on the associated aquatic ecosystems

Description of potential impact	Proposed Bulk Water Infrastructure (BWI) associated with the GLeWaP	
Nature of impact	Negative, direct and indirect	
Legal requirements	NWA, NEMA, NBA & 2006 RDS	
Stage	Construction and commissioning	Operation
Nature of Impact	Negative, direct and indirect	Negative, direct and indirect
Extent of impact	Local	Local
Duration of impact	Short term	Long term
Intensity	Medium	Medium
Probability of occurrence	Medium	Medium
Confidence of assessment	Medium	Medium
Level of significance before mitigation	Medium	Medium
Mitigation measures (EMP requirements)	• Prevent underground seepage, runoff or direct discharge from any of the activities from entering the aquatic and wetland ecosystems through effective construction engineering • Incorporate preventative measures into the design process to minimize the mobilization of sediments • Establish buffer zones • Limit the amount of disturbances to local construction site only and confine most major construction to the dry season • Design and implement a Biodiversity Action Plan (BAP) to facilitate planning and zonation of human activities • Use of existing impacts such as roads, bridges and servitudes • Maintain natural water flow through effective construction engineering • Keep habitat alteration to a minimum by limiting the foot print of construction activities and the spatial extent of infrastructure • Implement rehabilitation where construction site footprint impacts occur • Implementation of a suitable management action plan based on bi-annual water and biological monitoring data	• Comply with 2006 RDS requirements • Maintain buffer zones • Implementation of a suitable management action plan based on bi-annual water and biological monitoring data
Level of significance after mitigation	Low	Low
Cumulative Impacts	As discussed in Section 6.6.8 and include biotic and abiotic impacts	As discussed in Section 6.6.8 and include biotic and abiotic impacts
Comments or Discussion: As discussed in Section 6.6.8		

6.6.7 Potential impacts of the proposed GLeWaP on the aquatic ecosystems of the Hans Merensky Nature Reserve, the Kruger National Park (KNP), and Mozambique

The potential impacts of the proposed GLeWaP including the raining of the Tzaneen Dam wall, the construction of the Nwamitwa Dam, the flow gauging weir and the BWI as discussed in this EIR will have a cumulative impact on the downstream reaches and users. This includes the Hans Merensky Nature Reserve, the Kruger National Park (KNP), and Mozambique. Potential impacts include indirect impacts on the low flow seasons, flow regimes and aquatic ecosystems along the downstream reaches.

According to the 2006 RDS, the ecological objectives for the PES are not currently being met in the Kruger National Park due to the existing allocation of 0.6 m^3/s from Tzaneen Dam not being sufficient. According to the sediment specialist report (GLeWaP, 2008b), the Letaba River in the KNP upstream of the Olifants River confluence will be impacted in terms of the GLeWaP by the reduction of channel width of 17 % (70 m on 411 m channel width). This is likely to have a significant impact on the aquatic ecosystems within this reach and will make compliance with the REC of C at sites EWR5, EWR6 and EWR7 unattainable and will have further implications on the Elephates River in Mozambique.

Mitigations measures as mentioned in this report may reduce or alleviate these impacts to some degree.

7. RECOMMENDED MITIGATION MEASURES

The following recommended mitigation measures were identified:

7.1 CONSTRUCTION AND COMMISSIONING PHASE

7.1.1 Raising of the Tzaneen Dam wall

Implementation of a suitable management action plan during the construction phase, based on monthly water quality and bi-annual biological monitoring surveys of sites downstream of the raised Tzaneen Dam wall. .

7.1.2 Construction of the proposed Nwamitwa Dam

- Implementation of a suitable management action plan during the construction phase, based on analysis of monthly water quality and bi-annual biological monitoring data collected at sites upstream, downstream and within the Nwamitwa Dam;

- Natural features such as trees should not be removed from the proposed dam margin, so as to provide habitats for colonising aquatic biota and perches for aquatic birds;

- Confining the majority of disturbance to the development footprint;

- Planting larger, more developed rooted riparian trees as well as suitable riparian vegetation and specific marginal aquatic macrophytes along the margin of the Nwamitwa Dam basin and in the immediate downstream river channel;

- The translocation of red data or rare riparian plant species to alternative areas;

- Prevention of exotic vegetation encroachment;

- Identifying and assessing the suitability and accessibility of remaining riverine habitats upstream or downstream of the Nwamitwa Dam. Areas of remaining riverine habitats should be afforded special conservation significance of flow

dependant fish and macroinvertebrates are to be maintained. This assessment should be initiated prior to construction;

- Ensure adequate stabilisation of the downstream river bed and banks below the Nwamitwa Dam wall;

- Assess the genetic linkage between of fish populations upstream and downstream of the proposed dam. This assessment should be conducted prior to construction;

- Maintain connectivity between fish assemblages and remaining riverine habitats upstream and downstream of the dam by means of a fishway;

- Prevent any new introductions or the further proliferation *of M. salmoides* (Largemouth Bass) and *O. niloticus* (Nile Tilapia) within the dam basin;

- Control recreational/subsistence fishing activities within the proposed Nwamitwa Dam. The role of recreational/subsistence fishermen in the spread of invasive fish species should not be underestimated;

- Utilise biotic compensation through the setup of an ecoregion (a wildlife park, or eco-reserve) around the Nwamitwa Dam basin and provide adequate habitats for species; and

- Establish eco-awareness of local communities and visitors through environmental and ecosystem education programmes.Construction of the proposed flow gauging weir

7.1.3 Construction of the Bulk Water Infrastructure (BWI) associated with the GLeWaP

- Prevent underground seepage, runoff or direct discharge from any of the activities from entering the aquatic and wetland ecosystems during the construction phase through effective construction engineering;
- Incorporate preventative measures into the design process of the BWI during the construction phase to minimize the mobilization of sediments;
- Establish buffer zones around the BWI during the construction phase;
- Maintain established buffer zones within BWI during the construction phase;
- Design and implement a Biodiversity Action Plan (BAP) to facilitate planning and zonation of human activities associated with the BWI during the construction phase;
- Make use of existing impacts such as roads, bridges and servitudes so as to minimize impacts;
- Maintain natural water flow within the BWI during the construction phase through effective construction engineering;
- Keep habitat alteration to a minimum by limiting the footprint of construction activities and the spatial extent of BWI; and
- Implement rehabilitation where construction site footprint impacts occur within the BWI.

7.2 OPERATIONAL PHASE

7.2.1 Raising of the Tzaneen Dam wall

Implementation of a suitable management action plan based on monthly water quality assessments and bi-annual biological monitoring surveys of selected sites downstream of the raised Tzaneen Dam wall.

7.2.2 Operation of the proposed Nwamitwa Dam

- Implementation of a suitable management action plan during the operational phase phases, based on monthly water quality assessments and bi-annual biomonitoring surveys of selected sites within, upstream and downstream of the Nwamitwa Dam;

- A properly managed timing and release strategy that will ensure that presently existing or naturally seasonal variability in flows are released and or maintained within the downstream Groot Letaba River. This will enable specific ecosystem functions such as migration queues, seasonal floodplain inundation and temperature variations to be maintained.

- Annual bioaccumulation assessments of plant and biotic tissues in order to assess levels of potential POPs and toxicants;

- Monitor the effects of fluctuating water levels on the marginal vegetation, recommended bi-annual biomonitoring;

- Prevention and removal of exotic vegetation encroachment;

- Identified habitat areas to which aquatic biota could migrate to, if any, should be made conservation areas during the operational phase of the Nwamitwa Dam. This will ensure the sustainability of the upstream aquatic biodiversity;

- Prevent any further introductions or the proliferation of introduced fish species such as *M. salmoides* (Largemouth Bass) and *O. niloticus* (Nile Tilapia);

- Control access to recreational/subsistence fishing activities within the proposed Nwamitwa Dam basin. The role of recreational/subsistence fishermen in the spread of invasive fish species should not be underestimated;

- Encourage ecotourism developments within this ecoregion with the specific aim of benefiting local communities;

- Establish eco-awareness of local communities and visitors through environmental and ecosystem education programmes; and

- Ensure a proper release management strategy based on the measures set out in the aquatic EIR.

7.2.3 Operation of the Bulk Water Infrastructure (BWI) associated with the GLeWaP

- Prevent underground seepage, runoff or direct discharge from any of the activities from entering the aquatic and wetland ecosystems during the operational phase through effective construction engineering;

- Monitor established buffer zones within BWI during the operational phase;

- Maintain natural water flow during construction activities by means of effective environmentally sensitive construction methods;

ENVIRONMENTALLY SENSITIVE CONSTRUCTION METHODS

It is recommended that the most of the major construction be limited to dry season so as to limit the amount of sediments or runoff that could be transported via runoff into the river. When this is not possible, a concerted effort to prevent any sediment and pollution contamination into the receiving aquatic ecosystem should be ensured.

Any rubble, sand, litter, fuels, sewage and other materials or wastes associated with the construction process must be prevented from entering the aquatic environments.

Proper storage of construction materials and storm-water runoff measures must be implemented.

MARGINAL AND RIPARIAN VEGETATION

Adequate marginal and riparian vegetation along the margin of the Nwamitwa Dam as well as downstream of the dam wall must be planted. This must be done in consultation with the aquatic ecologist and wetland specialists.

Special attention must be given to any red data or rare plants species that may have to be removed from any of the construction sites or from the proposed inundated areas of the Nwamitwa Dam basin. Mitigation measures may include translocation of such plant species to alternative areas.

BIOTIC COMPENSATION THROUGH THE SETUP OF ECOREGIONS, ECOTOURISM AND ECO-AWARENESS PROGRAMMES

In regard to the potential loss of certain macroinvertebrate taxa and fish species, one mitigation option may be in the form of biotic compensation. The loss of certain aquatic macroinvertebrate taxa and fish species may be compensated by ensuring that habitats are provided and protected for these other aquatic-dependant fauna.

This could be in the form of the setup of an ecoregion (a wildlife park, or eco-reserve) around the dam that provides adequate cover, food, and other required habitats for these biota to inhabit. Ecotourism may also benefit the local communities and create eco-awareness through environmental and ecosystem education programmes focusing on the Nwamitwa Dam and associated ecosystems.

MAINTENANCE OF EXISTING FLOW REGIME AND RELEASE STRATEGY FOR THE NWAMITWA DAM

This was not part of the scope of work, but a brief description was complied after the review process. A brief description of a recommended flow and release strategy is given in Appendix G.

It is recommended that a full assessment of this be conducted.

PRESERVATION OF NATURAL FISH MIGRATION ROUTES

In order to preserve the natural migration routes of the fish with the study reach (EWR3), it is recommended that a suitable and navigable fishway or ladder be constructed so as to allow free passage for migration.

The successful design of a fishway or ladder depends largely on providing the hydraulic and physical characteristics that cater for all the migratory species expected to use it (Bok *et al*., 2007). The following characteristics will need to be incorporated into the fishway design:

- Biological information of the fish assemblage in the area. This will include specific data on the migratory behaviour and swimming ability of species expected to use the fishway.

- Hydrological and hydraulic characteristics needed in order to operate effectively and to ensure that the appropriate fishway type is used and that the fishway is designed correctly

- Topographical features of the site where the fishway is to be placed should be considered in the design of the fishway.

8. THE PUBLIC PARTICIPATION PROCESS

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 July 2007 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 four languages,
- placement of site notices in the project area,
- publishment of advertisements in regional and local newspapers,
- publishment of information on the DWAF web site,
- announcement on local and regional radio stations; and
- the hosting of five focus group meetings in the project area.

Comments received from stakeholders were captured in the Issues and Response Report (IRR) which formed part of the Draft Scoping Report (DSR). The DSR was made available for public comment in October 2007. A summary of the DSR (translated into four languages) was distributed to all stakeholders and copies of the full report at public places. Two stakeholder meetings were held in October to present and discuss the DSR. The Final Scoping Report was made available to stakeholders in December 2007.

The Draft Environmental Impact Assessment Report, its summary (translated in four languages), the various specialist studies, the Environmental Management Plans and Programmes were made available for a period of thirty (30 days) for stakeholders to comment. Stakeholder comments were 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.

9. COMMENTS RECEIVED

The following relevant comments were received from the Issues and Responses Report (GLeWaP, 2008c) and have been addressed in this Specialist Study:

- That the ecological reserve is immediately implemented and monitored – pre, during and post development monitoring of the water quality and riverine ecology both up and downstream of the dam;

- That all parties recognise from the outset that it is insufficient to state that the "ecological Reserve will be maintained". Clarity must be obtained on why existing ecological reserves of water are not being maintained (e.g. in the Olifant's River system even before construction of the De Hoop Dam, and in the Nyl River system and if this cannot be undertaken then this must be regarded as a fatal flaw;

- That the ecological reserve and downstream users be considered;

- That allocations for the Kruger National Park (KNP) and the allocations for the ecological reserve from the Tzaneen Dam will be affected by the proposed Nwamitwa Dam;

- That pollution of the water from the squatter area runs into the river through the Tzaneen Dam and it is affecting the quality of the existing water;

- That it was asked to what degree the proposed construction of the dam will increase evaporation losses in the river system;

- Will stream flow increase or decrease with the proposed new dam, adding that any changes in stream flow will have impacts on storks, freshwater mussels, hippo, crocodile, and birds, such as Pell's Fishing Owl, in the nature reserve;

- That Nodweni dam / weir is not mentioned when presentations refer to dams in the river system;

- That the movement of fish (the fish ladder) be considered;

- That it was enquired why ecological requirements incremented in tripled fold in the 2020 scenario that was presented;

- That the proposed project should improve the ecology along the river and the new proposed dam and should also focus on the protection of rare and sensitive fauna and flora in the proposed dam basin;

- That the possible increase of invader plants species that might crowd out the indigenous riverine plants, congesting the water place be investigated;

- That the impact of the proposed new project be investigated on the ecosystem and biodiversity, aquatic habitat, functioning of species;

- That botanical and zoological surveys are carried out with reference to the latest publication on fauna and flora distribution, particularly the latest VegMap. Attention must be paid to the possible occurrence of biodiversity hotspots in the area;

- That the engineering proposal factor in the expected 20% reduction in rainfall predicted by Climate Change scientists. The EIA must explain how this reduction has been factored in;

- That the riverine bush – recovery of wood should be considered;

- That indigenous knowledge on natural trees around the proposed project area be undertaken for record purposes;

- That most of the dams in the study area are silted up as a result of erosion from the adjacent badly managed land. What will the positive impacts be of a new dam in terms of the siltation situation in the river system;

- That mitigation should receive a high priority when protected species are removed;

- That safety for the people staying close to the proposed dam site should be considered when constructing the dam;

- That it was asked whether it will be considered to clear the dam basin of vegetation before inundation;

- That the effect on water quality as a result of pesticides and any other hazardous materials in the dam basin be investigated;

- That action plans when the proposed dam might be in flood should be developed;

- That it is expected that the proposed project will create many job opportunities for local stakeholders to alleviate poverty in the area;

- The EIA does not consider human-animal interaction in the region. Hippo attacking humans, and even vehicles, is highly problematic in the Tzaneen region. Environmental departments of government do not take action on this matter. Such departments should come to the region and inform stakeholders of what action will be taken regarding the matter;

- That sedimentation (likelihood of that in the dam and downstream) be investigated;

- That the environmental rehabilitation and restoration aspects and costs should be considered from inception, through operations, closure and ongoing maintenance phases of the project;

- That the question of sustainability as per the SA Water Policy must be considered by DWAF in terms of the number of dams, by infinite quantities of water, to sustain increasing numbers of people rather than the reality that ecological constraints will limit the number of people who can live in this area; and

- That the EIA specialist studies should consider the possibility of increased water borne diseases such as malaria.

- The Biodiversity offset mitigation measures for the Red Data, endemic and near endemic species that will be lost to the dam construction should be investigated.

- The Mean Annual Runoff that can support the downstream ecology should be investigated as the conservation of the dam will alter the stream flow and mean Annual Runoff

- Construction of the dam will have impact on aquatic species migratory routes and some might lose the spawning areas and habitat that support the critical stages of their life cycle e.g. the larval stage. Therefore migratory aquatic species should be investigated

- There is a need to study the effects of this dam to the ecological functions and character of the downstream in the Kruger National Park, especially the impacts on the protected wild flora and fauna that are entirely dependent on the river system for survival

10. OTHER INFORMATION REQUESTED BY THE AUTHORITY

No additional information was required by the authority.

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GLEWAP, 2008B	GROOT LETABA RIVER WATER DEVELOPMENT PROJECT (GleWaP), Environmental Impact Assessment: SEDIMENT IMPACT ASSESSMENT. DEAT Ref No 12/12/20/978
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APPENDIX A: SITE PHOTOS

Site NWA1

Site NWA2

Site NWA3

Site LET01

APPENDIX B: AQUATIC MACROINVERTEBRATE DATA

Taxon	Common name	Nov-07			
		NWA01	NWA02	NWA03	LET01
TURBELLARIA	Flat worms				
ANNELIDA					
Oligochaeta	Aquatic earthworm	B			B
Hirudinae	Leeches				A
CRUSTACEA					
Atyidae	Freshwater shrimps				A
Potamonautidae	Crabs				1
HYDRACARINA	Water mites			B	
EPHEMEROPTERA					
Baetidae 2sp	Small minnow mayflies		B		
Baetidae >2sp	Small minnow mayflies	B		B	B
Caenidae	Cainflies	B		A	B
Heptageniidae	Flat-headed mayflies				B
Leptophlebiidae	Prongils				B
Tricorythidae	Stout crawlers				B
ODONATA					
Aeshnidae	Dragonflies	1	A		1
Calopterygidae	Damselflies				1
Coenagrionidae	Damselflies	B		B	B
Gomphidae	Dragonflies	B	A		A
Libellulidae	Dragonflies	B	B	A	1
LEPIDOPTERA					

Taxon	Common name	Nov-07			
		NWA01	NWA02	NWA03	LET01
Pyralidae	Aquatic caterpillars				A
HEMIPTERA					
Belostomatidae	Giant water bugs		A	A	
Corixidae	Water boatmen		B	B	
Naucoridae	Creeping water bugs	B	B	B	A
Nepidae	Water scorpions			A	
Notonectidae	Back swimmers	1		B	
Pleidae	Pygmy backswimmers			A	
Velidae	Broad-shouldered water striders	A			B
TRICHOPTERA					
Hydropsychidae 1sp	Caseless caddisflies				A
COLEOPTERA					
Dytiscidae	Predacious diving beetles			B	
Elmidae	Riffle beetles				B
DIPTERA					
Ceratopogonidae	Biting midges			A	
Chironomidae	Midges	B		B	1
Culicidae	Mosquitoes			A	
Simuliidae	Blackflies	B			B
Tabanidae	Horseflies				B
GASTROPODA					
Ancylidae	Freshwater limpets	1			
Lymnaeidae	Pond snails	B	A	B	
Physidae	Pouch snails	B			A

Taxon	Common name	Nov-07			
		NWA01	NWA02	NWA03	LET01
Planorbidae	Orb snails	B			A
Thiaridae	Snails				B
PELECYPODA					
Corbiculidae	Clams				C
Sphaeriidae	Pill clams				1
SASS5 scores		78	40	56	161
Number of taxa		16	8	15	27
ASPT*		4.9	5	3.7	6

*ASPT - Average Score per Taxa

APPENDIX C: AQUATIC MACROINVERTEBRATE PREFERENCES

Preferences of aquatic macroinvertebrate taxa to flow categories, biotope types and water quality sensitivity (adapted from Kleynhans *et al*., 2005b). Species of concern loss are highlighted in red

Flow Category	Macroinvertebrate Taxa	Flow preference rating	Biotope Preference	Biotope preference rating	Water quality sensitivity rating
> 0.6 m/s	Trichorythidae	4	Cobbles	4	Moderate
Fast flows	Hydropsychidae 1sp	4	Cobbles	3	Low
	Ceratopogonidae	4	Cobbles	3	Low
	Simuliidae	4	Cobbles	3	Low
0.3 - 0.6 m/s	Elmidae	4	Cobbles	4	Moderate
Fast flows	Potamonautidae	3	Cobbles	3	-
	Heptageniidae	3	Cobbles	4	High
	Pyralidae	3	Cobbles/Vegetation	3	High
	Coenagrionidae	3	Vegetation	4	Low
	Libellulidae	3	Cobbles	4	Low
	Gomphidae	3	Gravel, Sand & Mud	5	Low
	Naucoridae	3	Water Column	4	Low
0.1 - 0.3 m/s	Chironomidae	3	-	-	-
Slow flows	Calopterygidae	3	Vegetation	3	Moderate
	Corixidae	3	Water Column	4	-
	Tabanidae	3	Gravel, Sand & Mud	3	Low
	Corbiculidae	3	Gravel, Sand & Mud	4	Low
	Sphaeridae	3	Gravel, Sand & Mud	4	-
< 0.1 m/s	Veliidae	5	Water Column	5	Moderate
Slow flows	Belostomatidae	4	Vegetation	4	-
	Nepidae	4	Vegetation	5	-
	Notonectidae	4	Water Column	4	-
	Pleidae	4	Vegetation	4	Low
	Dytiscidae	4	Vegetation	3	Low
	Culicidae	3	Water Column	5	-
	Caenidae	3	Gravel, Sand & Mud	3	Low

	Leptophlebiidae	3	Cobbles	3	Moderate
	Lymnaeidae	3	Vegetation	3	-
	Physidae	3	Vegetation	3	-
	Planorbinae	3	Vegetation	3	-
	Thiaridae	3	Vegetation	3	-

APPENDIX D: FISH PREFERENCES

Velocity-depth and flow intolerance preferences for expected fish (adapted from Kleynhans *et al*., 2005b). Species of concern (fast velocity preferenced and flow modification intolerant >3.0) are highlighted in red

Fish Species	VELOCITY-DEPTH PREFERENCE				FLOW INTOLERANCE			
	FD	FS	SD	SS	Intolerant	Moderately intolerant	Moderately tolerant	Tolerant
Barbus toppini	-	-	3.3	4.3	-	-	-	1.1
Barbus trimaculatus	-	-	3.9	3.2	-	-	2.7	-
Barbus unitaeniatus	-	-	5	4.3	-	-	2.3	-
Barbus viviparus	-	-	-	4.8	-	-	2.3	-
Clarias gariepinus	-	-	4.3	3.4	-	-	-	1.7
Chiloglanis paratus	4.2	4.9	-	-	-	3.2	-	-
Chiloglanis pretoriae	4.3	4.9	-	-	4.8	-	-	-
Laboebarbus marequensis	4.1	4.4	4.4	3.4	-	3.2	-	-
Labeo cylindricus	3.4	4.8	-	-	-	3.1	-	-
Labeo molybdinus	3.3	4.3	3.7	-	-	3.3	-	-
Labeo rosae	-	-	4.7	-	-	-	2.5	-
Micralestes acutidens	-	-	4.3	4.3	-	3.1	-	-
Mesobola brevianalis	-	-	4.3	4.2	-	-	-	1.1
Micropterus salmoides	-	-	4.5	-	-	-	-	1.1
Oreochromis mossambicus	-	-	4.6	3.8	-	-	-	0.9
Pseudocrenilabrus philander	-	-	-	4.3	-	-	-	1
Tilapia rendalli	-	-	4.9	3.9	-	-	-	1.8
Tilapia sparrmanii	-	-	-	4.3	-	-	-	0.9

Cover and tolerance to modified physico-chemical preferences for expected fish (adapted from Kleynhans *et al*., 2005b). Species of concern (cover and intolerant preferenced >4.0) are highlighted in red

Fish Species	COVER PREFERENCE					TOLERANCE: MODIFIED PHYSICO-CHEM			
	Overhanging vegetation	Undercut banks and roots	Substrates	Aquatic macrophytes and marginal vegetation	Water column	Intolerant to modification	Moderately intolerant to modification	Moderately tolerant to modification	Tolerant to modification
Barbus toppini	4.7	-	-	-	-	-	-	3	-
Barbus trimaculatus	3.9	-	-	-	-	-	-	-	1.8
Barbus unitaeniatus	4.6	-	-	-	-	-	-	2.2	-
Barbus viviparus	4.9	-	-	3.2	-	-	-	3	-
Clarias gariepinus	-	-	-	-	-	-	-	-	1
Chiloglanis paratus	-	-	4.9	-	-	-	3.1	-	-
Chiloglanis pretoriae	-	-	4.9	-	-	4.5	-	-	-
Laboebarbus marequensis	-	-	4.5	-	4.1	-	-	2.1	-
Labeo cylindricus	-	-	4.9	-	-	-	3.1	-	-
Labeo molybdinus	-	-	4.7	-	-	-	3.2	-	-
Labeo rosae	-	-	5	-	-	-	-	3	-
Micralestes acutidens	3.1	-	-	-	4	-	3.1	-	-
Mesobola brevianalis	-	-	-	-	5	-	-	2.8	-
Micropterus salmoides	3.1	-	3.1	3.2	-	-	-	2.3	-
Oreochromis mossambicus	-	-	-	-	3.9	-	-	-	1.3
Pseudocrenilabrus	4.5	3.2	-	-	-	-	-	-	1.4

Fish Species	COVER PREFERENCE					TOLERANCE: MODIFIED PHYSICO-CHEM			
	Overhanging vegetation	Undercut banks and roots	Substrates	Aquatic macrophytes and marginal vegetation	Water column	Intolerant to modification	Moderately intolerant to modification	Moderately tolerant to modification	Tolerant to modification
philander									
Tilapia rendalli	4.3	-	-	4.1	-	-	-	2.1	-
Tilapia sparrmanii	4.5	-	-	3.6	-	-	-	-	1.4

APPENDIX E: FISH MIGRATION POTENTIAL

Migration potential for expected fish (Kleynhans *et al*., 2005b). Potentially impacted species are highlighted in red

Fish Species	MIGRATION POTENTIAL
	5 - catchment scale migrations, 3 - movement between reaches & 1 - movement within reaches
Barbus toppini	3
Barbus trimaculatus	3
Barbus unitaeniatus	3
Barbus viviparus	3
Chiloglanis paratus	3
Chiloglanis pretoriae	3
Clarias gariepinus	3
Labeo cylindricus	3
Labeo molybdinus	3
Labeo rosae	3
Laboebarbus marequensis	3
Mesobola brevianalis	3
Micralestes acutidens	3
Orechromis mossambicus	3
Pseudocrenilabrus philander	1
Tilapia rendalli	3
Tilapia sparrmanii	3

APPENDIX F ENVIRONMENTAL MANAGEMENT PROGRAMME (EMP)

1. ENVIRONMENTAL MANAGEMENT PROGRAMME (EMP)

This document recommends measures that can be implemented by the Great Letaba Water Development Project (GLeWaP) for the pre-construction, construction and operation phases of the proposed dam at the Nwamitwa site, so as to minimise the potential impacts on the aquatic ecosystems identified during the compilation of the Environmental Impact Report (EIR).

1.1.1 OBJECTIVES

It is the objective of this document to ensure compliance with the following South African legislation:

1.1.2 The Environment Conservation Act, 1989 (No. 73 of 1989)

In terms of Regulations (Section 21, Schedule 1, No.1 (j) published in Government Gazette No. 18261, 5 September 1997, in terms of the Environment Conservation Act, 1989 (ECA), appropriate environmental investigations (EIA's) are mandatory before approval for the “construction or upgrading of dams, levees or weirs affecting the flow of a river” will be given by the relevant authority.

1.1.3. The National Environmental Management Act (Act 107 of 1998)

The National Environmental Management Act (Act 107 of 1998), in terms of Regulation 386, Activity 1 (m) gazetted in terms of Section 24, a basic assessment is required to be conducted before approval for any in-stream barrier construction is granted.

1.1.4. National Water Act, 1998 (Act No. 36 of 1998)

In the National Water Act (NWA), use of water is no longer limited to consumptive use, such as the abstraction of water, but includes non-consumptive activities that may have an impact on the resource quality. These “water uses”, which require authorization (usually in the form of a license) are given in Section 21 of the NWA, and include:

- Section 21 (a): storing water;
- Section 21 (c): impeding or diverting the flow of water in a watercourse;
- Section 21 (i); altering the bed, banks, course or characteristics of a watercourse.

Thus, in terms of the NWA, the erection of any in-stream structure within a watercourse, which could theoretically impede river flow, such as bridges, causeways, weirs, dams, etc., is listed as a water use, and would require a license. If the proposed structure or "alteration" of the watercourse could impede aquatic biota migration, the granting of the water license should be conditional on providing free passage of aquatic biota past the potential man-made barrier.

This also attempts to comply with the 2006 Letaba Catchment Reserve Determination Study (2006 RDS) (DWAF, 2006).

2. POTENTIAL IMPACTS ON AQUATIC ECOSYSTEMS

The EMP is based on the results of the Aquatic Environmental Impact Report (EIR). The impacts are addressed in terms of the potential mitigation measures recommended for implementation during the pre-construction, construction and operation phases of the proposed development. This was done according to the areas of potential impact identified in the EIR Report namely:

- The potential impact of raising the dam wall of Tzaneen Dam on the aquatic ecosystems both upstream and downstream of the dam wall;
- The potential impact of the proposed Nwamitwa Dam on aquatic ecosystems within the proposed dam basin, in the Nwanedzi River and in the Groot Letaba River downstream of the dam basin;
- The potential impact of the proposed Nwamitwa Dam as a migration barrier on fish assemblages in the Groot Letaba River;
- The potential impact of the proposed flow gauging weir downstream of the proposed Nwamitwa Dam on the aquatic ecosystems upstream and downstream of the proposed weir; and

- The potential impact of the proposed Bulk Water Infrastructure (BWI) associated with the GLeWaP on the associated aquatic ecosystems.

2.1 THE POTENTIAL IMPACT OF RAISING THE DAM WALL OF TZANEEN DAM ON THE AQUATIC ECOSYSTEMS BOTH UPSTREAM AND DOWNSTREAM OF THE DAM WALL

(a) Phase of Project

CONSTRUCTION	OPERATION
•	•

(b) Management Objectives

To minimize the degradation of the aquatic ecosystem due to the raising the dam wall of Tzaneen Dam, both upstream and downstream of the dam wall, during the construction and operational phases.

(c) Management and Mitigation Measures

- Comply with the 2006 RDS requirements;
- Implementation of a suitable management action plan during the construction phase, based on monthly water quality and two biological monitoring surveys of selected sites downstream of the raised Tzaneen Dam wall;
- Accurate full supply-level calculations during the construction phase, taking into account the impacts addressed in this report; and
- Implementation of a suitable management action plan during the operational phase, based on bi-annual water quality and biological monitoring surveys of selected sites downstream of the raised Tzaneen Dam wall.

2.2 THE POTENTIAL IMPACT OF THE PROPOSED NWAMITWA DAM ON AQUATIC ECOSYSTEMS WITHIN THE PROPOSED DAM BASIN, IN THE NWANEDZI RIVER AND IN THE GROOT LETABA RIVER DOWNSTREAM OF THE DAM BASIN

(d) Phase of Project

CONSTRUCTION	OPERATION
•	•

(e) Management Objectives

To minimize the degradation of the aquatic ecosystem due to the construction of the proposed Nwamitwa Dam on aquatic ecosystems within the proposed dam basin, the Nwanedzi River and in the Groot Letaba River downstream of the dam basin, during the construction and operational phases.

(f) Management and Mitigation Measures

- Comply with the 2006 RDS requirements;
- Implementation of a suitable management action plan during the construction phase, based on monthly water quality and two biological monitoring surveys of selected sites within and upstream of the Nwamitwa Dam as well as at selected sites downstream of the Nwamitwa Dam;
- Implementation of a suitable management action plan during the operational phase phases, based on bi-annual water quality and biomonitoring surveys of selected sites within and upstream of the Nwamitwa Dam as well as at selected sites downstream of the Nwamitwa Dam;
- Identifying the sources of excess phosphates entering the proposed Nwamitwa Dam and reducing them during the both construction and operational phases;
- Annual bioaccumulation assessments of plant and biotic tissues in order to assess levels of potential POPs and toxicants during the operational phases;
- Systematic removal of required riparian and terrestrial vegetation within the dam basin in phases and limiting the amount of exposed areas during the construction phase;

- Confining the majority of disturbance to construction sites and preferably within the dry season;

- Planting larger, more developed rooted riparian trees as well as suitable riparian vegetation and specific marginal aquatic macrophytes along the margin of the Nwamitwa Dam basin and in the immediate downstream river channel;

- Monitor the effects of fluctuating water levels on the marginal vegetation, recommended bi-annual biomonitoring during the operational phase;

- The translocation of red data or rare riparian plant species to alternative areas;

- Prevention of exotic vegetation encroachment at all the sites;

- Bi-annual identification and removal of exotic vegetation within the Nwamitwa Dam basin during the construction and operational phases;

- All natural obstructions (i.e. large trees and forests) should not be removed from the proposed inundated areas of the Nwamitwa Dam basin during the construction phases, so as to provide underwater habitats, cover and refuge for aquatic biota. This should be conducted and monitored by an aquatic ecologist;

- Identifying and assessing the suitability and accessibility of remaining habitats upstream or downstream of the Nwamitwa Dam for specific biota (i.e. Aquatic macroinvertebrates and fish) that may migrate upstream or downstream in search of specific habitat requirements. This should be done prior to construction;

- Identified habitat areas to which aquatic biota could migrate to, if any, should be made conservation areas during the operational phase of the Nwamitwa Dam. This will ensure the sustainability of the upstream aquatic biodiversity;

- Restrict access to areas where dangerous fauna may occur during the construction and operational phases or alternatively translocate these animals to other locations (hippopotami and crocodile) during the construction phase;

- Further investigate the life stages of occurring amphibians within the proposed inundated areas of the Groot Letaba River and implement a suitable management action plan during the construction phase;

- Construction of a multiple level outlet structure, with outlets at 4 meter intervals from 6 meters below the full supply level of the dam;

- Ensure adequate stabilisation of the downstream river bed and banks below the Nwamitwa Dam wall during the construction and operational phases;

- Assess the likelihood of genetic lineages and correlations occurring within populations of key fish species at selected sites within the study reach of the Groot Letaba River. This should be done prior to construction;

- Assess the necessity of construction of a fish ladder or fishway based on the genetic and habitat studies so as to allow these specific fish species to overcome the Nwamitwa Dam wall during migration periods. This should be done prior to construction;

- Prevent any new introductions of M. salmoides (Largemouth Bass) and O. niloticus (Nile Tilapia) at any of the sites, in particular the Nwamitwa Dam basin during both the construction and operational phases;

- Restrict access to, and prevent recreational fishing activities within the proposed Nwamitwa Dam basin during both the construction and operational phases;

- Setup of a suitable management action plan during the operational phase, based on bi-annual monitoring of the population levels of M. salmoides;

- Investigate the possibility of stocking the dam with additional indigenous: O. mossambicus individuals during the operational phase;

- Utilise biotic compensation through the setup of an ecoregion (a wildlife park, or eco-reserve) around the Nwamitwa Dam basin and provide adequate habitats for species during the construction phases;

- Establish ecotourism within this ecoregion during the operational phases that will also benefit the local communities;

- Establish eco-awareness of local communities and visitors during both the construction and operational phases through environmental and ecosystem education programmes; and

- Ensure a proper release management strategy from the multi-level outlets during the operational phase, based on the measures set out in the aquatic EIR.

2.3 THE POTENTIAL IMPACT OF THE PROPOSED NWAMITWA DAM AS A MIGRATION BARRIER ON FISH ASSEMBLAGES IN THE GROOT LETABA RIVER

(g) Phase of Project

CONSTRUCTION	OPERATION
•	•

(h) Management Objectives

To minimize the degradation of the aquatic ecosystem due to the potential impact of the proposed Nwamitwa Dam as a migration barrier on fish assemblages in the Groot Letaba River, during the construction and operational phases.

(i) Management and Mitigation Measures

- Comply with the 2005 RDS requirements;

- Identifying and assessing the suitability and accessibility of remaining habitats upstream or downstream of the Nwamitwa Dam for specific biota (i.e. Aquatic macroinvertebrates and fish) that may migrate upstream or downstream in search of specific habitat requirements. This should be done prior to construction;

- Identified habitat areas to which aquatic biota could migrate to, if any, should be made conservation areas during the operational phase of the Nwamitwa Dam. This will ensure the sustainability of the upstream aquatic biodiversity;

- Assess the likelihood of genetic lineages and correlations occurring within populations of key fish species at selected sites within the study reach of the Groot Letaba River. This should be done prior to construction; and

- Assess the necessity of construction of a fish ladder or fishway based on the genetic and habitat studies so as to allow these specific fish species to overcome the Nwamitwa Dam wall during migration periods. This should be done prior to construction.

2.4 THE POTENTIAL IMPACT OF THE PROPOSED FLOW GAUGING WEIR DOWNSTREAM OF THE PROPOSED NWAMITWA DAM ON THE AQUATIC ECOSYSTEMS UPSTREAM AND DOWNSTREAM OF THE PROPOSED WEIR

(j) Phase of Project

CONSTRUCTION	OPERATION
•	•

(k) Management Objectives

To minimize the degradation of the aquatic ecosystem due to the proposed flow gauging weir downstream of the proposed Nwamitwa Dam on the aquatic ecosystems upstream and downstream of the proposed weir, during the construction and operational phases.

(l) Management and Mitigation Measures

It was considered that there was no need for the proposed flow gauging weir due to the fact that release flows from the proposed Nwamitwa Dam can be obtained from the operational procedures and discharges from the dam wall (from the multi-level outlets). Downstream data on the flows can be obtained from the existing downstream weirs (Prieska Weir – B8H017).

Should a weir be built in spite of the fact that it is unnecessary, the following impacts and mitigation measures were assessed:

Mitigation is limited to the design of a weir that does not impede low flows and sediment transport and allows minimum base flow of the Groot Letaba River to continue throughout the year.

2.5 THE POTENTIAL IMPACT OF THE PROPOSED BULK WATER INFRASTRUCTURE (BWI) ASSOCIATED WITH THE GLEWAP ON THE ASSOCIATED AQUATIC ECOSYSTEMS

(m) Phase of Project

CONSTRUCTION	OPERATION
•	•

(n) Management Objectives

To minimize the degradation of the aquatic ecosystem due to the proposed Bulk Water Infrastructure (BWI) associated with the GLeWaP, during the construction and operational phases.

(o) Management and Mitigation Measures

- Comply with the 2006 RDS requirements;
- Prevent underground seepage, runoff or direct discharge from any of the activities from entering the aquatic and wetland ecosystems during the construction and operational phases through effective construction engineering;
- Incorporate preventative measures into the design process of the BWI during the construction phase to minimize the mobilization of sediments;
- Establish buffer zones around the BWI during the construction phase;
- Monitor established buffer zones within BWI during the construction and operational phases;
- Design and implement a Biodiversity Action Plan (BAP) to facilitate planning and zonation of human activities associated with the BWI during the construction phase;
- Make use of existing impacts such as roads, bridges and servitudes so as to minimize impacts;

- Maintain natural water flow within the BWI during the construction and operational phases, through effective construction engineering;
- Keep habitat alteration to a minimum by limiting the footprint of construction activities and the spatial extent of BWI; and
- Implement rehabilitation where construction site footprint impacts occur within the BWI.

APPENDIX G: MAINTENANCE OF EXISTING FLOW REGIME AND RELEASE STRATEGY FOR THE NWAMITWA DAM

This was not part of the scope of work, but a brief description was complied after the review process.

It is recommended that a full assessment of this be conducted.

Hydrological information on discharges for the past 30 years was obtained from the DWAF Hydrology website from two gauging weirs situated upstream (Junction weir: B9H009) and downstream (Prieska weir: B9H017) of the proposed Nwamitwa Dam site. The monthly discharge data from these two weirs was assessed in terms of seasonal differences in the annual flow regime and then plotted into hydrographs.

A large degree of similarity can be seen in the annual flow regimes over the last 30 years at these two sites (**Figure G.1** to Figure G.4). The monthly discharges and magnitude of events are slightly increased at the downstream weir, but this is considered to be normal due to three additional tributaries entering the system between the two weirs. An assessment of the annual hydrographs form both weirs indicated two distinct seasonal differences between November to April and from May to October.

These seasonal flow regimes should be mimicked by a properly managed release programme for the operation phase of the dam. This can be effectively accomplished by:

- The construction of a multiple level outlet structure, with outlets at 4 meter intervals from 6 meters below the full supply level of the dam. This will enable a range of seasonal flows and flow velocities to be released into the downstream river; and

- A properly managed timing and release strategy that will ensure that presently existing or naturally seasonal variability in flows are released and or maintained within the downstream Groot Letaba River. This will enable specific ecosystems functions to be maintained (migration ques, seasonal floodplain inundation, temperature variations, etc.) within the downstream river.

During the construction and operational phases of the Nwamitwa Dam, the seasonal flow regime in terms of timing and magnitude shown by these hydrographs should be maintained in order to reduce the potential impacts on the receiving environment.

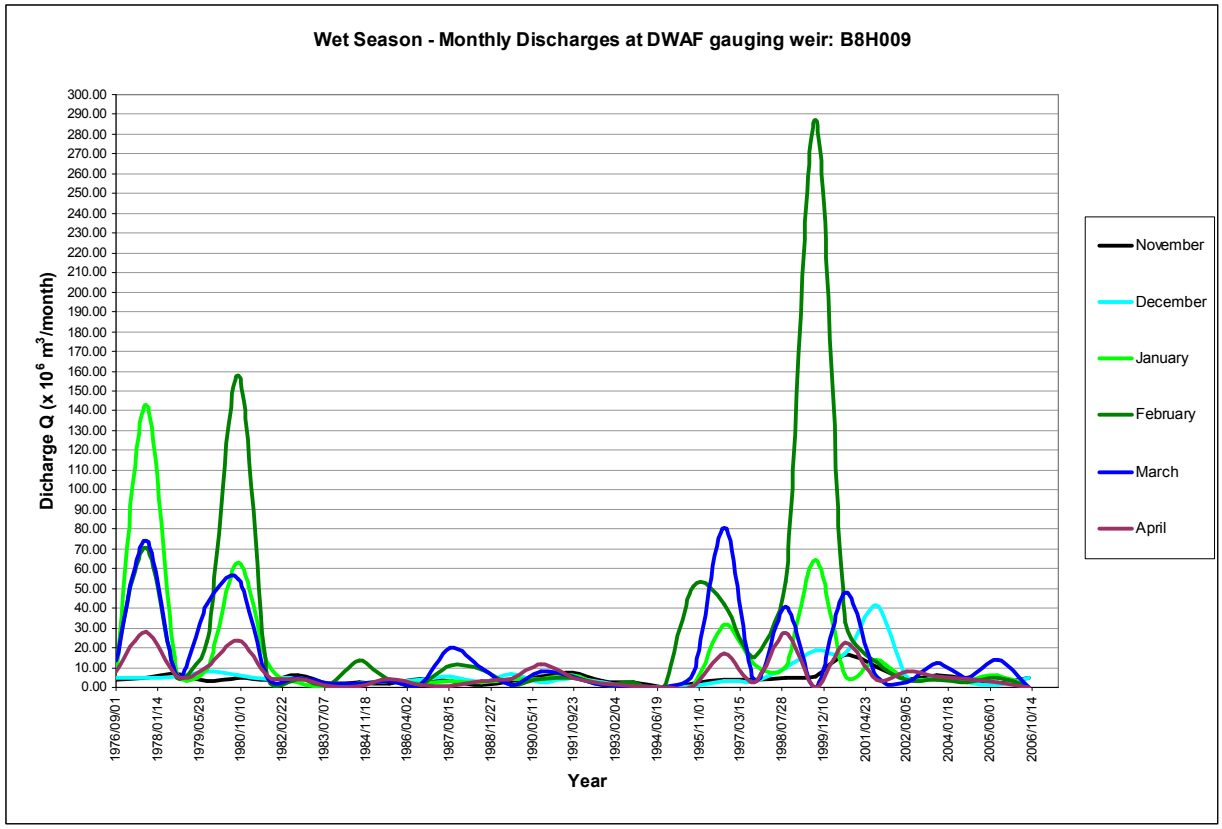

Figure G.1: Hydrograph of wet season discharges at the B8H009 weir over the last 30 years

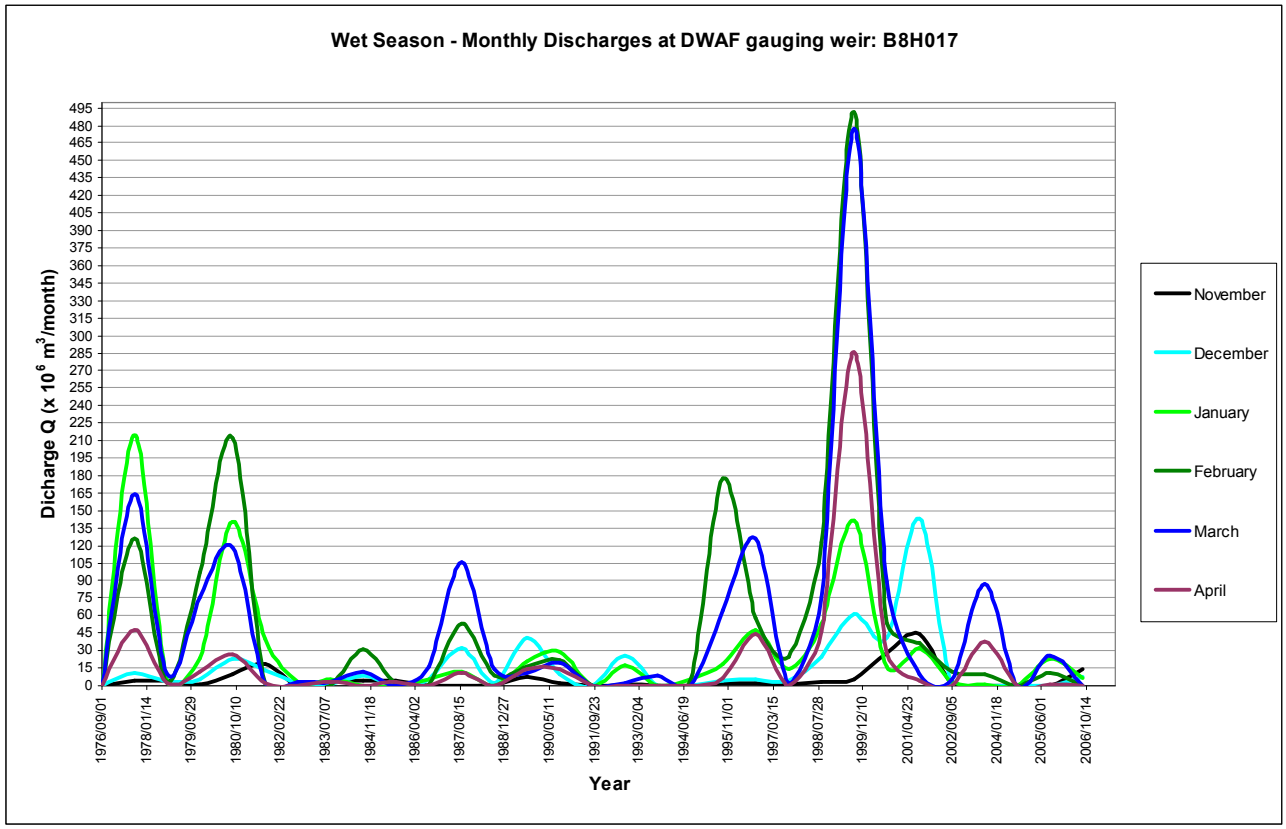

Figure G.2: Hydrograph of wet season discharges at the B8H017 weir over the last 30 years

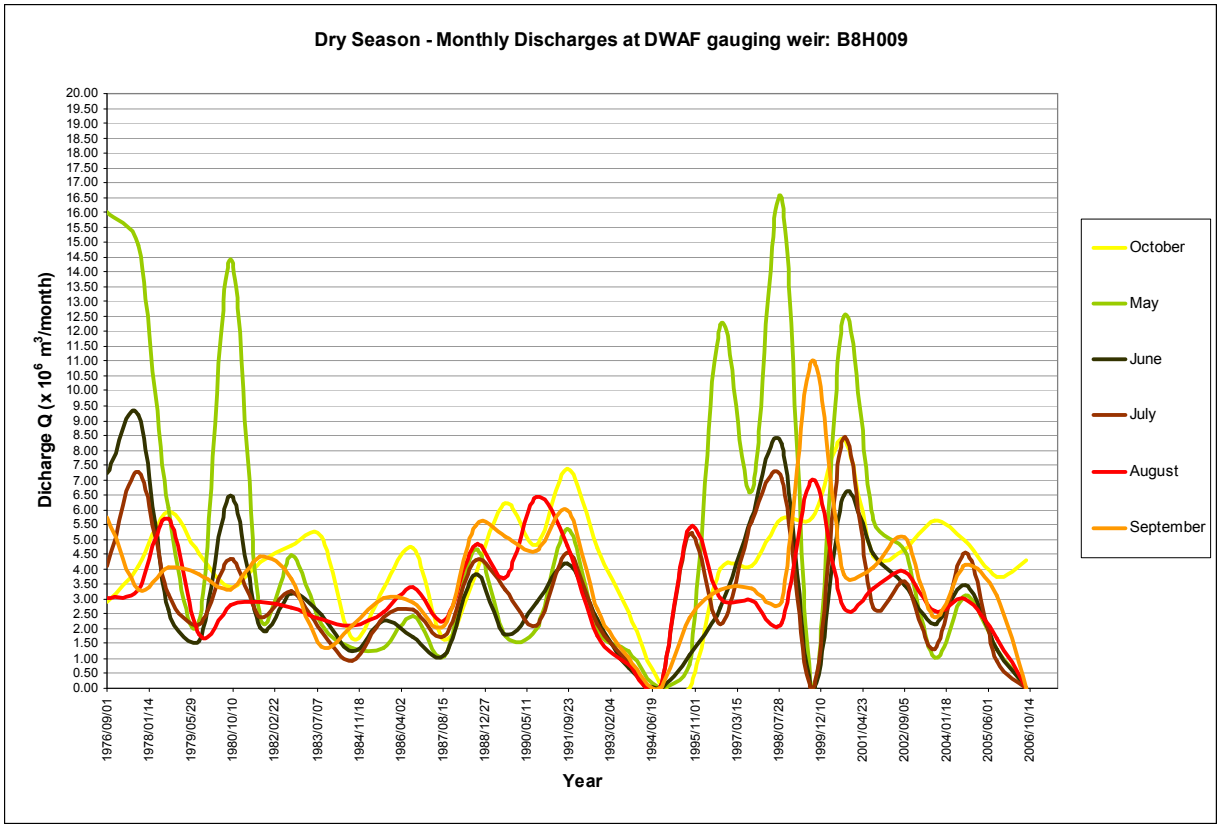

Figure G.3: Hydrograph of dry season discharges at the B8H009 weir over the last 30 years

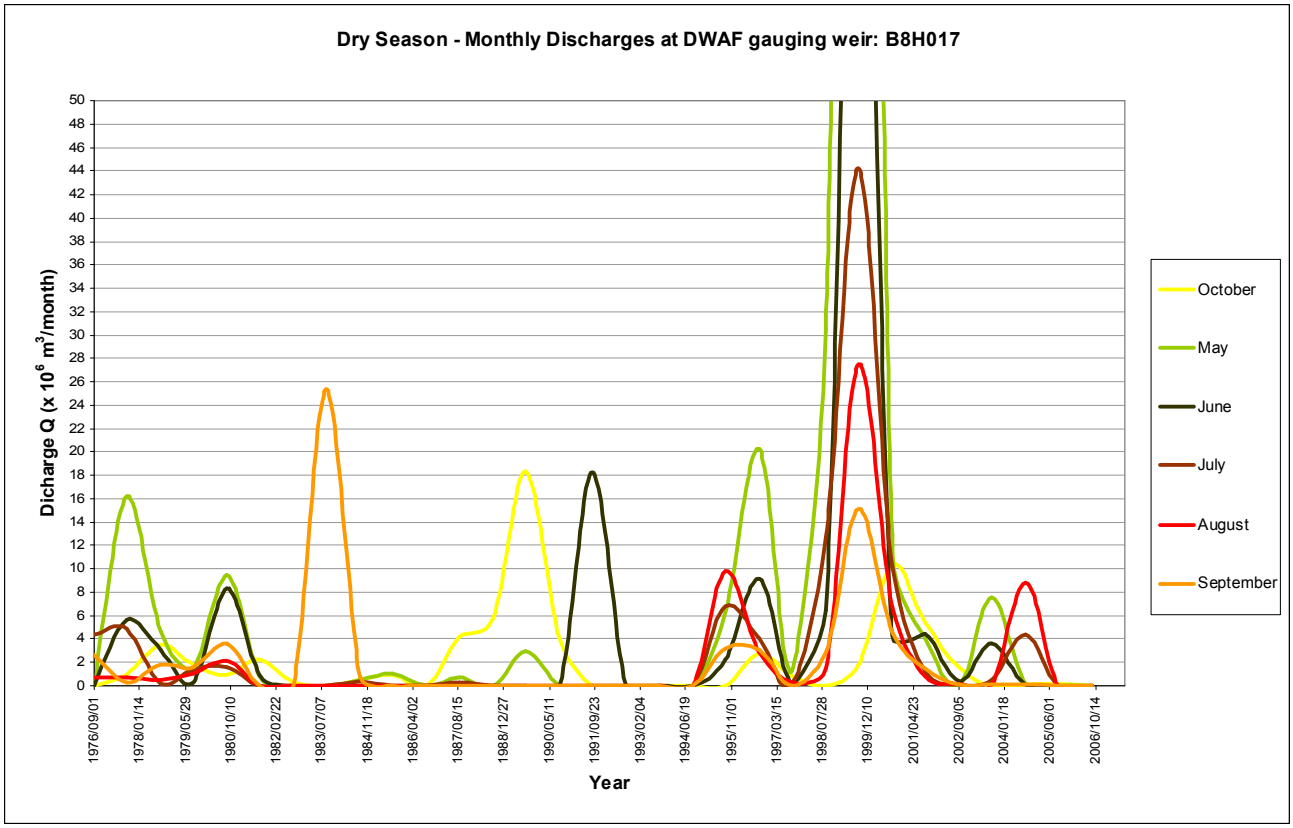

Figure G.4: Hydrograph of dry season discharges at the B8H017 weir over the last 30 years

The release strategy should have the same timing (monthly basis) and magnitude (small freshets, small flood events, high flow and low flow seasonality and larger flood events) as shown by the increases in discharge recorded at the two weirs.

Recommended monthly discharges from the Nwamitwa Dam should correspond with or be similar to the average monthly discharges of both weirs as shown in **Table G**.1.

Table G.1: Average monthly discharges of the two weirs over the last 30 years, the difference in discharge between the two weirs and the average combined discharge of the two weirs (Discharge = Q (x 10^6 m^3/month)

Month	Average discharges at B8H009 weir since 1976	Average discharges at B8H017 weir since 1976	Discharge difference	Average discharge of both weirs
January	14.623	28.285	13.661	21.454
February	26.481	50.795	24.314	38.638
March	18.451	49.387	30.936	33.919

April	9.886	19.091	9.205	14.488
May	5.880	9.705	3.825	7.792
June	3.891	5.089	1.198	4.490
July	3.403	3.138	-0.265	3.271
August	3.051	2.060	-0.991	2.555
September	3.473	2.165	-1.308	2.819
October	3.950	2.146	-1.803	3.048
November	4.231	5.230	0.999	4.731
December	7.727	15.292	7.565	11.509

According to the 2006 RDS (DWAF, 2006), specific flow scenarios are recommended in order to maintain the Present Ecological State (PES) These specific flow scenarios are summarised in **Table G**.2.

Table G.2: Recommended flow scenarios for the EWR3 site from the Reserve Determination study (DWAF, 2006)

SITE	REC	MAINTENANCE LOW FLOWS (%)	DROUGHT LOW FLOWS (%)	HIGH FLOWS (%)	LONG-TERM MEAN OF MAR (%)
EWR3	**C/D**	**1.29**	**0.23**	**11.78**	**14.15**
ANNUAL EWR (MILLION M^3): 42.448					
VIRGIN MAR (MILLION M^3): 364.49					
ANNUAL EWR (% NMAR): 11.65					

If the release strategy described in this report is implemented, mitigation of the potential impacts of the proposed Nwamitwa Dam may be reduced and will certainly aid in attempting to meet and maintain the requirements set out in the 2006 RDS in terms of the REC and Ecospecs for this reach (EWR3).