Start

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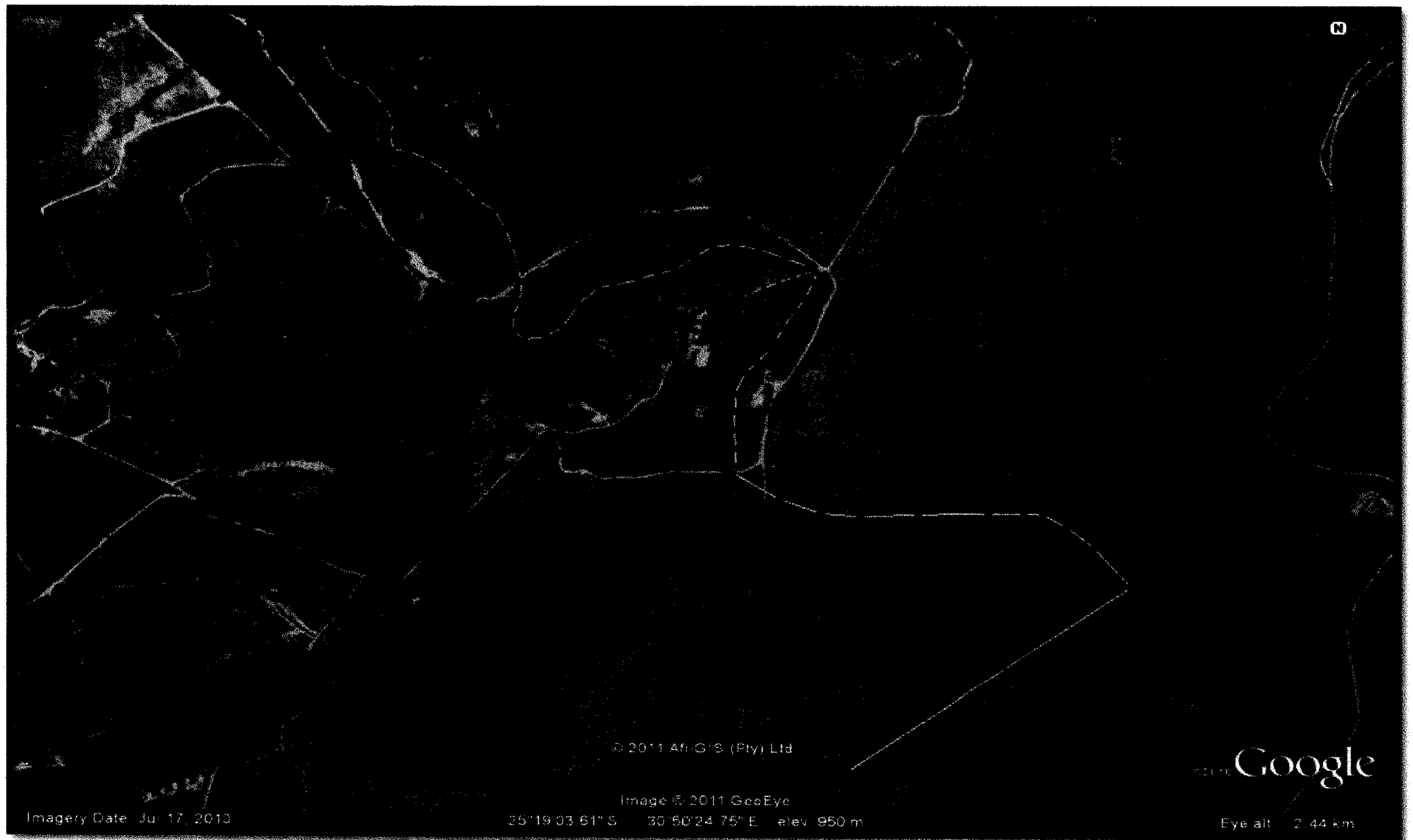
1. ABBREVIATIONS

ASAP	As Soon As Possible
Asl	Above sea level
BEE	Black Economic Empowerment
cm	centimetre
CEMP	Construction Environmental Management Programme
DEDET	Department of Economic Development, Environment and Tourism
DWA	Department of Water Affairs
EAP	Environmental Assessment Practitioner
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
ESCOM	Electricity Supply Commission
GPS	Geographical Positioning System
ha	Hectare
I&AP's	Interested and Affected Parties
IEM	Integrated Environmental Management
m	metre
mm	millimeter
MPTA	Mpumalanga Tourism and Parks Agency
MW	megawatts
m/s	metre per second
NA	Not Applicable

NHBRC	National Housing Building Regulations Council
OHASA	Occupational Health and Safety Act
OMP	Operational Management Plan
PDI	Previously Disadvantaged Individual
PPP	Public Participation Process
RES	Rhengu Environmental Services
ROD	Record of Decision
SABS	South African Bureau of Standards
SAHRA	South African Heritage Resources Agency
sqm	square metre

APPENDIX A:
SITE PLANS AND MAPS



Preferred Route and Option for the Donora Hydro Project

Northern Route Option

Southern Route Option 2

Southern Route Option 3

Southern Route Option 4

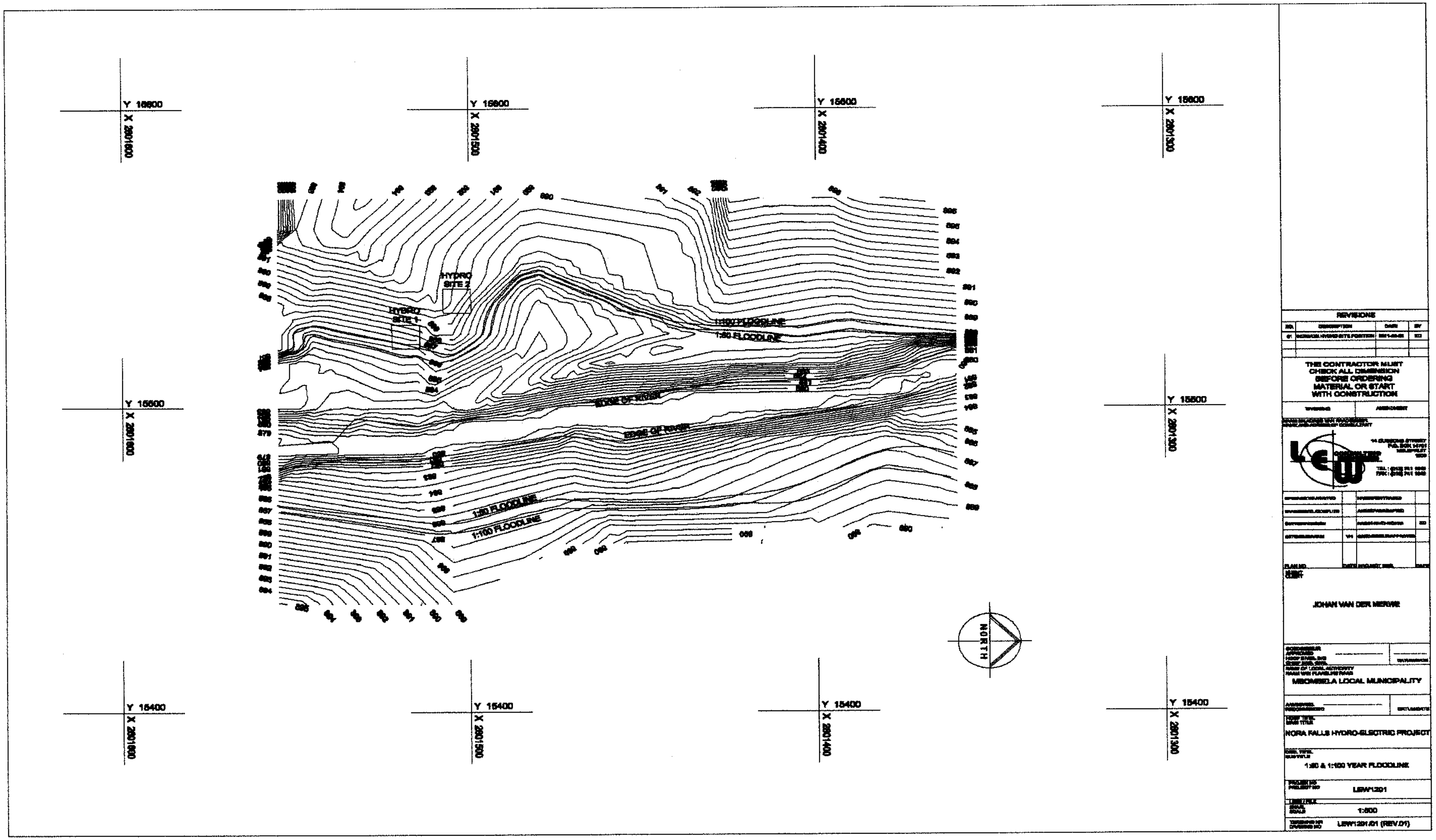
A number of route alternatives were considered. To summarise the following is relevant:

Option	Description	Disadvantage/Advantage	Cost	kWatt	R/KWatt
1.	North of Nels River	Construct a new canal through natural untouched vegetation.	R 12 000 000.00	1000	R 12 000.00
2.	South of Nels River above lodge/s.	Low elevation which will result in low kWatts produced.	R 13 000 000.00	1000	R 13 000.00
3.	South of Nels River below lodge/s.	Use existing canal, high elevation. More kWatt produced.	R 19 000 000.00	1800	R 10 555.00
4.	South of Nels River- end of the farm.	Very long, costly canal to upgrade 2.7km. More kWatt produced. Very costly.	R 22 000 000.00	1900	R 11 578.95

Note: Option 3 is the Preferred Route.

GPS Positions of the Entire Preferred Route: See Map in Appendix A:

	Site	Description	South	East	Elevation m/asl
1.	Weir	Fish way and water sluice.	25°18'45.49"	30°50'08.24"	953
2.	Weir	Inlet sluice to canal.	25°18'46.72"	30°50'08.22"	953
3.	Canal	Cross over gravel road.	25°18'57.15"	30°50'16.52"	950
4.	Canal	Below house: Gravel road cross.	25°18'56.68"	30°50'29.69"	943
5.	Canal	Pressure Pipe Start.	25°19'06.06"	30°50'26.02"	940
6.	Pipe	Halfway down the slope.	25°19'08.17"	30°50'33.26"	916
7.	Pipe	Right turn to Hydro Plant.	25°19'08.15"	30°50'40.11"	895
8.	Hydro Plant	End of pressure pipe. Hydro plant.	25°19'12.24"	30°50'45.15"	875
9.	Eskom Pole	Eskom Pole.	25°19'19.64"	30°50'31.15"	907



1:100 YEAR FLOODLINE DEMARCATION: DONORA FALLS HYDRO SITE

APPENDIX B:
SITE AND ASSOCIATED ASPECTS PHOTOGRAPHS

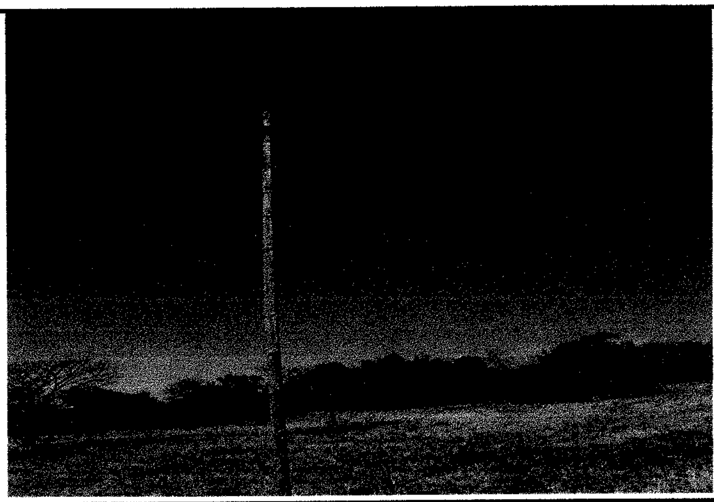


Figure 1: Eskom Point on the Farm Doornkraal.

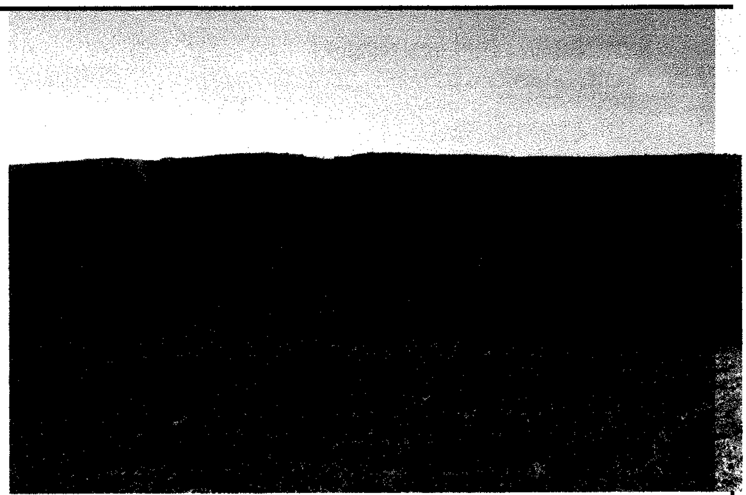


Figure 2: Eskom Line Route: Through pasture fields.

Figure 3: Pipeline Route next to the security farm fence.

Figure 4: Canal: Site where pipeline to hydro will commence.

Figure 5: Weir: Will be raised by 0.5m in places.

Figure 6: Example of road stabilization to Hydro Plant.

Figure 7: Example of on-site Tourism Facilities.

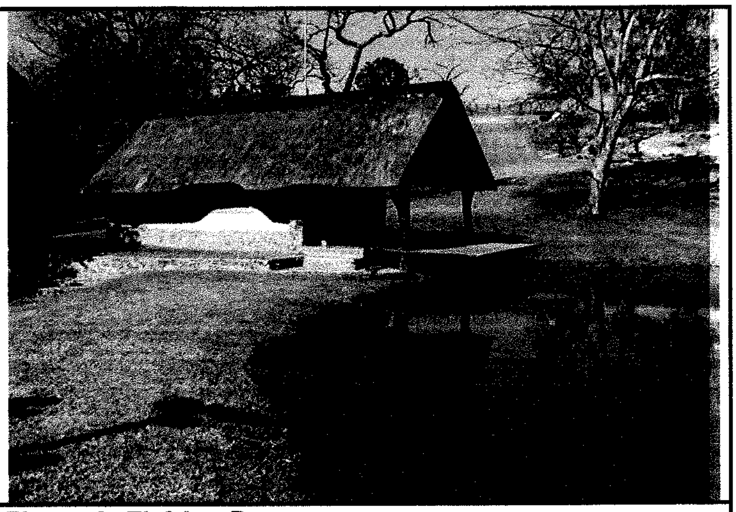


Figure 8: Fishing Dam.

Figure 9: Example of Hydro Equipment.

Figure 10: Site Visit: DEA.

Figure 11: Existing canal with earth walls.

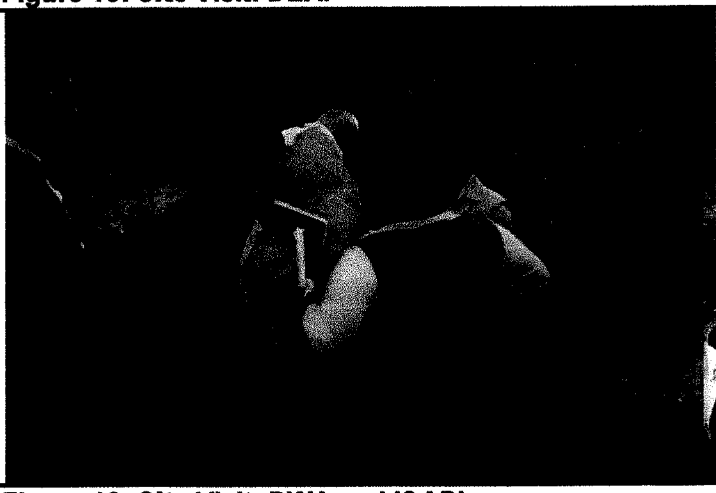


Figure 12: Site Visit: DWA and I&AP's.

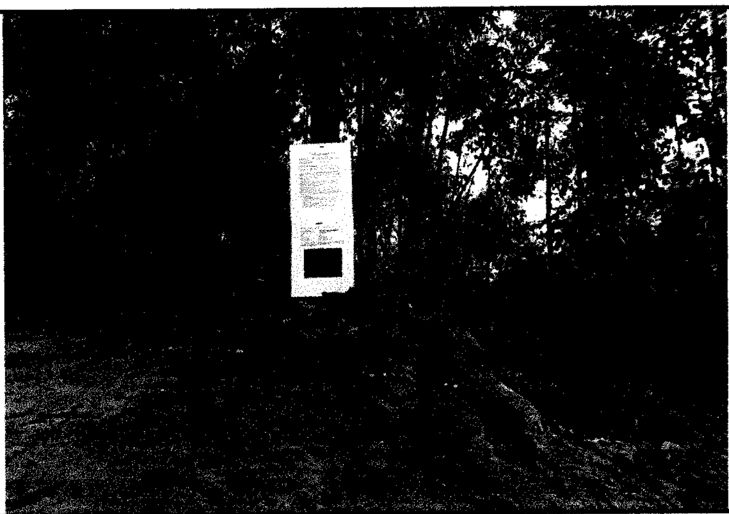


Figure 13: Site Notice: Nelspruit-Lydenburg Road.

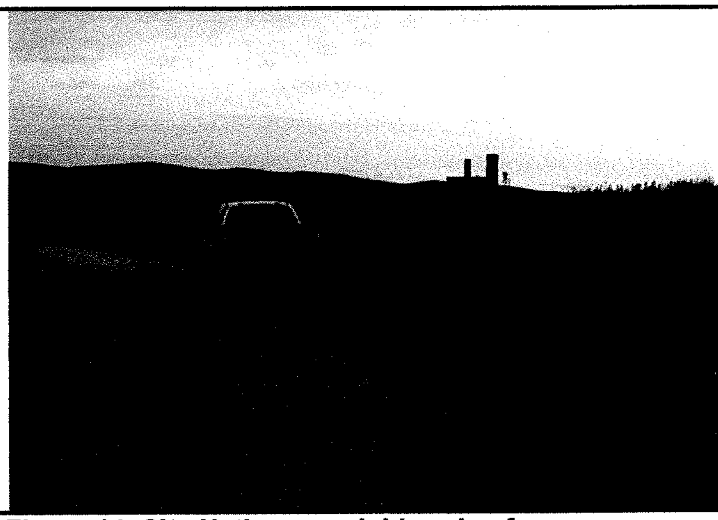


Figure 14: Site Notice on neighbouring farm.

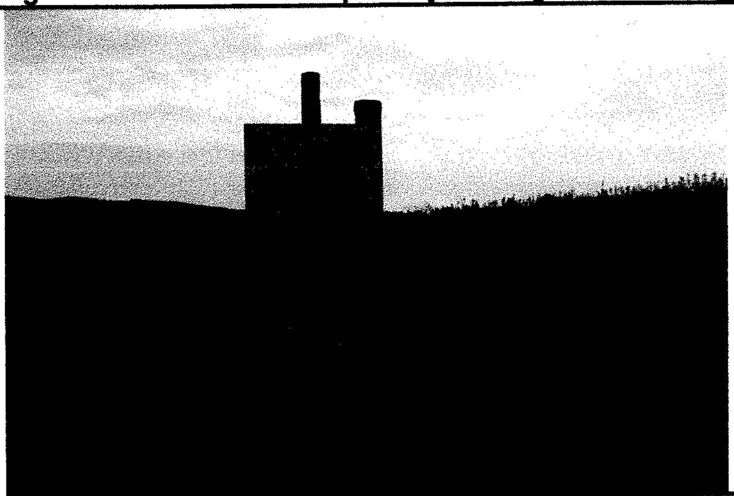


Figure 15: Site Notice on access route to site.

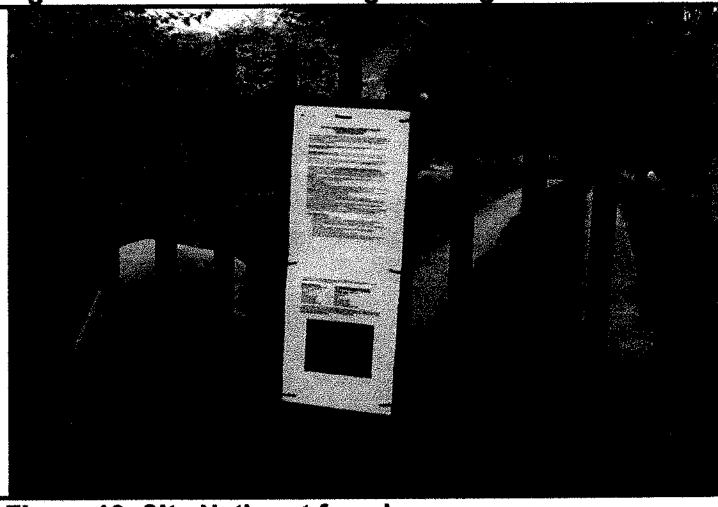


Figure 16: Site Notice at farm house.

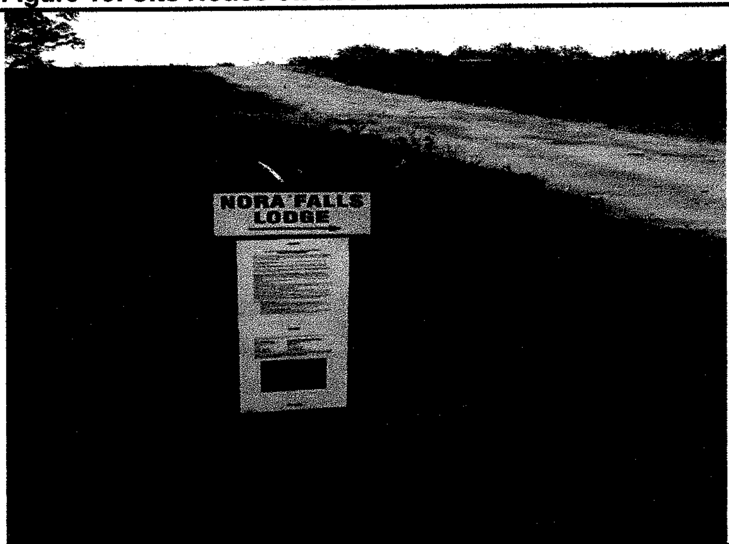


Figure 17: Site Notice on route to farm.

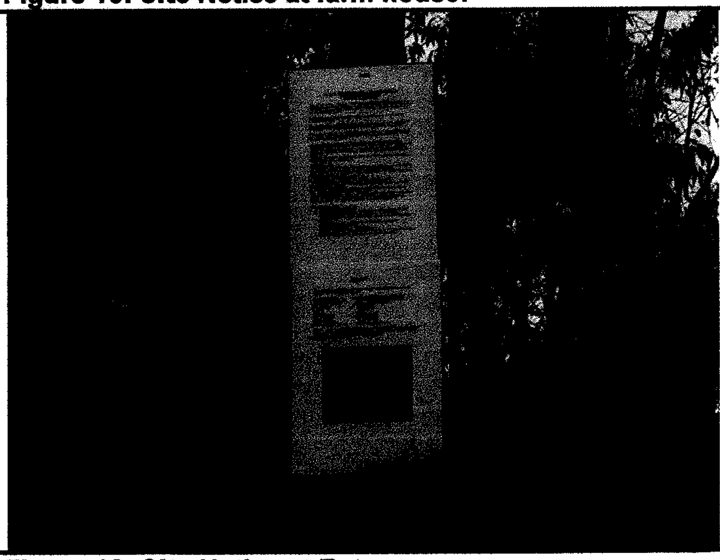


Figure 18: Site Notice at Entrance.

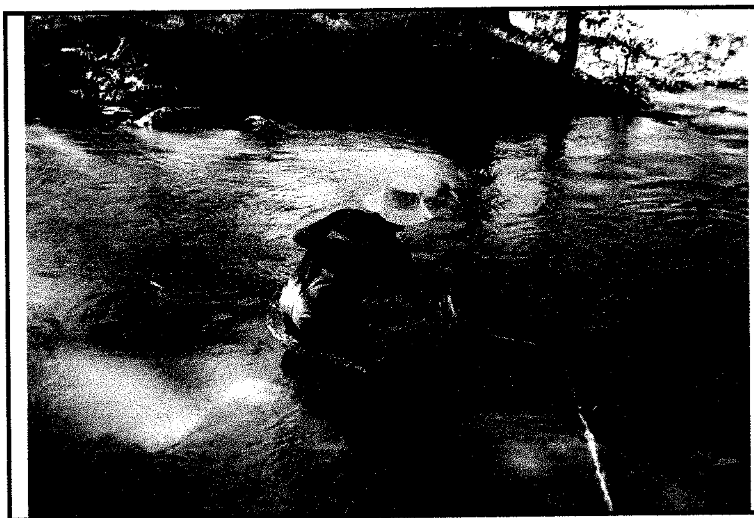


Figure 19: RHAM Survey August 2011.

Figure 20: RHAM Survey August 2011.

Figure 21: RHAM Survey August 2011.

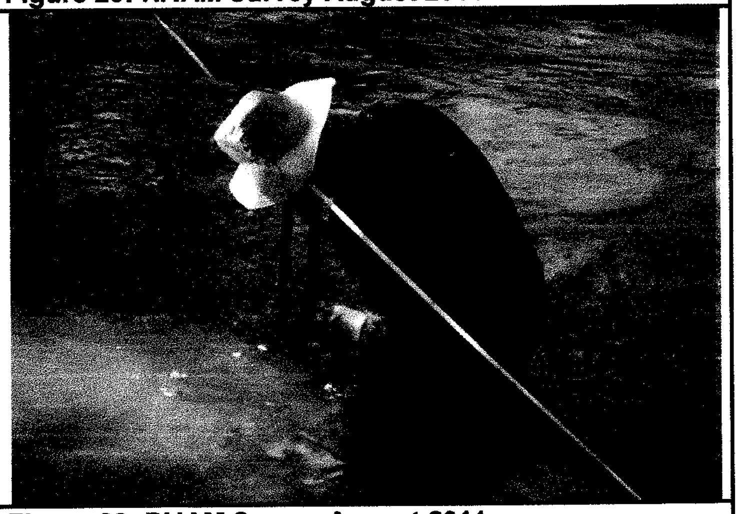


Figure 22: RHAM Survey August 2011.

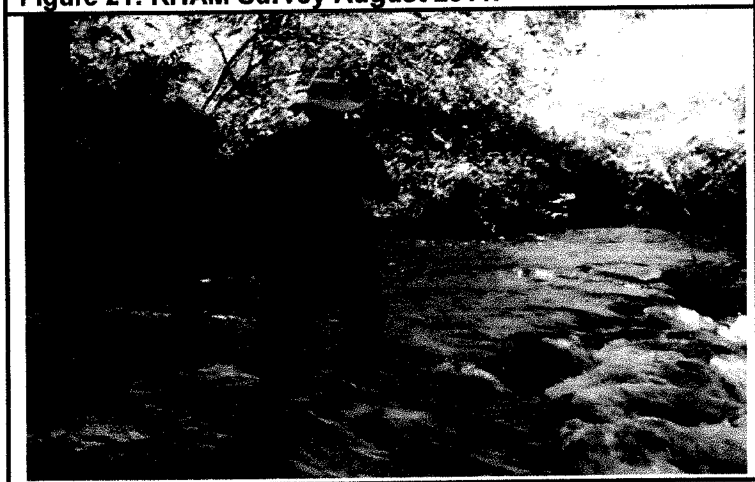


Figure 23: RHAM Survey August 2011.

Figure 24: RHAM Survey August 2011.

Examples of two fishways which will be used to construct similar structures at the weir

APPENDIX C:
FACILITY ILLUSTRATIONS AND DIAGRAMS

Donora Hydro – Turbine and Plant Characteristics

Principle: In this project a Cross Flow turbine is recommended and the most efficient turbine of this kind is currently built by OSSBERGER in Germany. The OSSBERGER turbine is a radial and partial admission free stream turbine. From its specific speed it is classified as a slow speed turbine. The guide vanes impart a rectangular cross-section to the water jet. It flows through the blade ring of the cylindrical rotor, first from the outside inward, then after passing through the inside of the rotor from the inside outward.

This flow pattern also has the advantage in practice that leaves, grass and wet snow, which when the water enters are pressed between the rotor vanes, are flushed out again by the emerging water - assisted by centrifugal force - after half a revolution of the rotor. Thus the self-cleaning rotor never becomes clogged.

Where the water supply requires, the OSSBERGER is built as a multi-cell turbine. The normal division in this case is 1:2. The small cell utilises small and the big cell medium water flow. With this breakdown, any water flow from 1/6 to 1/1 admission is processed with optimum efficiency. This explains why OSSBERGER turbines utilise greatly fluctuating water supplies with particular efficiency.

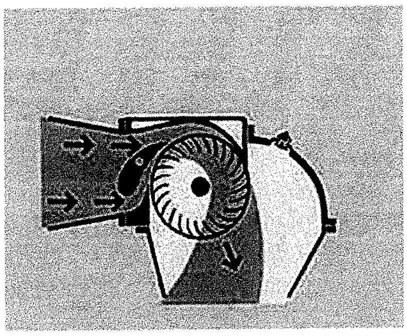


Figure1: Inflow horizontal

Efficiency: The mean overall efficiency of OSSBERGER turbines is calculated at 80% for small power outputs over the entire operating range. These efficiencies are normally exceeded. Efficiencies of up to 86% are measured in the case of medium-sized and bigger units.

Figure 2 clearly illustrates the superiority of the OSSBERGER turbine in the partial load range. Small rivers and water courses often have reduced water flow for several months of the year. Whether or not power can be generated during that time depends on the efficiency characteristics of the particular turbine. Turbines with a high peak efficiency, but a poor partial load behaviour, produce less annual power output in run-of-river power stations with a fluctuating water supply than turbines with a flat efficiency curve.

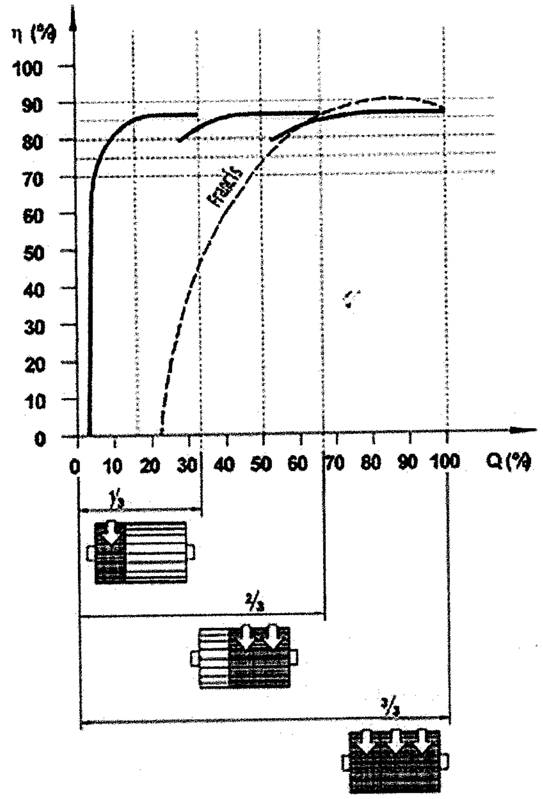


Figure 2:

Guide Vanes: In the subdivided OSSBERGER turbine the admission of feed water is controlled by two balanced profiled guide vanes which divide the water flow, direct it and allow it to enter the rotor smoothly independent of the opening width. Both guide vanes are fitted very precisely into the turbine casing. They keep the amount of leakage so low that in the case of small heads the guide vanes may serve as shut-off devices. Main slide valves between the pressure pipe and the turbine can then be dispensed with. Both guide vanes can be adjusted independently of one another via regulating levers to which the automatic or manual control is connected. The guide vane bearings are maintenance-free.

Casing: The casing of the OSSBERGER turbine is entirely made of steel, exceedingly robust, lighter than a grey cast iron, impact and frost resistant.

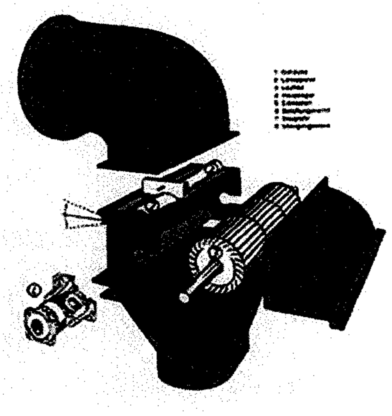


Figure 3: Design of a two-cell OSSBERGER turbine

Rotor: The heart of the turbine is the rotor. It is equipped with blades, manufactured of bright-rolled profiled steel by a well-proven procedure, adapted to end disks on both sides and welded by a special procedure.

The rotor has up to 37 blades depending on the size. The linear curved blades produce only limited axial thrust so that the multi-collar thrust bearings with all their disadvantages are eliminated. In the case of wider rotors the blades have multiple interposed support plates. The rotors are carefully balanced prior to final assembly.

Bearings: The main bearings of OSSBERGER turbines are fitted with standardized spherical roller bearing inserts. Roller bearings have undeniable advantages in water turbines provided that the design of the bearing housing prevents any leakage or condensation occurring. This is the essential feature of the patented bearing construction in OSSBERGER turbines. At the same time the rotor is centered in relation to the turbine casing. Maintenance-free sealing elements complete this superior technical solution. Apart from an annual grease change the bearing does not require any maintenance.

Draft Tube: In its design principle, the OSSBERGER turbine is a free-stream turbine. In the medium to low head range a draft tube is essential however. It serves reconcile the need for high-water safety and loss free utilisation of the full head. On a free-stream turbine with a wide operating range therefore the suction water column must be controllable if the turbine is to be constructed as a draft tube turbine. This is achieved by means of an adjustable air inlet valve which regulates the vacuum in the turbine casing. In this way even heads of as little as 2 m can be fully utilised by OSSBERGER draft tube turbines. This means that the water flowing out of the turbine back to the river will have very little energy. (Compares to a small 1meter rapid in the stream.)

Operating Characteristics: Due to its very design, cavitation does not occur in an OSSBERGER turbine. The turbine is always arranged above the tail water level. Thus, essential savings are obtained with regard to the civil costs. The machine can also be run within the whole range of admission without restrictions.

Due to the relatively low run-away speed of 180 rpm several generators can be used with the turbine.

"Keep it simple" is the watchword of this development. It is designed for continuous operation over a period of decades and can be run without any special maintenance equipment. It is frequently installed and commissioned by non-experts - especially in third world countries.

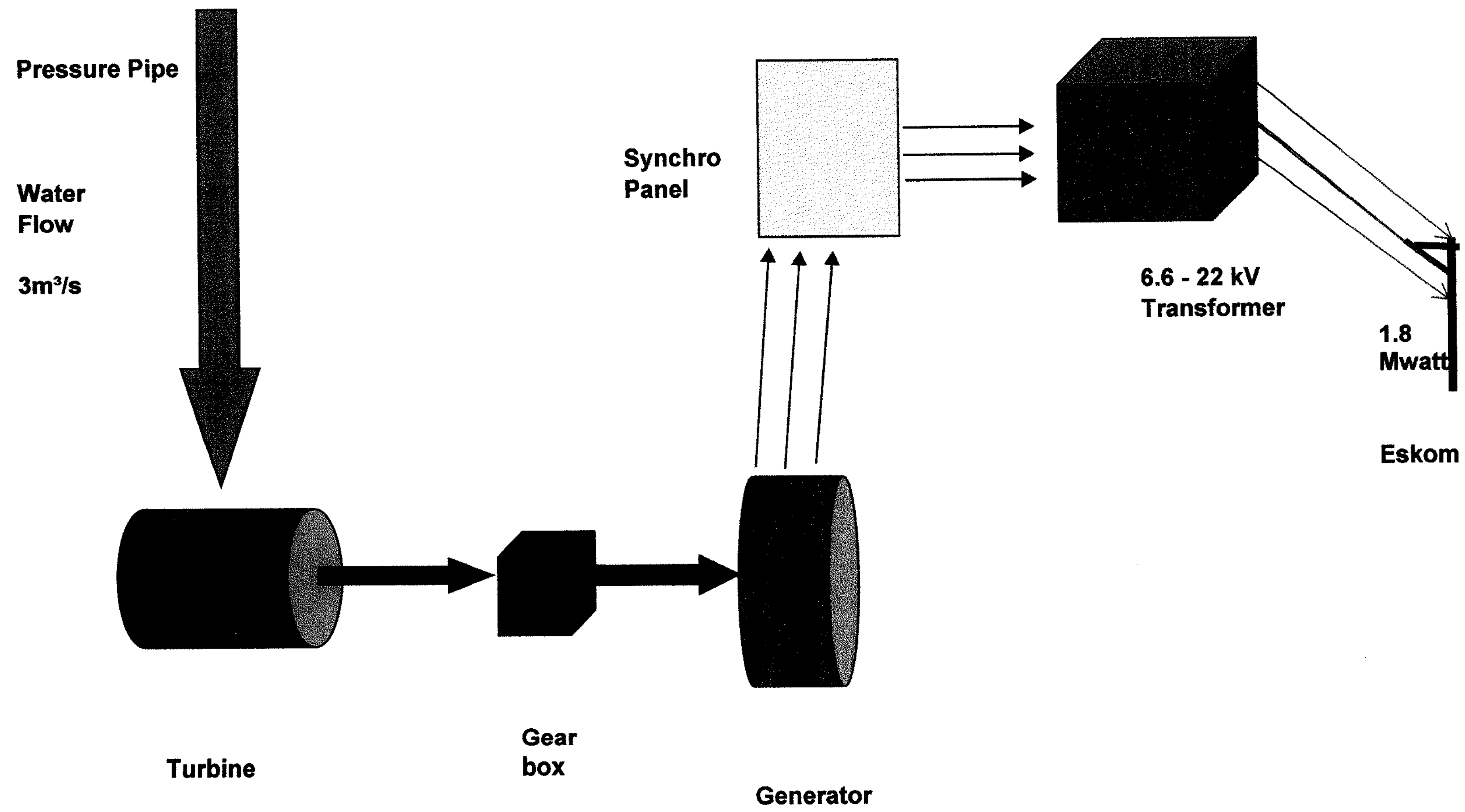
Low-Cost Design Formula: Great environmental awareness means striving to harness natural forces without wasting materials or harming the environment, e.g. generating electricity from recycled energy sources. The use of hydro-electric plants is limited however by one major factor: the high investment costs associated with the design and planning and the construction of machinery and hydraulic engineering.

Consultant engineers and turbine manufacturers have therefore attempted to reduce the overall costs by standardizing water turbines. This possible course with large turbines leads, however, to problems in the design of small water turbines connected with the water flow and annual range of fluctuation in the water supply.

This Cross Flow turbine are built from standardized components which can be configured according to requirements, that is according to the water flow and head of the particular barrage, to produce a tailor-made plant. This modular system facilitates low-cost manufacture whilst still designing the functions to suit the particular project.

Gearbox and Generator: The turbine is coupled to a gearbox which speeds up the shaft coupled to a sincrone generator. This generator is the supply of electrical energy. After the generator is running at the synchronized speed, it is electrically coupled to the national grid to pump electrical energy into the grid.

Transmission Line: The electrical energy are transmitted by a private High Tension (22 kV) overhead line to the Eskom owned line where it is coupled with the national grid with an auto reclose breaker.



Generic Layout of the Proposed Facility and System: Donora Falls Hydro Project

APPENDIX D:
SPECIALIST REPORT: TERRESTRIAL- AND AQUATIC ECOLOGY:
DR. ANDREW DEACON

PROPOSED HYDRO-ELECTRICAL PROJECT ON THE NEL'S RIVER AT DONORA, MPUMALANGA.

A SPECIALIST STUDY REGARDING THE EXPECTED IMPACT ON THE AQUATIC AND TERRESTRIAL ECOLOGY.

DR ANDREW DEACON

MARCH 2011

(Project reference: 17/2/3/E-7; Contact details: Cell phone – 0823255583; email – andrewd@mpu.co.za)

Executive summary

A survey of the project area in the Nel's River was completed to establish whether there could be any impacts on the natural environment due to the proposed development, and to obtain baseline information should future monitoring be required.

According to the Mpumalanga Biodiversity Conservation Plan Handbook, the wetland value of the Donora site along the Nel's River region are categorized as "Ecosystem Maintenance", indicating that the aquatic ecosystem in this area is not considered as very important. The following aspects regarding the riverine ecosystem were obtained:

- Instream ecological category (EC) = A/B (89.0%), indicating the high level of aquatic integrity.
- Riparian EC (A=90.8%),
- Overall EC for the reach is a reach a high A/B (89.0%).

Therefore, even though the conservation value does not emerge as high ("Ecosystem Maintenance"), the Nel's River is a very important river with a high integrity according to the EcoClassification process, while the intact riverine vegetation with high integrity plays a definite role in habitat corridors for migrating animal species. These corridors act as migration routes for fauna along the river, connecting the Drakensberg Escarpment with the Lowveld, as well as radiating from the river into the terrestrial areas, especially along drainage lines with intact vegetation. In the process of riparian delineation, 6 riparian indicator plant species were observed in the riverine zone, as well as one protected tree species, the Matumi (*Breonadia salicina*).

According to the Mpumalanga Biodiversity Conservation Plan Handbook the terrestrial aspect is classified as a matrix of "No natural habitat available" and "Least concern." However, the Legogote Sour Bushveld is 57.5% transformed, mostly through cultivation and urbanisation. In addition the vegetation type is considered poorly protected, resulting in the ecosystem status being classified as "Endangered". About 19 endemic animal species and 43 threatened species that have distribution ranges coinciding with the study area, but due to development in the region, this list will be reduced. But critical and intact habitats on the Donora farm will certainly accommodate a component of these species and should be considered at a high level of importance.

The proposed Donora hydro project consists of the following proposed activities:

- Raise the **existing** weir
- Enlarge the **existing** canal
- Install a **pressure pipe** from the canal to the hydro station.
- Build the **hydro building** with an outlet.
- Construct a **maintenance road** to the hydro site
- Build 22kV **overhead power line** to join up with the Eskom network

Due to the importance of the area, it is cautioned that all activities related to the project are carried out with care, recognizing the sensitivity of the local environment. Since the fish assemblage of the Nel's River represents a Class B ("largely natural with few modifications") it will be necessary to construct a fish ladder in the weir, even though the weir is upstream of a major waterfall. A series of simple fish ladders placed strategically in certain areas of the weir will successfully cater for any migratory fish that populate the river.

The amount of water abstracted from the river for power generation, will impact on the reach of river between the weir and the hydro station due to a) lower flows, b) altered temperature regimes and c) lower

oxygen levels. These changes will impact on sensitive fish- and frog species, as well as animals utilizing these as prey species (otters, storks, kingfishers, herons, etc.). The riparian zone will also be influenced by a lower water level and varying flows. To mitigate successfully for these conditions, it is essential that the environmental flows formulated during the DWA comprehensive reserve for the Crocodile River Catchment: Nel's River, will be incorporated in the management of the weir and canal.

The Donora low-head hydropower facility generally will not have the problems associated with larger hydroelectric facilities because it is a run-of-river facility with a small weir without the potential dissolved oxygen- and sediment problems related to larger impoundments.

Since the Donora hydropower plant is a run-of-river facility receiving water from a small weir, this facility will not have the potential dissolved oxygen-, temperature- and sediment problems associated with larger hydroelectric facilities fed by larger impoundments.

The construction of the line structures (canal, pipeline, maintenance road and power line, which are proposed traverses this ecologically important landscape), will invariably impact on the environment in a limited and localized way. It is therefore important to avoid the removal of large or protected trees; layer topsoil correctly during the refill of trenches; and finish the planned construction of structures as swiftly as possible with the minimum disturbance to the immediate environment. If these regulations are adhered to, no significant adverse impacts are expected to occur during the construction phase. Furthermore, if the prescribed mitigation measure is implemented on the power line to increase its visibility to birds, no significant impacts are expected to occur regarding the line structures during the operational phase.

Finally, it must be reiterate that the Donora project area is situated in the endangered Legogote Sour Bushveld, a region of high biodiversity values and endemism, while the ecological status of the Nel's River is rated as "High", signifying the level of aquatic integrity. Additionally 2 protected tree species are present, while 19 endemic- and 43 threatened animal species have distribution ranges coinciding with the study area.

Ultimately, it will be of vital importance that the project should be implemented with maximum care regarding the environment, and the prescribed mitigation measures should be implemented comprehensively. Providing the success of this process, no significant adverse impacts are envisaged to either the aquatic- or terrestrial ecology.

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Abbreviations

AQV	Aquatic vegetation
ASPT	Average Score per Taxon
DWA	Department of Water Affairs (post-2010)
DWAF	Department of Water Affairs (pre-2010)
EC	Ecological Category
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EWR	Environmental Water Requirements
FAII	Fish Assemblage integrity Index
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
ha	Hectare
HCR	Habitat Cover Ratings
HQI	Habitat Quality Index
HSI	Habitat Suitability Index
IHAS	Integrated Habitat Assessment System
ISP	Internal Strategic Perspective
IUCN	International Union for Conservation of Nature
m	Meter
m3/s	Cubic meter
MCDA	Multi Criteria Decision Analysis
MCM	Million cubic meter
mm	Millimetre
MV	Marginal vegetation
NEMBA	National Environmental Management & Biodiversity Act
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RHP	River Health Programme
SANBI	South African National Biodiversity Institute
SASS5	South African Scoring System version 5
SIC	Stones in current
SOOC	Stones out of current
TOPS	Threatened or Protected Species
VEGRAI	Riparian Vegetation Index
WRC	Water Research Commission

1. Introduction

1.1 Background to micro schemes

Hydroelectric power plants are power plants that produce electrical energy by driving turbines and generators thanks to the gravitational force of falling or flowing water. Through the natural water cycle mainly evaporation, wind and rain, the water is then brought back to its original level. It is thus a renewable form of energy.

Micro-hydro schemes produce power from streams and small rivers. The power can be used to generate electricity, or to drive machinery. In the developed world, micro-hydro schemes supply power to existing mains electric grids.

Small hydro power facilities use the flow of water to turn turbines that are connected to a generator for the production of electricity. Certain power plants use the flowing water in rivers to generate power, without needing changes to the river flow. Mini-, micro- and pico- power plants generally have no dam and are therefore "run-of-the-river" power plants.

There are two factors that determine the amount of power that can be produced: the head (i.e. the height of the water drop) and the flow rate; the higher the head the smaller the flow rate needed to produce the same amount of electricity. The overall production capacity depends on the seasonal and yearly differences in water availability.

A cross-flow turbine is drum-shaped and uses an elongated, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. Cross-flow or Banki turbines (even lower head and higher flow) are made as a series of curved blades fixed between the perimeters of two disks to make a cylinder. The water flows in at one side of the cylinder and out of the other, driving the blades around.

The cross-flow turbine allows the water to flow through the blades twice. The first pass is when the water flows from the outside of the blades to the inside; the second pass is from the inside back out. A guide vane at the entrance to the turbine directs the flow to a limited portion of the runner. The cross-flow was developed to accommodate larger water flows and lower heads.

The power available in a river or stream depends on the rate at which the water is flowing, and the height (head) at which it falls down.

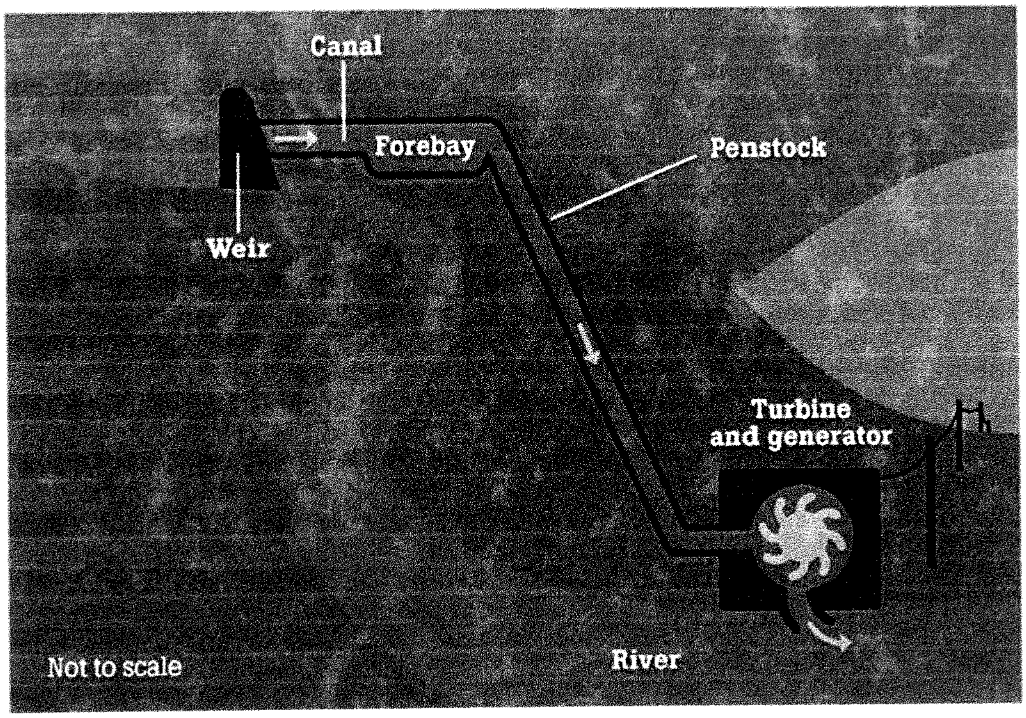


Figure 1: A micro-hydro system

Most micro-hydro systems are 'run-of-river' which means that they don't need large dams to store water. However, they do need some water-management systems.

A small dam in the river bed directs the water to a settling tank. This allows silt to settle out of the water, and the clean water to flow into a canal or a pipe to a second settling tank called the 'fore bay', which is sited above the power house. The canal or pipe can be fairly long, 1 km or more, if a suitable stream is far from where the power is required. The outlet from the fore bay has a screen to trap silt and floating debris. Water flows out into a pipe called the 'penstock', which is made as steep as possible to transfer water to the turbine. Water leaving the turbine is led back to the stream through the outlet pipe or 'tail-race'.

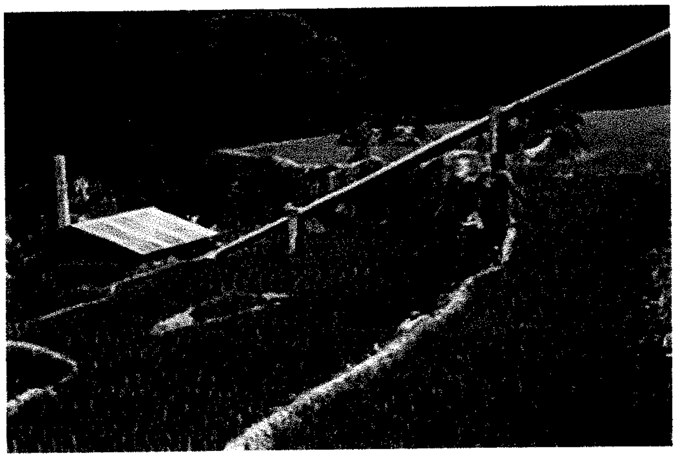


Figure 2: An example of a penstock and turbine house for micro-hydro scheme

Micro-hydro schemes can be connected to a mains grid if available to reduce the amount of electricity which it has to purchase from the national grid, and also improve the reliability of the supply to its customers.

In remote areas, micro-hydro schemes can bring electricity for the first time to whole communities. This provides lighting, television and communications for homes, schools, clinics and community buildings. The electrical power from micro-hydro also is sufficient to run machinery and refrigerators, thus supporting small businesses as well as homes.

Water turbines are generally considered a clean power producer, as the turbine causes essentially no change to the water. They use a renewable energy source and are designed to operate for decades. They produce significant amounts of the world's electrical supply.
The main environmental benefit of micro-hydro is reducing greenhouse gas emissions and local pollution from fossil fuels. This includes kerosene for lighting, diesel for driving machinery, and diesel and other fossil fuels for generating electricity.

Carefully-designed micro-hydro schemes take only a limited amount of water from a river or stream, have a small storage volume, and return the water a short distance downstream, thus have very little environmental impact. Several small hydro systems have less environmental impact than a single large hydro scheme supplying the same power.

A large amount of small and medium sized hydro plants in South Africa have been decommissioned due to the development of Eskom coal fired power generators. As coal resources became scarce and expensive, Eskom is more and more considering alternative natural resources to generate power.

Water resources are scarce in South Africa the number of potential sites are limited. South African rivers also add to some complications to the selection of potential hydro power station sites, factors to consider are:

(a) Availability of reliable source of water
(d) Sufficient flow for most of the year
(c) The availability of suitable land falls at the site
(d) Possibility to deviate water out of river to generate height, for sufficient pressure on the turbine

1.2 Project description

The Donora hydro-electrical Station will be constructed on the farm Doornkraal 244 portion 5 on the western banks of the Nel's River. The farm is north east from Nelspruit on the road to Lydenburg.

The project will start from the existing weir above the Nora falls, diverting the water into the existing irrigation canal which delivers water to three farmers of which this farm is part of. The water will follow the existing canal on the contour for 1260 meter where the larger part will be diverted back to the Nel's River through a 600 meter long, 1.2 meter diameter pressure pipe with a fall of 76 meter down to the turbine. The turbine and generator will generate electricity from $3m^3$/second water to generate 1.8 MWatt at a maximum capacity. The Hydro Station will operate for 24 hours, 7 days per week, except when maintenance is done.

Canal and pressure pipe from Donora Weir to Hydro Station.

Coordinates of Weir in Nel's River 25°18'46.47"S 30°50'07.82"E
Coordinates of Hydro Station 25°19'12.14"S 30°50'45.42"E
Coordinates of Eskom point: MB 136/2225°19'19.25"S 30°50'30.43"E

The project will include the following specific aspects:

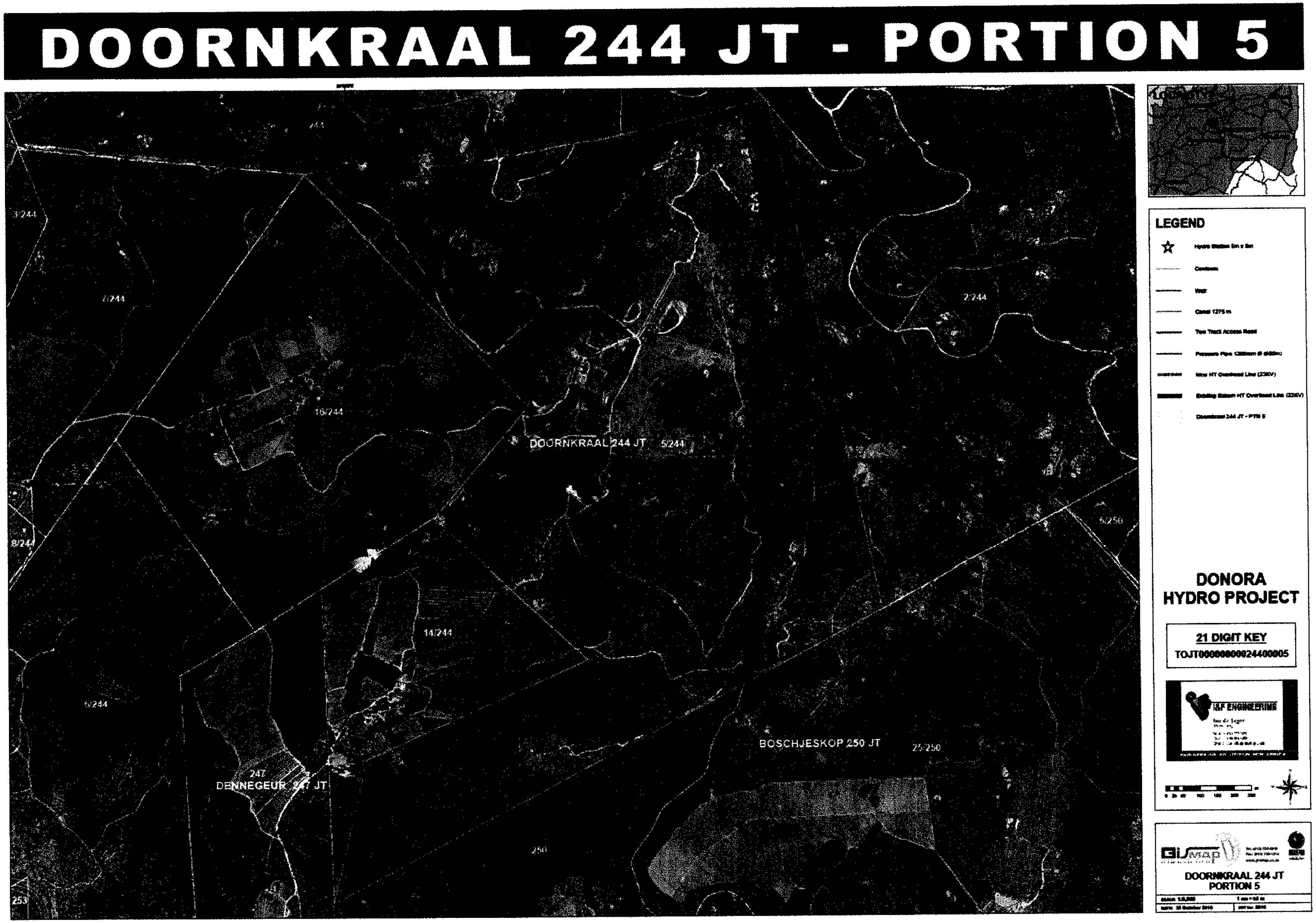
- Raise the **existing** weir by 500 mm to 1.5 meters where applicable.

- Enlarge the **existing** canal to 2m X 1.5m wide where necessary over a distance of 1278m to convey water at $3m^3$/second (10 800 m^3/hour = 259 200 m^3/day).
- Install a **sluice gate** at the end of the canal to **feed** the rest of the canal for the farmers downstream.
- Install a **water meter** at this point to ensure that the correct allocated amount of water is sent down the canal to the farmers downstream.
- Install a **pressure pipe** (1.2m diameter) from the canal to the hydro station.
- Build the **hydro building** (approx. 48sqm) with an outlet.
- Generate **1.8 Mega Watt** of electricity.
- Construct a **maintenance road** to the hydro site (distance 250m and less than 4m wide).
- Build 22kV **overhead power line** to join up with the Eskom network (400m).

The developers of the Donora hydro-electrical station intend to sell the electricity generated by the hydro-electrical plant to Eskom and this will contribute to alleviate the electricity shortage currently experienced in the area. The customer will further benefit by using green energy for products produced on the farm or for the use of green energy at the lodge.

The project will be labour intensive and approximately 15 to 20 people will be employed for 6 to 9 months (the duration of the project) and subsequently two fulltime persons. A maintenance crew will periodically be used to tend to the upkeep of the project infrastructure.

Figure 3: The study area depicting contours of the area and the proposed hydro infrastructure.



1.3 Scope of work

Since the activities in the project area will impact on the riverine system (raising of weir and abstracting water from the river) and the terrestrial ecology (deepening canal, construction of pipeline, construction of hydro plant and connecting with power line), this report will address both the aquatic- and terrestrial impact assessment for the project.

1.3.1 Aquatic impact assessment and riparian wetland assessment

This specialist study forms part of the EIA required for the proposed Donora hydro scheme in the Nel's River.

The scope of work is based on the Department of Water Affairs document: Supplementary Water Use Information (Section 21 (c) and (i) Water Uses; Section 21(c) - impeding of diverting the flow of water in a watercourse; Section 21 (i) - altering the bed, banks, course or characteristics of a watercourse). Following abstract (Table 1) only refer to the sections relevant to the ecological aspects of the project (other aspects such as lay-out plans, work method, engineer design drawings, investments made, etc. are not included in this specialist report):

Table 1: Supplementary Water Use Information

1. Watercourse Attributes	
1.2 Description	*1.2.2 < Provide a map indicating the segment and affected reach/es of the watercourse in which the water use/s is to take place and which indicates/delineates the regulated area including:* *1.2.2.1. The extent of the riparian habitat* *1.2.3 <Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):* *1.2.3.1. Flow and sediment regimes at appropriate flows* *1.2.3.2. Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime* *1.2.3.3 Riparian and Instream Habitat.* *1.2.3.3.1 Morphology (physical structure)* *1.2.3.3.2 Vegetation* *1.2.3.4 Biota>* *1.2.4 <Describe the ecological importance and sensitivity (EIS)as well as the Socio-cultural Importance (SI) of the affected reach/es of the watercourse including the functions[6]>* *1.2.5 <Discuss existing land and water use impacts (and threats) on the characteristics of the watercourse>* *1.2.6 <List and map sensitive environments in proximity of the project locality-sensitive environments include wetlands, nature reserves, protected areas, etc.>*
3. Impact Assessment and Management	
3.1 Impact Prediction and Assessment	*3.1.1 < Provide a prediction and assessment of the likely environmental and socio-economic impacts or effects[10] associated with the water use/s for different phases:* *3.1.1.1 On the watercourse and its characteristics as set out in 1.2.3 above* *3.1.1.2 On other water users* *3.1.1.3 On the broader public and property* *3.1.1.4 If the water use/s is not authorised* *3.1.2 < Provide a description of the methodologies employed to undertake impact prediction and assessment as well as a motivation for these>*
3.4 Mitigation and Management Measures	*3.4.1 < Provide mitigation measures to prevent, reduce, remediate or compensate the pre-determined impacts; also provide emergency response>*
3.5 Changes to the Watercourse	*3.5.1 < Assess to what extent the impacts after mitigation will bring about changes in respect of the PES (and recommended ecological category, if this*

information is available at the stage of study) and functionality of the <u>watercourse</u>; as well as the <u>socio-economic</u> <u>environment</u> (including redress considerations as well impacts on other water users)>

The main components of the assessment should include the following:

Riparian delineation

EcoClassification

As defined by the WRC Reports on EcoClassification, specifically Report no TT 329/08 on determining EcoStatus.

Ecological Category (EC)

Ecological Categories are ascribed to driver and response components. The term *Ecological* when describing a Driver category can strictly be used in terms of the EcoClassification process only.

Present Ecological State (PES)

Describe within context of the immediate catchment and segment, the historic as well as current state (Present Ecological State or PES) of the affected reach/es of the watercourse with regards to the following characteristics (attributes):

- Flow and sediment regimes (quantity, pattern, timing, water level and assurance of instream flow);
- Water quality (including the physical, chemical and biological characteristics of the water) in relation to the flow regime.
- Morphology (physical structure)

Ecological Importance and Sensitivity (EIS)

- Describe the ecological importance and sensitivity (EIS)
- Refer to the RDM procedure for determining Ecological Importance and Sensitivity.
- The EIS of a watercourse is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. Both biotic and abiotic components of the system are taken into account.

Aquatic and riparian surveys

Aquatic and riparian surveys are proposed in the riverine habitats in the vicinity of the proposed development. The objective of this survey is to provide information on the aquatic environment of the proposed development regarding the fish and macro-invertebrate integrity, integrity of the aquatic habitat and possible impacts and mitigation.

The Aquatic specialist will assess the condition of the proposed development and its impact on the aquatic environment. The following recognized bio-parameters and methods will be used:

- Aquatic invertebrates (South African Scoring System version 5 — SASS5).
- Fish communities (Fish Assemblage integrity Index— FAII)
- Riparian habitat surveys (Riparian Vegetation Index — VEGRAI)

The study scope is to focus on the reach of water between the weir and the hydro releases. Any downstream considerations should also received attention.

Impact assessment & mitigation

- Provide a description of the methodologies employed to undertake impact prediction and assessment as well as a motivation for these. Impact assessment should include planning, construction and operational phases.
- Provide mitigation measures to prevent, reduce, remediate or compensate the pre-determined impacts; also provide emergency responses
- Assess to what extent the impacts after mitigation will bring about changes in respect of the PES (and recommended ecological category, if this information is available at the stage of study) and functionality of the watercourse;
- Assess the potential impacts with regard to their nature, extent, magnitude, duration, probability and significance – each impact must be described in terms of source of impact, pathway (propagation of impact) and receptor (target that experience the risk or impact).

1.3.2 Terrestrial impact assessment

The scope of work for the terrestrial part of the study should include the following specialist components:

- Specialist study as part of the Environmental Impact Assessment (EIA): terrestrial vertebrates (amphibians, reptiles, birds and mammals – high conservation value and their probability of occurrence on site)
- Impact assessment of the following activities as part of the study:
  - Weir and abstraction – riverine (aquatic & riparian)
  - Canal – woodland and grassland
  - Pipeline and hydro plant – woodland
  - Power line – woodland and grassland
- Recommendations/mitigation measures to be included

2. Biophysical background of the proposed project site

According to Mucina & Rutherford (2006), the study area is situated in Legogote Sour Bushveld within the Lowveld Savannah Bioregion in the Savanna Biome. This land type is found on the lower eastern slopes and hills of the north-eastern escarpment from Mariepskop in the north through White River to the Nelspruit area extending westwards up the valleys of the Crocodile, Elands and Houtbosloop rivers. It has an altitude of 600m -1000 m and higher in some places.

The landscape consists of gently to moderate sloping upper pediment slopes with dense woodland including many medium to large shrubs. Short thicket occurs on less rocky sites. Exposed granite outcrops have low vegetation cover. At places on the foot slopes this vegetation becomes very dense and is transitional to forests in kloofs on the eastern slopes of the escarpment.

Legogote Sour Bushveld originally covered about 352 314 ha, of which 57.5% has been transformed, mostly through cultivation and urbanisation. The vegetation type is considered poorly protected and has an ecosystem status of Endangered (Ferrar & Lötter, 2007).

2.1 Study area description

The Crocodile River in Ecoregion 5.05 (Middle Crocodile) is typical of lower escarpment reaches and the start of the lowveld (Figure 4). Altitude range falls to between 800m - 1000m, with moderate relief. The rainfall is variable within the ecoregion with some areas receiving as little as 400 mm per year, although most areas receive within 600 to 1 000 mm. Temperatures are higher (16-22^{0}C), and soils are sandy, sandy loams, and clays overlaying iron, jaspilite, syenite, hornblende granite, foskorite, and gneiss, which is conducive to a shift in vegetation from grassland to bushveld. The river in this long section is mostly characterized by large rocky pools with occasional rapids (WRC, 2001).

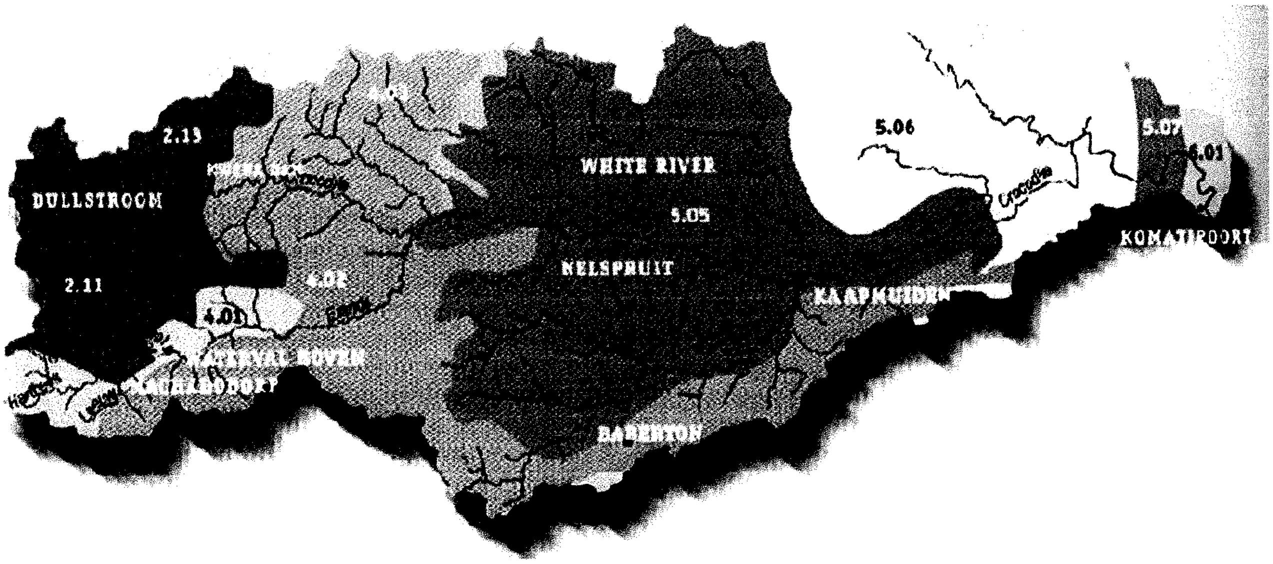
The Middle Crocodile catchment consists of the following veld types:

- N-E Mountain Sourveld (7.8%)
- Lowveld Sour Bushveld (50.7%)
- Lowveld (39.2%)

The Crocodile River and its major tributaries display marked seasonal and year-to-year variations in flow. Highest flows are recorded during the wetter summer months and lowest flows occur towards the end of the dry winter months. Under current land use practices, it is estimated that the mean annual runoff has been reduced by at least 20% from the runoff which would be expected under virgin conditions. The construction of the Kwena Dam (Braam Raubenheimer) caused a marked change in the hydrological characteristics of the Crocodile River. It is considered to yield sufficient water to supply 70% of the irrigation quota and full domestic and industrial requirements during dry periods.

In the Crocodile River catchment, land use and rainfall intensity appears to be the most important determinants of sediment yields. Land use, and particularly misuse, tends to cause a rapid increase in sediment yields. Even activities such as forestry can lead to increased sediment yields, particularly during planting- and logging operations.

Figure 4: Ecoregions of the Crocodile River Catchment



sources.

Catchment constituents of concern for the Middle Crocodile River are as follow (Ideal-Acceptable – Tolerable - Unacceptable):

Chloride – Ideal
Total suspended solids – Ideal
Sodium – Ideal
Iron – Ideal
Manganese – Unacceptable
Electrical conductivity – Ideal
Zinc – Ideal
Arsenic – Ideal
Sulphate – Ideal
Ammonium – Unacceptable
Potential microbiological hazards - Acceptable

Manganese is produced by forestry activities (logging) and industries (DWAF, 1995). The ammonium and nitrate values have increased sharply. This suggests that there is contamination or enrichment of the river water. The enrichment can come from agricultural return flows, storm water runoff or from sewage treatment works. Occasionally high phosphate values indicate that the river is being enriched, probably from the same sources as ammonium and nitrate.

The overall state of this section can be described as **fair**. Upstream of Nelspruit the in-stream biota reflects as **good** to **fair** ecological state. Around Nelspruit the in-stream and riparian conditions deteriorate as indicated by riparian habitats and vegetation (**poor**), fish (**fair** to **poor**) and invertebrates (**poor** to **unacceptable**). Downstream from Nelspruit the river gradually recovers to a **fair** state (WRC, 2001).

A higher diversity of fish species occurs in this reach than in the upper reaches. *Chiloglanis bifurcus* could not be found in the section around and immediately upstream of Nelspruit, an area which forms part of their original distribution. The reason for its absence is most likely because of the inundation caused by the Mataffin Weir as well as urban and industrial pollution originating from Nelspruit (NAEBP, 1998).

Dense stands of trees and shrubs dominate the riparian vegetation, which is in a fair to good condition. Areas within the riparian zone and adjacent to the river are occasionally used for irrigation of citrus. In the area below Mataffin Weir the river bed is covered in extensive reed beds as a consequence of flow regulation and nutrient enrichment from irrigation return flows and urban and industrial effluent.

2.2 Site description

The Donora project site consists of a mixture of farmed area and intact slope forest and woodland (Figure 5). The riverine area from the Donora Falls in the west, flowing towards the "elbow" in the east before it turns south to leave the farm, consists of a relative narrow riparian zone (Figure 3) on a very steep slope. Therefore the instream habitat consists of a large waterfall (Figure 6), a few cascades and many rapids (Figure 8 & 10) in this reach. The abstraction weir is situated just above the first major cascades in the west (Figure 7).

The existing canal flows through a dense valley forest for (Figure 9) the first few hundred meters, and then through farmland and patches of lowveld woodland. The pipeline leading from the canal to the river follows a fence line for the first part (Figure 12) and then transverses some dense lowveld woodland. The hydro plant will be built in this woodland (Figure 13).

Most of the planned power line will cross a patch mosaic of grassland and woodland towards the hydro plant (Figure 14). The last portion transverses the dense lowveld woodland to the hydro plant (Figure 12).

Figure 5: View to the west of the project area towards the waterfall with the dense riparian forest and the agriculture in the background.

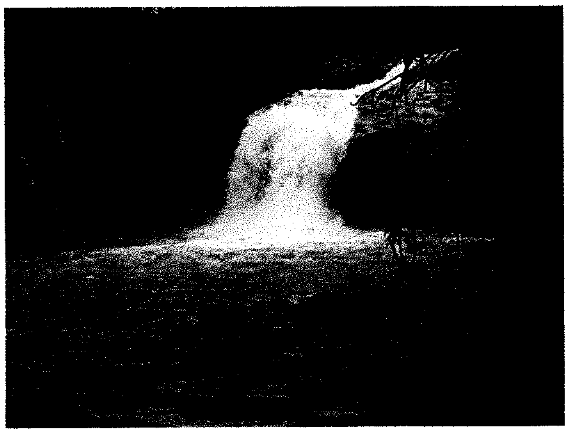


Figure 6: The Donora Falls.

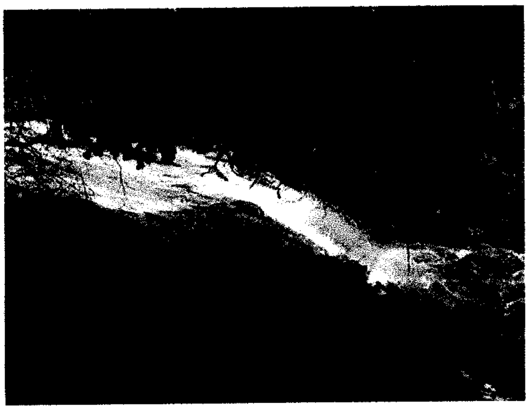


Figure 7: Cascades just below the canal weir.

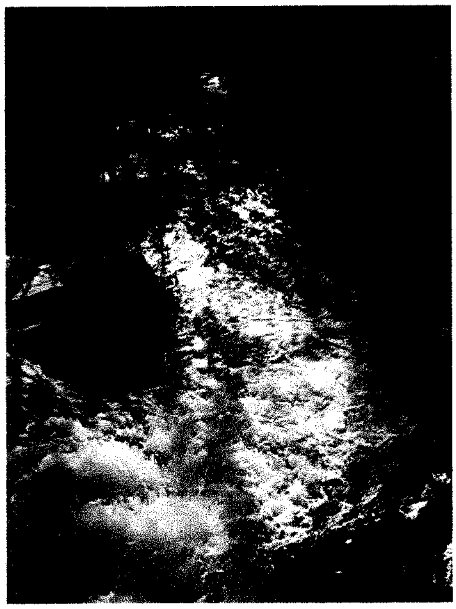


Figure 8: The steep slope at Donora creates a fast flowing river with abundant bedrock rapids.

Figure 9: Lower down the river flows through dense riparian forest.

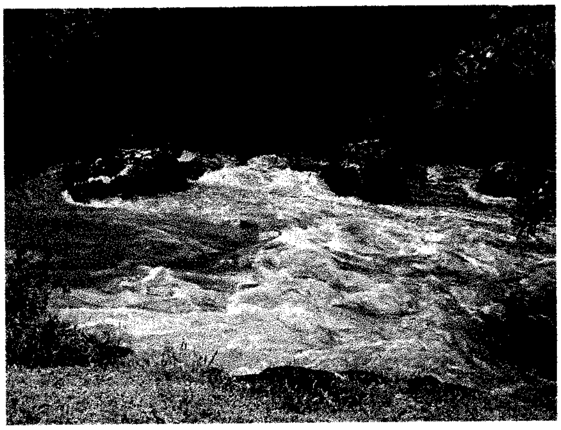


Figure 10: Bedrock rapids in the river.

Figure 11: The canal runs through kloof forest for a few hundred metres.

Figure 12: The pipeline runs along a fence and then through some lowveld woodland.

Figure 13: The hydro plant is to be built in dense lowveld woodland just outside the riparian zone.

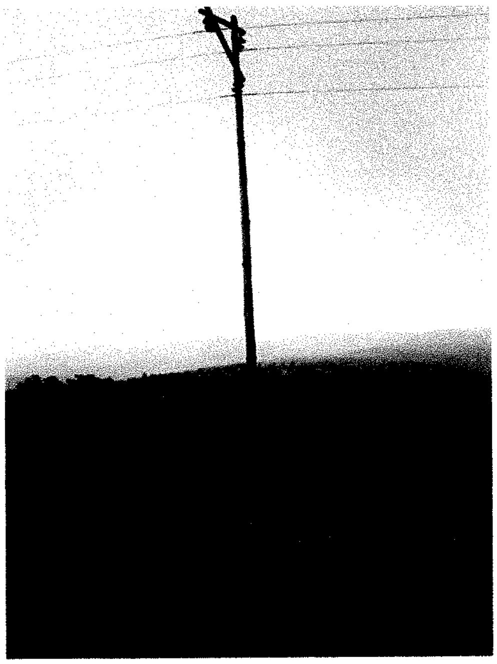
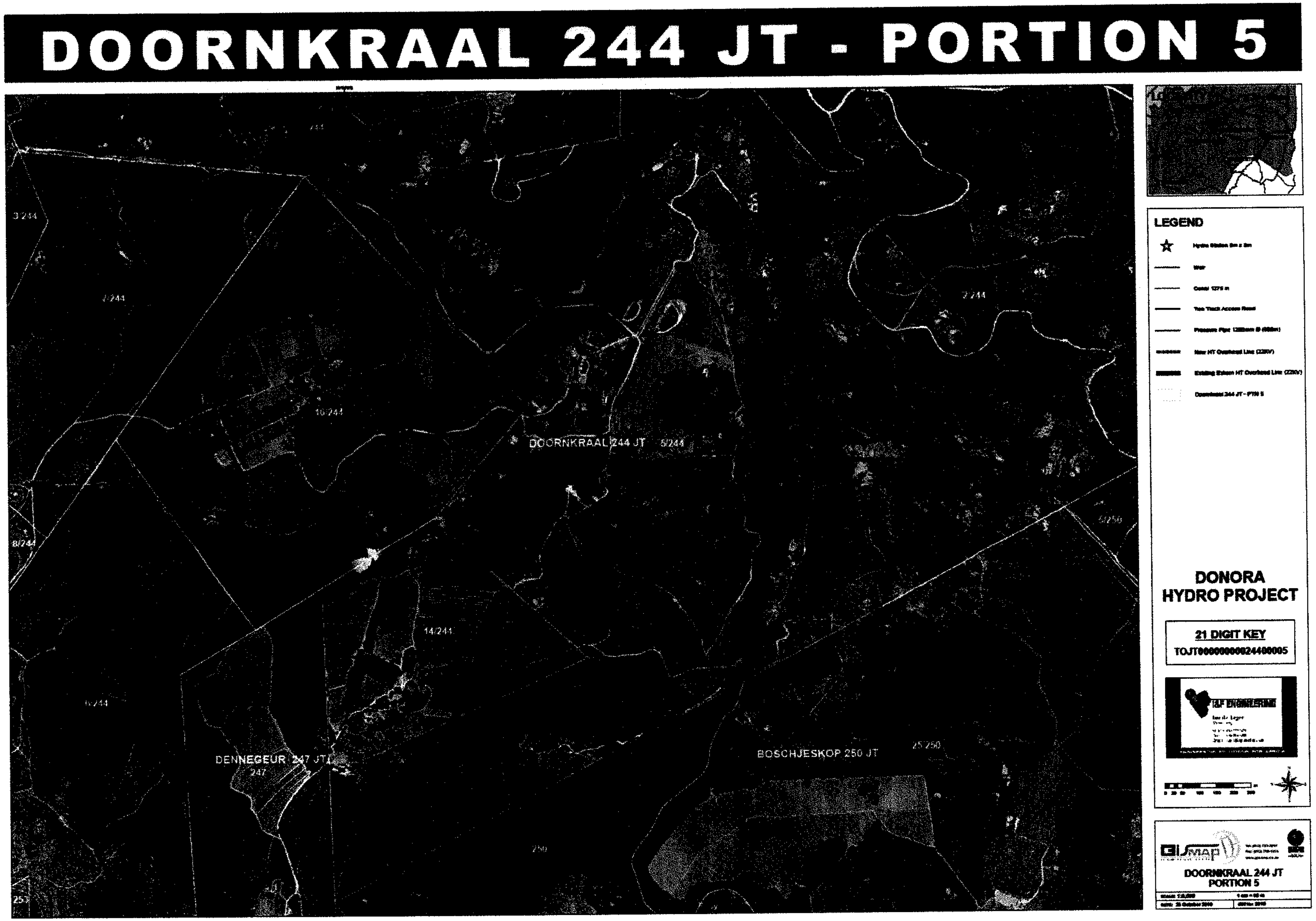


Figure 14: The power line will span a mixture of grassland and lowveld woodland.

Figure 15: The Donora project area depicting the mixture of farmed area, intact slope forest and woodland as seen in relation to development aspects of the project.



3. Methods

The main objective of the study was to undertake an aquatic ecological assessment in order to 1) outline environmental flow requirements at the site, and 2) assess the significance of potential impacts on the aquatic and terrestrial environments, so that authorities may take an informed decision regarding the proposed hydropower plant.

The Department of Water Affairs (DWA) requires that a fishway is installed at the weir, and that water quality parameters above and below the release point of the return water are measured, and that an impact study on the effect of the off take on the remaining stretch of river (in-stream flow requirement) be undertaken.

Following is a description of the methodologies to be employed in undertaking the impact prediction and assessment, including a motivation. The impact assessment will include planning, construction and operational phases (incorporating mitigation measures to prevent, reduce, remediate or compensate the pre-determined impacts; as well as emergency responses) of the following proposed activities:

- Raising of weir
- Deepening canal
- Construction of hydro plant
- Abstracting water from the river, released downstream

As partial requirement for the EIA process, specific biodiversity surveys were recommended by the environmental consultant. The terms included for this investigation are as follow:

- Assess the ecological status, importance and sensitivity of the site as required for section 21 (c) and (i) water use license applications by the Department of Water Affairs (DWA),
- Aquatic and riparian surveys are proposed in the riverine habitats in the vicinity of the proposed development. The objective of this survey is to provide information on the aquatic environment of the proposed development regarding the fish and macro-invertebrate integrity, integrity of the aquatic habitat and possible impacts and mitigation.

For the purposes of this report, the site was assessed during 14 - 19 December 2010 and again on 13 March 2011.

3.1 Riparian delineation

It is important to differentiate between wetlands and riparian habitats. Riparian zones are not wetlands, however, depending on the ecosystem structure, wetlands can be also be classified as riparian zones if they are located in this zone (e.g. valley bottom wetlands). Although these distinct ecosystems will be interactive where they occur in close proximity it is important not to confuse their hydrology and eco-functions.

Riparian delineations are performed according to *"A practical field procedure for identification and delineation of wetlands and riparian areas"* as amended and published by the Department of Water Affairs and Forestry (2005); (Henceforth referred to as DWAF Guidelines (2005).

Aerial photographs (Figure 3 and 15) and land surveys were used to determine the different features and riparian areas of the study area. Vegetation diversity and assemblages were determined by completing survey transects along all the different vegetation communities identified in the riparian areas.

Riparian areas are protected by the National Water Act (Act 36 of 1998), which defines a riparian habitat as follows:

> *"Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."*

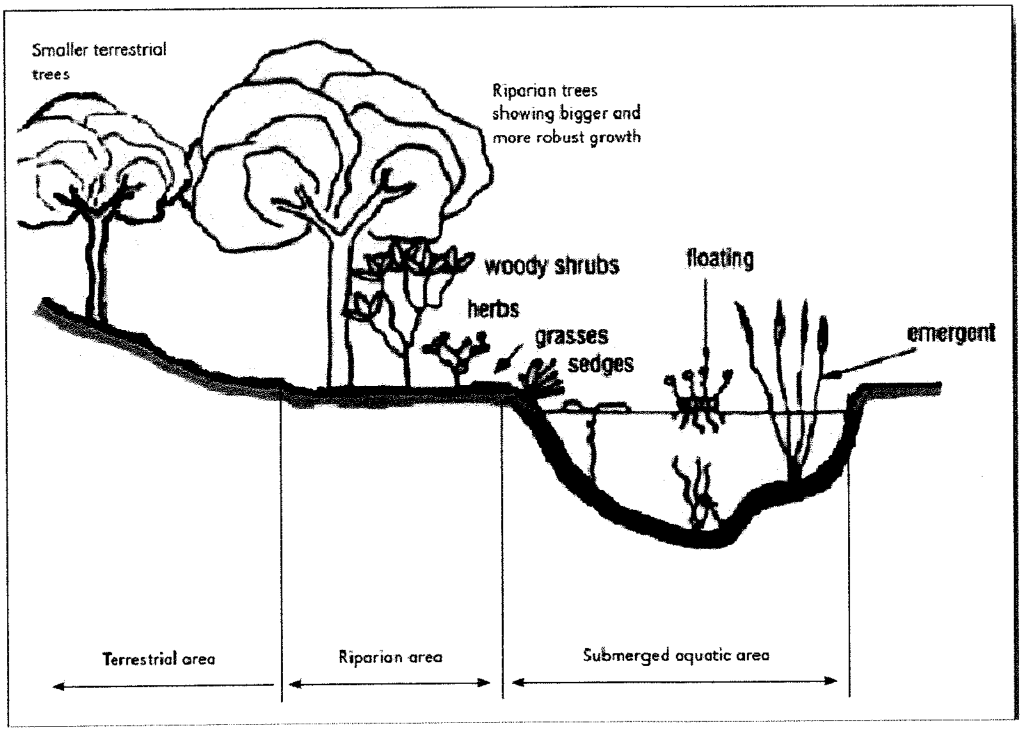
Riparian areas include plant communities adjacent to and affected by surface and subsurface hydrologic features, such as rivers, streams, lakes, or drainage ways. Due to water availability and rich alluvial soils, riparian areas are usually very productive.

Tree growth rate is high and the vegetation is lush and includes a diverse assemblage of species. The delineation process requires that the following be taken into account:

- Topography associated with the watercourse;
- Vegetation;
- Alluvial soils and deposited material.

A typical riparian area according to the DWAF Guidelines (2005) is projected in Figure 16.

Figure 16: A cross section through a typical riparian area (DWAF Guidelines, 2005).



In addition to the DWAF Guidelines (2005), the unpublished notes: *Draft riparian delineation methods prepared for the Department of Water Affairs and Forestry, Version 1* (Mackenzie & Roundtree, 2007) were used for classifying riparian zones encountered on the property according to the occurrence of nominated riparian vegetation species.

3.2 EcoClassification

During recent years DWA has published the *River Ecoclassification* series of methods used to determine the health of rivers and streams in South Africa. As part of this series the methods for ecological status determination and the classification of riparian and aquatic systems, is published in Module A: *EcoClassification and EcoStatus Determination* (Kleynhans & Louw, 2007). The following sections are extracted and modified (where appropriate) from the last mentioned authors.

EcoClassification refers to the determination and categorisation of the present ecological state (PES) (health or integrity) of various biophysical attributes of rivers compared to the natural (or close to natural) reference condition. The purpose of EcoClassification is to gain insight into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river.

The state of the river is expressed in terms of biophysical components:

- Drivers (physico-chemical, geomorphology, hydrology), which provide a particular habitat template; and
- Biological responses (fish, riparian vegetation, riverine fauna (other than fish) and aquatic invertebrates).

3.2.1 Present Ecological State (PES)

The PES of the river is expressed in terms of various components. That is, **drivers** (physico-chemical, geomorphology, hydrology) and **biological responses** (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the EcoStatus. A rule-based procedure is followed to assign each component an Ecological Category for the PES (on a scale of A to F) using the following information:

- Biophysical surveys conducted during the project.
- Information and data from historical surveys, databases and reports.
- Aerial photographs and videos.
- Land-cover data.
- Internal Strategic Perspective (ISP) reports of DWAF.
- Expert knowledge is regularly used to estimate the degree of change to a particular component.

It must be emphasised that the A to F scale represents a continuum (Figure 16), and that the boundaries between categories are notional, artificially-defined points along the continuum. There may therefore be cases where there is uncertainty as to which category a particular entity belongs. This situation falls within the concept of a fuzzy boundary, where a particular entity may potentially have membership of both classes. For practical purposes these situations are referred to as boundary categories and are denoted as B/C, C/D, and so on. The B/C boundary category, for example, is indicated as the light green to dark-blue area in Figure 17.

Figure 17: The continuum on an A to F scale for rating Ecological Category

The models for each component all use a swing ranking system in which key ecological components are ranked and weighted to provide consistent results.

3.2.2 Trend

Trend is viewed as a directional change in the attributes of the drivers and biota (as a response to drivers) at the time of the PES assessment. A trend can be absent (close to natural or in a hanged state but stable), negative (moving away from reference conditions) or positive (moving back towards natural - when alien vegetation is cleared, for instance). The ultimate objective is to determine if the biota have adapted to the current habitat template or are still in a state of flux. Generally such an assessment can be approached from a driver perspective. This means that there can be a positive or negative trend response from the biota if the drivers (specifically geomorphology and water quality) are still in a directional state of change (+ or -).

3.2.3 Ecological Importance and Sensitivity (EIS)

The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity.

3.2.4 Ecological Category (EC)

The basis of the assessment of the importance of the metrics of biophysical components in determining the EC and EcoStatus is a Multi Criteria Decision Analysis approach (MCDA). The MCDA process allows the development of consistent rating systems or indices for the categorisation of ecosystem components and aggregates these mathematically in a theoretically justifiable way.

A six-point rating system is followed, where metrics of the drivers and biological responses are scored in terms of the degree to which they have changed compared to the natural or close-to-natural reference (if necessary, half points such as 1.5 and so on can also be used):

0 = No discernable change from reference/close to reference
1 = Small modification from reference
2 = Moderate modification from reference
3 = Large modification from reference
4 = Serious modification from reference
5 = Extreme modification from reference

These qualitative ratings are expert knowledge-based, and are assessed by the relevant expert in a particular speciality. It is preferable that the relative difference between for example, 0 – 1 be the same as between 3 – 4. However, this is difficult to control and is currently exclusively based on expert knowledge.

The calculation of the Ecological Categories of drivers and biological responses is done by totalling the weighted scores and expressing this as a percentage of the maximum. This value indicates the percentage change away from the expected reference and must be subtracted from 100 to arrive at the percentage value that represents the EC. This value is used to place the EC of the component in a particular category that ranges from A to F (Table 2).

Table 2: Generic ecological categories for EcoStatus components (Kleynhans et al, 2008).

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

After the Ecological Categories of the driver and ecological response components are determined, there remains the issue of how to integrate these to provide an indication as to the EcoStatus. Deriving the EcoStatus from the Ecological Categories of components is based on the following principles (Kleynhans *et al*, 2005):

- The Ecological Categories of the physical drivers (hydrology, geomorphology and physico-chemical integrity) are not integrated to provide an indication of the EcoStatus purely based on the drivers.
- Information on the driver metrics, i.e. how different they are from the reference is considered when assessing the biological responses. This is an expert knowledge approach and the attributes and environmental requirements of the biota should be considered when doing this.
- The biological responses are considered to provide the best indication of the EcoStatus of the river because it integrates the effect of the driver components

The steps in deriving the EcoStatus are:

- Criteria are considered that provide an indication of the relative indicator value of the two instream biological groups, fish and invertebrates. These criteria are used to weigh the relative importance of these two groups as indicators of instream health. The Ecological Categories of the two biological groups are proportioned according to these weights and combined to provide the instream Ecological Category.
- A suitable index to get an indication of riparian vegetation Ecological Category within the EcoStatus context is not yet available. Consequently the riparian vegetation zone can only be considered conceptually and in terms of its influence on the instream EC. In this regard the influence, importance and integrity of the riparian vegetation zones, i.e. marginal, lower and upper vegetation, are considered in terms of its significance for the instream biota. Some indication of the health of the riparian vegetation can also be gleaned from the geomorphological driver where certain metrics of this driver do serve as indicators.
- The riparian vegetation Ecological Category and the instream Ecological Category are integrated based on a proportioning of weights according to the availability of high confidence information. This provides the EcoStatus of the river.
- Where riparian vegetation information is insufficient, the instream EC is used as the

best indicator of the EcoStatus of the river.

The *modus operandi* followed by DWAF's Directorate: Resource Directed Measures (RDM) is that, if the EIS is high or very high, the ecological aim should be to improve the condition of the river. However, the causes related to a particular PES should also be considered to determine if improvement is realistic and attainable. This relates to whether the problems in the catchment can be addressed and mitigated. If the EIS evaluated as moderate or low, the ecological aim should be to maintain the river in its PES. Within the Ecological Reserve context, Ecological Categories A to D can be recommended as future states (REC - the Recommended Ecological Category) depending on the EIS and PES. Ecological Categories E and F PES are regarded as ecologically unacceptable, and remediation is needed.

3.3 Aquatic and riparian surveys

An aquatic specialist assessed the condition of the proposed development and its impact on the aquatic environment. The following recognized bio-parameters and methods were used.

- Aquatic invertebrates (South African Scoring System version 5 — **SASS5**). In addition to using this method the operators must be accredited SASS 5 practitioners.
- **IHAS** (Integrated Habitat Assessment System, version 2) habitat assessments were performed in conjunction with the SASS5 assessment to determine the role of habitat in the observed biotic integrity based on the macro-invertebrates.
- General **habitat assessment** (including photographic assessment) to assess the general physical habitat condition of the sites and identify potential sources and impacts responsible for deterioration of the aquatic ecosystem.
- Fish communities (Fish Assemblage Integrity Index — **FAII**). Applicable fish habitat assessments such as the Habitat Cover Ratings (HCR) and Site Fish Habitat Integrity Index (SHI) were used to assess the habitat potential and condition for fish assemblages.
- Riparian vegetation (Riparian Vegetation Index — **VEGRAII**)

3.3.1 Aquatic biota

Macro-invertebrates and fish are good indicators of river health. By making use of established and accepted survey methods (SASS5 for invertebrates and FAII-based surveys for fish) and incorporate the habitat aspects, a proper basis for biological diversity could be obtained.

The Aquatic specialist assessed the condition of the proposed development and its impact on the aquatic environment. The following recognized bio-parameters and methods were used:

- Aquatic invertebrates (South African Scoring System version 5 — SASS5).
- Fish communities (Fish Assemblage integrity Index— FAII)
- Riparian habitat surveys (Riparian Vegetation Index — VEGRAI)

3.3.1.1 Aquatic invertebrate assessment

Benthic macro-invertebrate communities of the selected sites were investigated according to the South African Scoring System, version 5 (SASS5) approach. An invertebrate net (30 x 30cm square with 0.5mm mesh netting) was used for the collection of the organisms. The available biotopes at each site will be identified on arrival. Each of the biotopes was then sampled separately and by different methods. Sampling of the biotopes was done as follows:

Stones in current (SIC): Movable stones of at least cobble size (3 cm diameter) to approximately 20 cm in diameter, within the fast and slow flowing sections of the river. Kick-sampling is used to collect organisms in this biotope. This is done by placing the net on the bottom of the river, just downstream of the stones to be kicked, in a position where the current will carry the dislodged organisms into the net. The stones are then kicked over and against each other to dislodge the invertebrates (kick-sampling) for ± 2 minutes.

Stones out of current (SOOC): *Where the river is calm, such as behind a sandbank or ridge of stones or in backwaters.* Collection is again done by method of kick-sampling, but in this case the net is swept across the area sampled to catch the dislodged biota. Approximately 1 m^2 is sampled in this way.

Sand: These include sandbanks within the river, small patches of sand in hollows at the side of the river or sand between the stones at the side of the river where flow was slow or no flow was recorded. This biotope is sampled by stirring the substrate, shuffling or scraping of the feet is done for half a minute, whilst the net is continuously swept over the disturbed area.

Gravel: Gravel typically consists of smaller stones (2-3 mm up to 3 cm). Sampling similar to that of sand.

Mud: *It consists of very fine particles, usually as dark-coloured sediment.* Mud usually settles to the bottom in still or slow flowing areas of the river. Sampling similar to that of sand.

Marginal vegetation (MV): *This is the overhanging grasses, bushes, twigs and reeds from the riverbank.* Sampling is done by holding the net perpendicular to the vegetation (half in and half out of the water) and sweeping back and forth in the vegetation (± 2m of vegetation).

Aquatic vegetation (AQV): *Rooted, submerged or floating waterweeds such as Potamogeton, Aponogeton and Nymphaea.* Sampled by pushing the net (under the water) against and amongst the vegetation in an area of approximately one square meter.

The organisms sampled in each biotope were identified and their relative abundance is also noted on the SASS5 datasheet. Habitat assessments, according to the habitats sampled, were performed due to the fact that changes in habitat can be responsible for changes in SASS5 scores. This was done by the application of SASS orientated habitat assessment indices. The indices used are the Integrated Habitat Assessment System (IHAS) score sheet and the Habitat Quality Index (HQI).

The SASS5 method was used to establish the macro-invertebrate integrity and it was attempted to sample all three of the main habitat assemblages: stones, vegetation and sand/mud/gravel. The associated habitats were determined with the Invertebrate Habitat Assessment System (IHAS) and the Habitat Quality Index (HQI).

Although the SASS5 method was used as prescribed by DWA, it must be kept in mind that this method was designed for water quality purposes. Therefore the macro-invertebrate integrity scores may vary throughout the year as water quality changes, due to flow variation, as should be the case in the pre- and post-construction phases of the monitoring project.

3.3.1.2 Fish communities - Fish Response Assessment Index (FRAI)

The biotic assessment method uses a series of fish community attributes related to species composition and ecological structure to evaluate the quality of an aquatic biota. Data on distribution, richness, length frequency and abundance will be collected. The sampling methods will be fish traps, seine nets, mosquito nets and electro-fishing.

Fish segment identification, species tolerance ratings, abundance ratings, frequency of occurrence and health status techniques are applied during this survey to determine the integrity of the fish communities.

On arrival at the site a basic on site visual appraisal is made of the habitats available on that particular day at that particular flow. A site diagram is sketched indicating the different habitats and the various components thereof. Sampling takes place in each of the different habitats. These different habitats are sampled separately using different methods.

a) Electro-shocking

Electro-shocking commences in the downstream component of the habitat. One person uses a backpack electro-shocker for shocking, using a scoop net to catch the stunned fish. The researcher progresses upstream, keeping the fish caught in a bucket until that particular habitat is finished. Each habitat shocked is timed. It is necessary to take care (as far as possible) when shocking so as not to disturb the rest of the habitat still to be worked. As each habitat is completed the fish species caught, are identified, recorded and released back into their respective habitats. Any fish species that cannot be identified at the time is preserved in 10% formalin (in a sample bottle with label inside) for later identification by experts. The data sheet is completed for that particular habitat – recording every fish, its age class (adult, sub-adult, juvenile) and whether any fish is diseased (e.g. visible ecto-parasites). Each habitat type is recorded (e.g. shoot, riffle or pool etc), as well as the width, depth, substrate, the extent sampled, the percentage of algae on substrate, whether there was any vegetation, and the turbidity. The flow of that particular habitat is classified into one of five flow classes (no flow, slow flow, medium flow, fast and very fast flow).

The electro shocking device is used to sample certain habitats: shoots, riffles, rapids, shallow- medium depth pools in stream and off stream, runs and back waters.

b) Cast net

A cast net (a weighted circular net that is thrown into the water) is used in pool type or slower flow and deeper habitats. As with method (a) all aspects of the habitat type are recorded as well as the fish species, numbers, age class and health. The number of throws / efforts per a habitat is also recorded.

3.3.2 Aquatic habitat assessments

Habitat assessments have been carried out to identify situations in which changes in habitat are responsible for changes in faunal populations. The nature and diversity of habitats available at the sampling point are factors of overwhelming influences on the biota present. The diversity of available biotopes itself is often incorporated in information on the conservation status of the river.

The habitat indices used in this survey are the Invertebrate Habitat Assessment System (IHAS) and the Habitat Quality Index (HQI).

a) IHAS (Integrated Habitat Assessment System)

b) HSI (Habitat Suitability Index)

c) HQI (Habitat Quality Index)

3.3.3 Riparian habitat surveys (Riparian Vegetation Index — VEGRAI)

The general components of the VEGRAI are specified as following:

It is a practical and rapid approach to assess changes in riparian vegetation condition.

It considers the condition of the different vegetation zones separately but allows the integration of zone scores to provide an overall index value for the riparian vegetation zone as a unit.

The vegetation is assessed based on woody and non-woody components in the respective zones and according to the different vegetation characteristics which include, inter alia:

- Cover
- Abundance
- Recruitment
- Population structure
- Species composition

It provides an indication of the causes for riparian vegetation degradation.

It is impact based. This means that the reference condition will only be broadly defined and based on the natural situation in the absence of impacts. Where possible, however, reference conditions should be derived based on reference sites or sections.

The index is based on the interpretation of the influence of riparian vegetation structure and function on instream habitat.

Although biodiversity characteristics are used in assessing the riparian vegetation condition, it is not a biodiversity assessment index *per se.*

For this study the Level 3 VEGRAI will be used as Level 3 is applied by the River Health Programme (RHP) and for rapid Ecological Reserve purposes. This level will be aimed at general aquatic ecologists.

3.3.4 Riparian and terrestrial biota

Physical alterations in the riverine area will modify the marginal vegetation on the riverbanks and consequently the associated fauna that occupies the riparian zone. The riparian vegetation consists of reeds, shrubs and woody vegetation, and these plants form important habitats for riparian birds, mammals, reptiles and frogs (create shelter and produce food sources).

In order to assess the possible impacts that the proposed development will have on the riparian environment of the river, it is important that a survey be performed to establish the current status of:

- Riverine habitats
- Riparian biota

This assessment will also provide an account regarding physical influences that the development might have on the riverine environment. The proposed activities include:

- Deepening canal
- Construction of pipeline
- Construction of hydro plant
- Connecting with power line

The proposed activities of the specialist studies are:

- Selected specialist ecological studies will be conducted in this area (including aquatic, terrestrial and amphibian fauna assessment) to determine the potential impact of the proposed activity. Predictive inventories fauna will be compiled for expected species assemblages and then correlated with the aspects of habitat present in the study area.

- Emphasis will be placed on Species of Special Concern that may be influenced by the proposed activity - Identify the potential presence of plant and animal (terrestrial and aquatic) species of conservation importance: threatened, IUCN red data listed, NEMBA protected, endemic, Mpumalanga Province requirements, SANBI listings, etc.

- Identify areas of concerns and potential impacts that may influence the study area due to the development
- Recommend mitigation methods regarding probable impacts

In order to establish a baseline in respect to the fauna of the study area, an assessment was made of the ecosystem template, which is a function of the geomorphology (abiotic) and the vegetation (biotic) structure of the area. By matching the fauna that are identified during the study or were previously observed in the area with those that are expected to be present, based on habitat type, the baseline integrity of the study area environment could be established.

4. RESULTS & DISCUSSION

4.1 Riparian delineation

During the process of riparian delineation, 5 transects from the terrestrial area through the riparian area to the edge of the river were surveyed (Figure 18). The results of the surveys are listed in Table 3. True riparian plant species noted in the project area, are listed in Table 4 (Abstracted from Appendix 1).

Table 3: The riparian transects surveyed along the Nel's River.

	Riparian transect 1	Riparian transect 2	Riparian transect 3	Riparian transect 4	Riparian transect 5
Nel's River					
	Grassland tree fern(Cyanthea dregei)	**Matumi (*Breonadia salicina*)**	**Water berry (*Syzygium cordatum*)**	**Matumi (*Breonadia salicina*)**	Bladdernut (*Diospyros whyteana*)
	Water berry (*Syzygium cordatum*)	**Pigeonwood (*Trema orientalis*)**	Broom cluster fig (*Ficus sur*)	**River bushwillow (*Combretum erythrophyllum*)**	Peanut senna (*Senna didymobotrya*)
	Pigeonwood (*Trema orientalis*)	Broom cluster fig (*Ficus sur*)	**Pigeonwood (*Trema orientalis*)**	Thorny rope (*Dalbergia armata*)	Flame thorn (*Acacia ataxacantha*)
	Mitzeeri (*Bridelia micrantha*)	Thorny rope (*Dalbergia armata*)	**Matumi (*Breonadia salicina*)**	Wild mulberry (*Trimeria grandifolia*)	Wild mulberry (*Trimeria grandifolia*)
	Rock cabbage tree (*Cussonia natalensis*)	Common coral tree (*Erythrina lysistemon*)	Thorny rope (*Dalbergia armata*)	Flame thorn (*Acacia ataxacantha*)	**River bushwillow (*Combretum erythrophyllum*)**
	Zebrawood (*Dalbergia melanoxylon*)	Common forest grape (*Rhoicissus tomentosa*)	Bladdernut (*Diospyros whyteana*)		**Pigeonwood (*Trema orientalis*)**
		Transvaal red milkwood (*Mimusops zeyheri*)			
Riparian		Common fig (*Ficus burkei*)			
	12.0m	29.3m	27.4m	29.5m	23.6m
	Bladdernut (*Diospyros whyteana*)	Velvet bushwillow (*Combretum molle*)	Bladdernut (*Diospyros whyteana*)	Thorny rope (*Dalbergia armata*)	Cross berry (*Grewia occidentalis*)
	Bugweed (*Solanum mauritianum*)	Red-leaved rock fig (*Ficus ingens*)	Monkey pod (*Senna petersiana*)	Bladdernut (*Diospyros whyteana*)	Bladdernut (*Diospyros whyteana*)
	Jacaranda (*Jacaranda mimosifolia*)	**Pigeonwood (*Trema orientalis*)**	Flame thorn (*Acacia ataxacantha*)	Cabbage tree (*Cussonia spicata*)	Transvaal milkplum (*Englerophytum magalismontanum*)
	Velvet bushwillow (*Combretum molle*)	Transvaal red milkwood (*Mimusops zeyheri*)	Pride-of-De Kaap (*Bauhinia galpinii*)	Transvaal milkplum (*Englerophytum magalismontanum*)	Transvaal currant (*Rhus transvaalensis*)
	Gland-leaf brides-bush (*Pavetta edentulata*)	Common tree Euphorbia (*Euphorbia ingens*)	Thorny rope (*Dalbergia armata*)	Flame thorn (*Acacia ataxacantha*)	Eastern bluebush (*Diospyros lycioides sericea*)
	Broad-leaved beechwood (*Faurea rochetiana*)	**Mitzeeri (*Bridelia micrantha*)**	**Wild custard-apple (*Annona senegalensis*)**		
	Transvaal teak (*Pterocarpus angolensis*)		Velvet bushwillow (*Combretum molle*)		
	Sickle bush (*Dichrostachys cinerea africana*)		Transvaal teak (Kiaat) (*Pterocarpus angolensis*)		
			Common tree Euphorbia (*Euphorbia ingens*)		
			Pigeonwood (*Trema orientalis*)		
			Wild mulberry (*Trimeria grandifolia*)		
			Lavender tree (*Heteropyxis natalensis*)		
Terrestrial			Small knobwood (*Zanthoxylum capense*)		
	51.3m E25 18 48.3 S30 50 06.5	74.2m E25 18 52.0 S30 50 17.6	94.9m E25 18 45.8 S30 50 23.3	40.3m E25 19 49 S30 50 04	42.8 E25 19 19 S30 50 41

Table 4: Riparian indicator plant species observed in the riverine zone at Donora.

FAMILY	TAXON	HABITAT
ANNONACEAE	*Annona senegalensis*	Sandy soils along rivers, also in mixed scrub or woodland, on rocky outcrops and in swamp forest.
RUBIACEAE	*Breonadia microcephala/ salicina*	Along banks of permanent streams and rivers, in riverine fringe forest.
EUPHORBIACEAE	*Bridelia micrantha*	Riverine forest; patches of relic forest, or in open woodland.
COMBRETACEAE	*Combretum erythrophyllum*	Along river banks where it can form thick stands, with trunks reclining in and overhanging the water.
MYRTACEAE	*Syzygium cordatum subsp. cordatum*	Along stream banks, in riverine thicket and forest, always near water or along watercourses, and in KZN, forming stands of almost pure swamp forest.
ULMACEAE	*Trema orientalis*	Variety of habitats, usually moist soils, on forest margins, along watercourses, often a constituent of riverine fringe thicket, also in ravines and valleys and even along dry, sandy river-beds (smaller in drier habitats).

Figure 18: Riparian zone demarcated along the Nel's River in the project area.

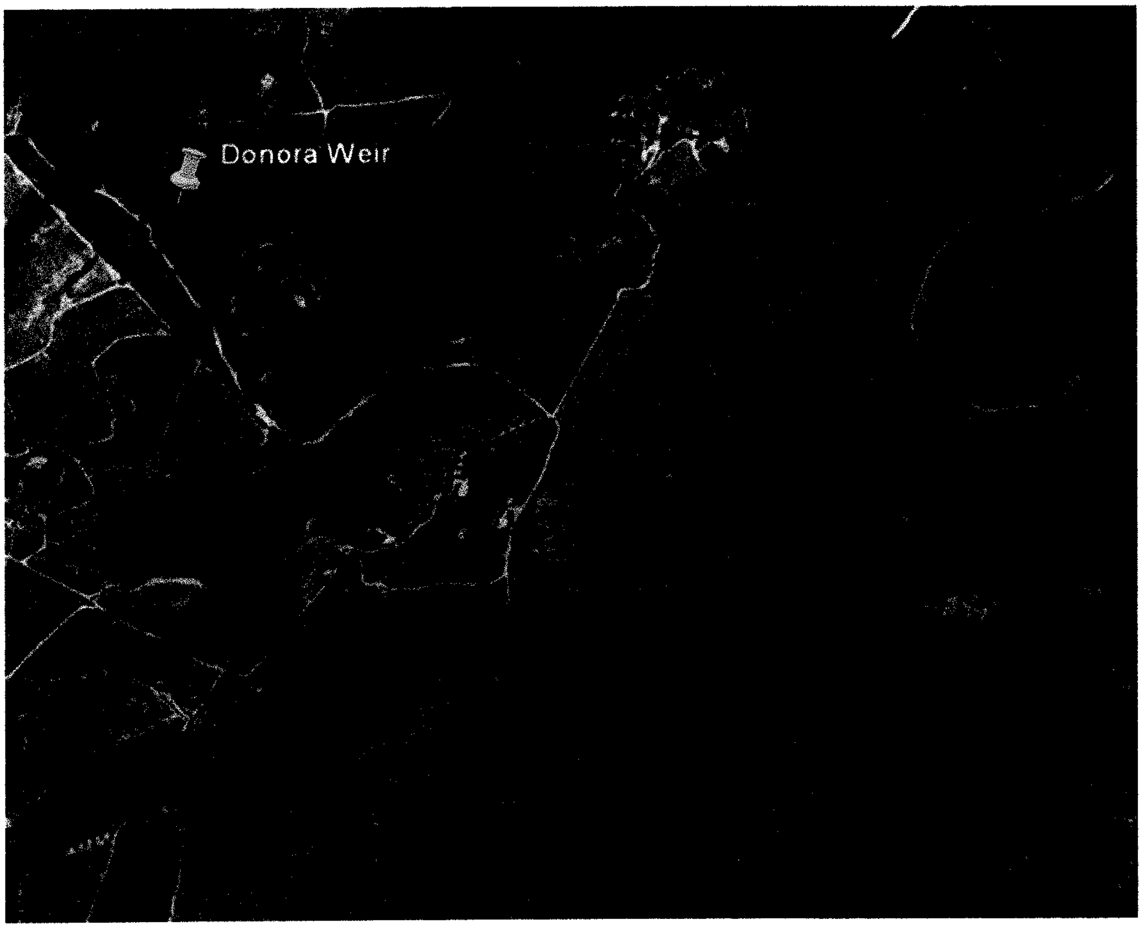


Figure 18a: Detail of the riparian zone along the Nel's River at Donora.

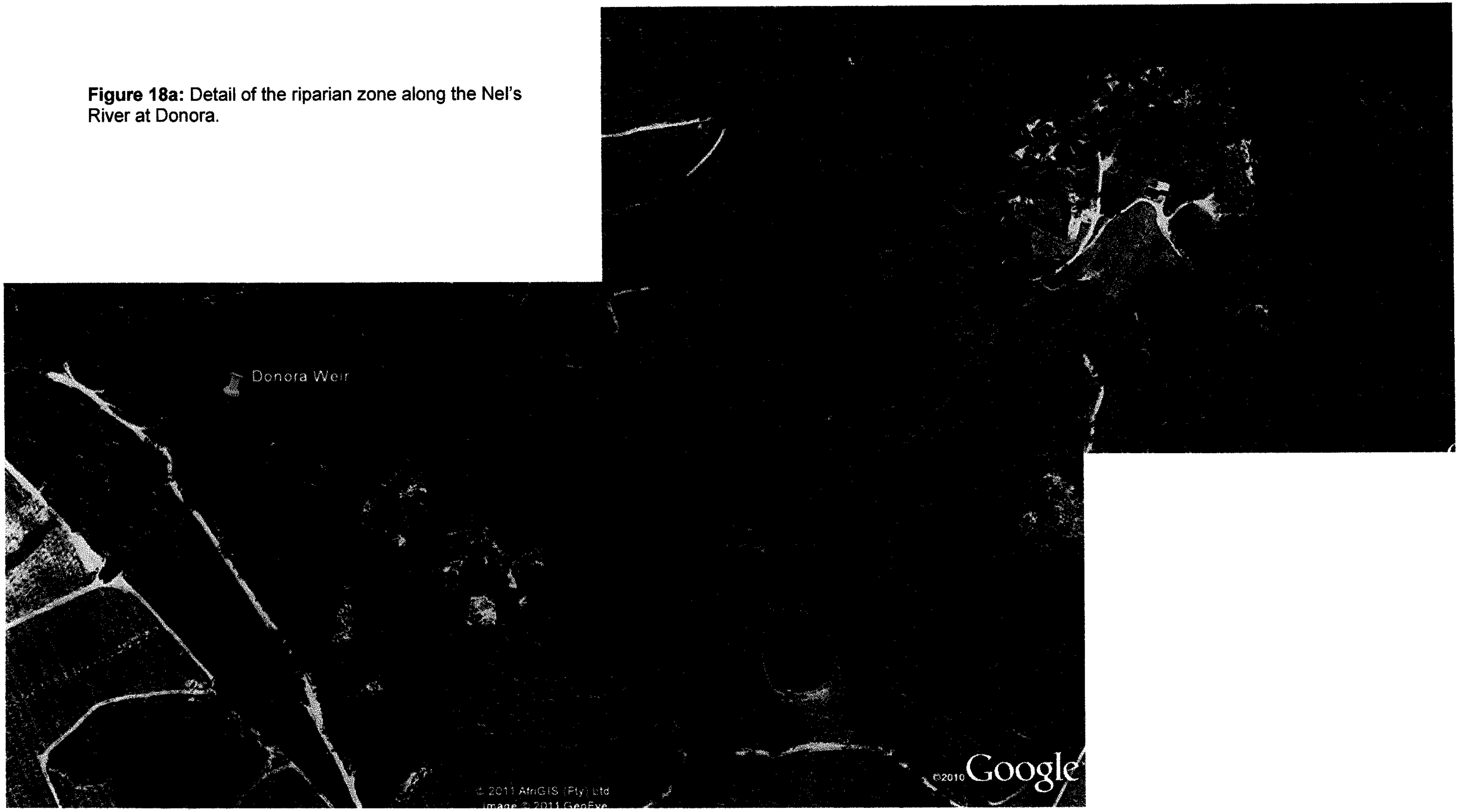
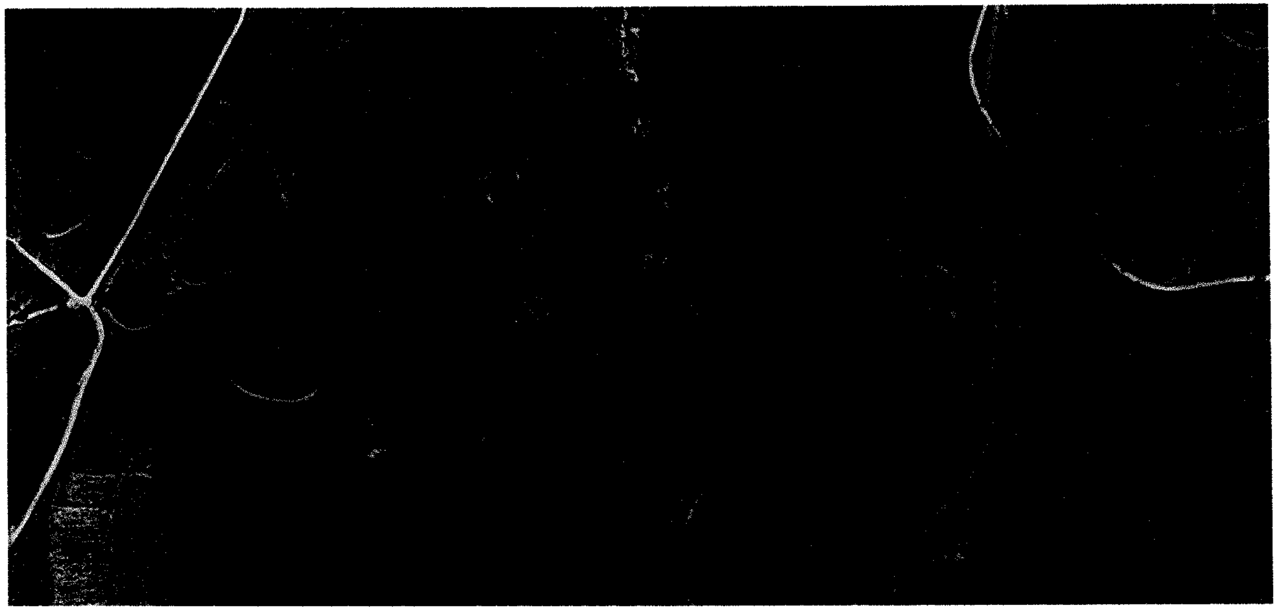
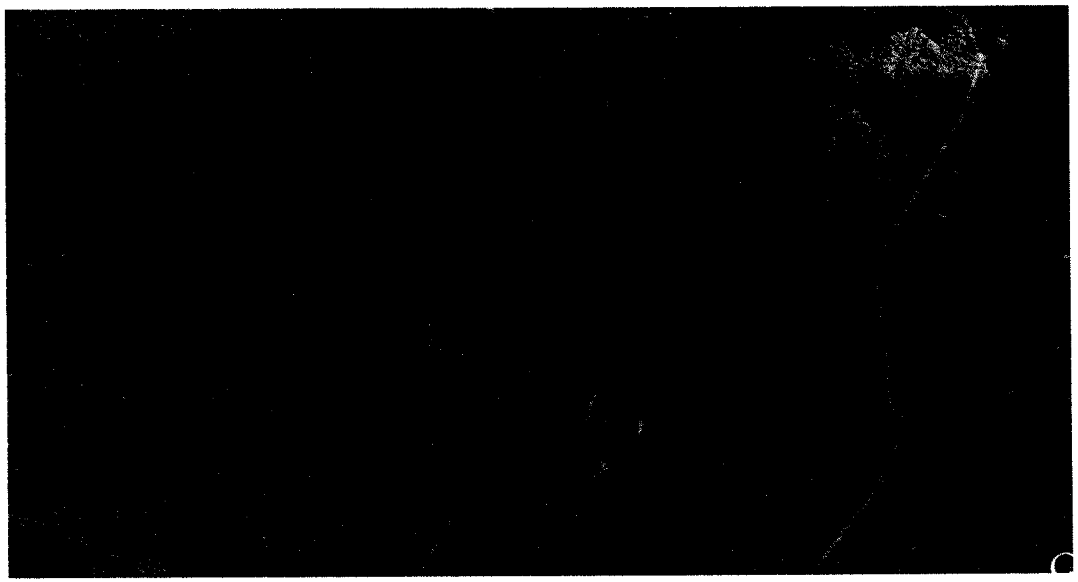


Figure 18b: Detail of the riparian zone along the Nel's River at Donora.





4.2 EcoClassification

EcoClassification - the term used for the Ecological Classification process - refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological management objectives for the river. The steps followed in the EcoClassification process are as follows:

- Determine reference conditions for each component.
- Determine the Present Ecological State for each component as well as for the EcoStatus. The EcoStatus refers to the integration of physical changes by the biota and as reflected by biological responses.
- Determine the trend (i.e. moving towards or away from the reference condition) for each component as well as for the EcoStatus.
- Determine causes for the PES and whether these are flow or non-flow related.
- Determine the Ecological Importance and Sensitivity (EIS) of the biota and habitat.

4.2.1 Background information of the Nel's River Catchment

The water of the Middle Crocodile River (incorporating the Nels's River) is of reasonably good quality. The water varies from slightly acidic to alkaline and the low conductivity values show that the water is very slightly mineralized. Water quality in the Nel's River shows some deterioration during the winter months. Where very little water is available during the dry winter months, there is a corresponding decrease in residual assimilative capacity (DWAF 1995).

4.2.2 Conservation value of the project area

Using the classification of vegetation types based on % of natural habitat remaining, the Biodiversity Act provides for listing threatened and protected ecosystems into the following categories:

- 'Critically endangered' ecosystems – that have undergone severe ecological degradation and are at an extremely high risk of irreversible transformation;

- 'Endangered', or 'vulnerable' ecosystems – being categories of reduced degradation and risk, each less than the previous category above;

- 'Protected' ecosystems – being ecosystems that are not threatened but nevertheless are worthy of special protection.

Figure 19: Land classification incorporating wetland values according to the Mpumalanga Conservation Plan

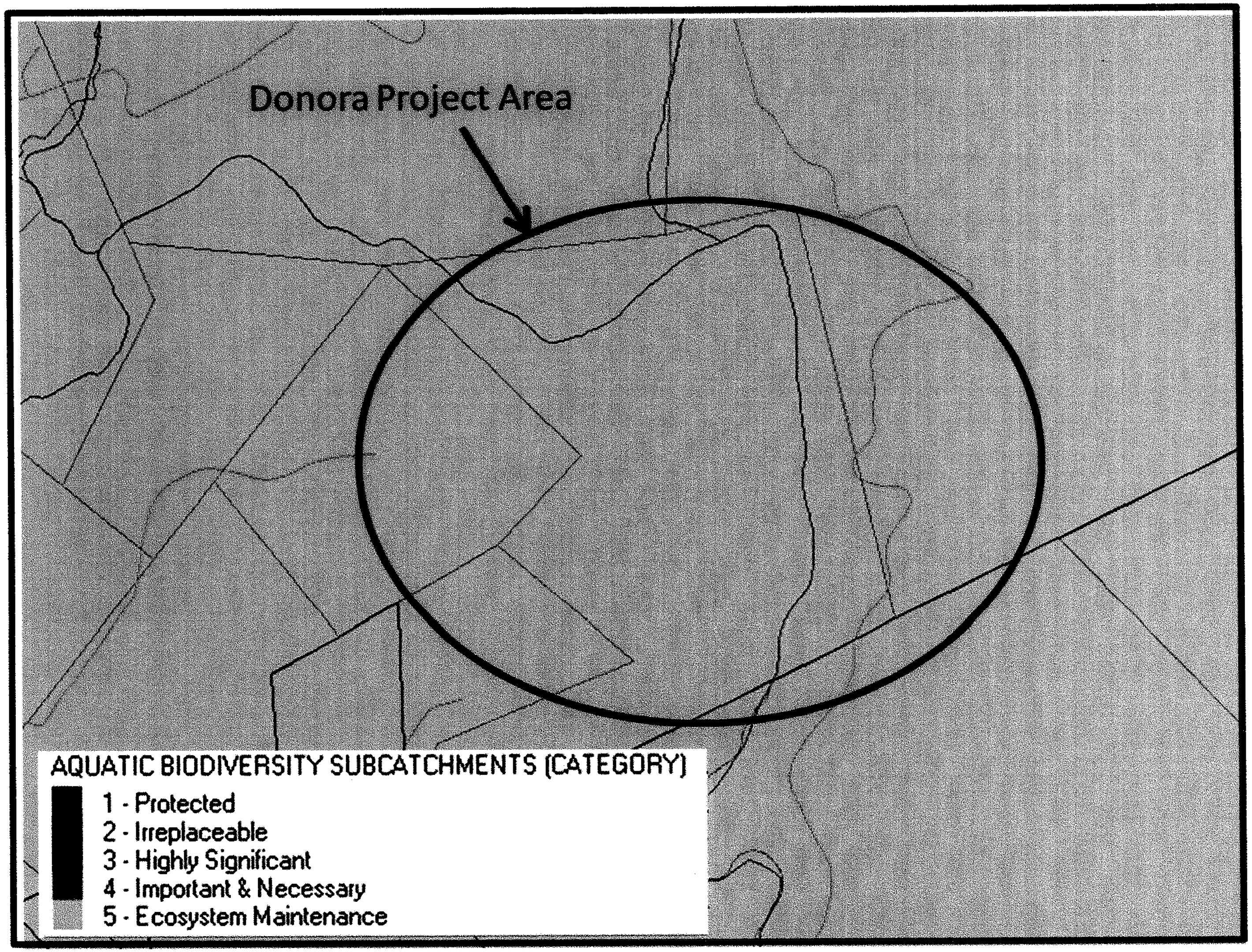
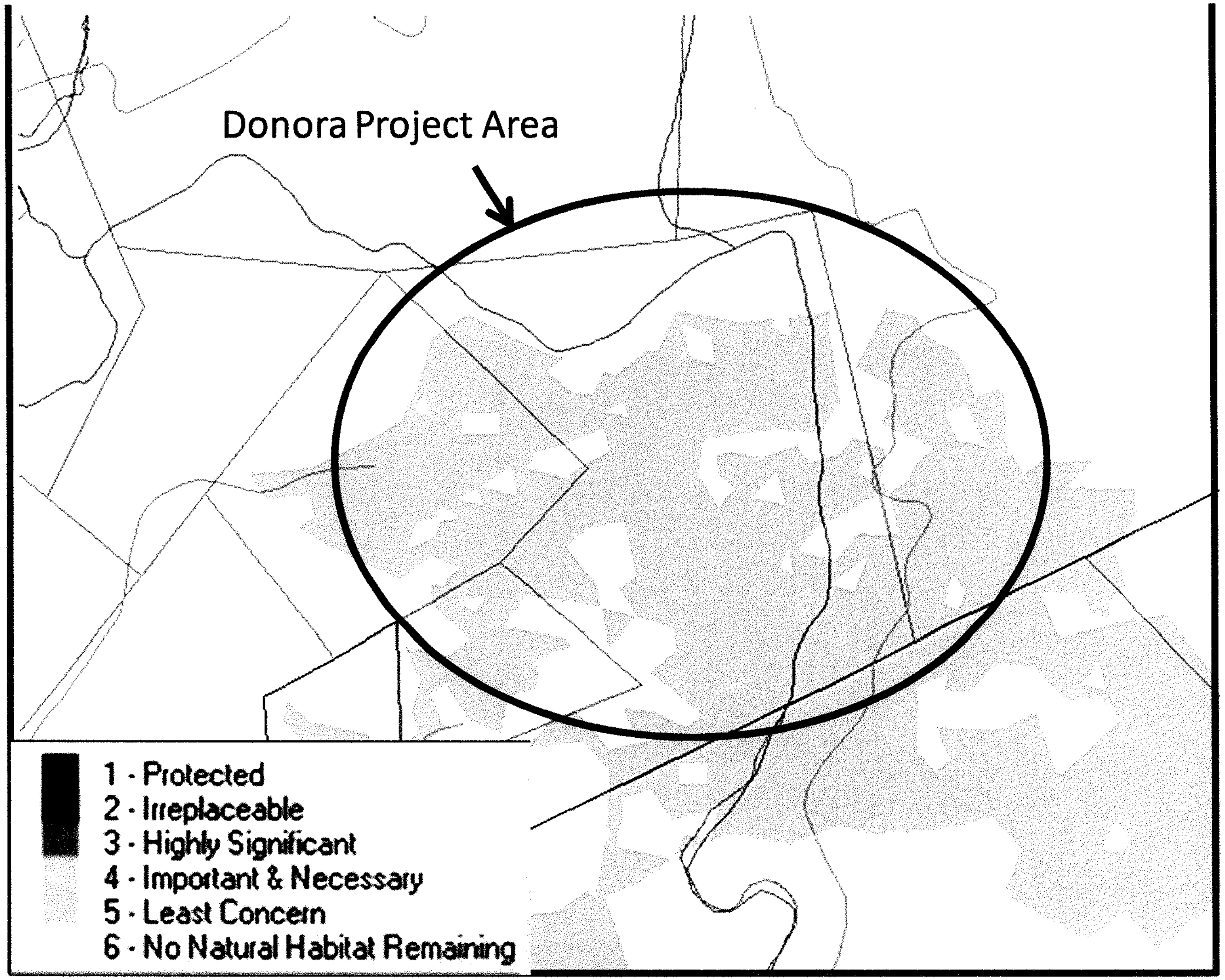


Figure 20: Land classification incorporating conservation values according to the Mpumalanga Conservation Plan



According to the Mpumalanga Biodiversity Conservation Plan Handbook (Ferrar & Lötter, 2007) the wetland value of the Donora site along the Nel's River region are classified as "Ecosystem Maintenance", indicating that the aquatic habitat in this area is not considered as very important (Figure 19). The terrestrial aspect (Figure 20) is classified as a matrix of "No natural habitat available" and "Least concern." For the reason that the reach is classified as "Least concern", the land uses associated with the hydro project are: Line structures – Restricted; Water projects – Restricted (Table 5).

Table 5: In these different colour-coded areas the following land-uses are recommended:

Class	**"No natural habitat remaining"**	**"Least concern"**	**"Important and Necessary"**	**"Highly significant"**
Colour code	White areas	Grey areas	Yellow areas	Orange areas
Line structures	Permitted	Restricted	Restricted	Restricted
Major development projects	Permitted	Restricted	Restricted	Not permitted
Dry land crops	Permitted	Permitted	Not permitted	Not permitted
Surface mining	Restricted	Permitted	Not permitted	Not permitted
Irrigated crops	Permitted	Permitted	Not permitted	Not permitted
Rural settlement	Permitted	Permitted	Restricted	Restricted
Underground mining	Permitted	Permitted	Restricted	Restricted
Conservation management	Permitted	Permitted	Permitted	Permitted
Water projects	Permitted	Restricted	Restricted	Restricted
Recreation development	Permitted	Permitted	Restricted	Restricted
Game farming	Permitted	Permitted	Permitted	Permitted
Animal farming	Permitted	Permitted	Not permitted	Not permitted
Livestock production	Permitted	Permitted	Permitted	Permitted
Timber production	Restricted	Restricted	Not permitted	Not permitted
Urban development	Permitted	Restricted	Not permitted	Not permitted

4.2.3 Present Ecological State (PES)

The PES of the river is expressed in terms of various components. That is, **drivers** (physico-chemical, geomorphology, hydrology) and **biological responses** (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the EcoStatus.

Table 6 summarizes the results from the excel sheet containing the PES model. The information is assembled from a number of known parameters, expert knowledge and other models (fish, macro-invertebrates and vegetation).

Table 6: The summary obtained from the PES model.

RIVER	**NEL'S RIVER**
Bed modification (0-5)	**0**
Flow modification (0-5)	**1.5**
Inundation (0-5)	**0.5**
	90%
Riparian/Bank condition (0-5)	**2.0**
Water quality modification (0-5)	**0.5**
DESKTOP HABITAT INTEGRITY	**85%**
Invertebrate Rating (0-5)	**0.5**
	90%
Fish rating (0-5)	**0.5**
INSTREAM EC%	**90%**
INSTREAM EC	**A/B**
Vegetation Rating (0-5)	**1.0**
	85%
ECOSTATUS %	**87.2%**
	B
ECOSTATUS EC	**B**
CONFIDENCE (1-5)	**4.0**

According to Table 6, the Desktop Habitat Integrity is 85%, the Instream Ecological Class a class B (90%) and the Overall Ecostatus is 87.2% (Ecological Class = B). According to Table 28, the Ecostatus class B is defined as: Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.

4.2.4 Ecological Importance and Sensitivity (EIS)

Ecological importance refers to the diversity, rarity or uniqueness of the habitats and biota. Consequently, it reflects the importance of protecting these ecological attributes, from a local, national and even international perspective. Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts. Therefore, the more sensitive the system is, the lower its tolerance will be to various forms of alteration and disturbance. This serves as a valuable indication of the degree to which a water resource (river, wetland) can be utilized without putting its ecological sustainability at risk.

The EIS/PES data is used in the eco-classification process of DWA (key process in the determination of the Reserve) to determine ecological sensitivity of a river reach as well as the present ecological state of such a river reach. From this an indication is provided whether the river reach is in a health category that is commensurate with its ecological importance and sensitivity. This relates to the determination of the eco-status of the river which refers to its overall condition or health and is based on its biophysical characteristics.

Table 7 summarizes the results from the excel sheet containing the PES/EIS model. The information is assembled from available information.

Table 7: The summary obtained from the PES/EIS model.

Main stem	Nel's River: Score and motivation.	Confidence
Aquatic/instream biota: rare and endangered	1 Chiloglanis bifurcus - Vulnerable	4
Riparian/wetland biota: rare and endangered	5 Southern African python (Python natalensis) – TOPS NEMBA: Protected species. Serval (Felis serval) - TOPS NEMBA: Protected species. Cape clawless otter (Aonyx capensis) - TOPS NEMBA: Protected species. Spotted-necked otter (Lutra maculicollis) - TOPS NEMBA: Protected species. African Finfoot (Podica senegalensis) - SA Red Data (Barnes 2000): Vulnerable. Half-collared Kingfisher (Alcedo semitorquata) - SA Red Data (Barnes 2000): Near-threatened. Orange Ground-Thrush (Zoothera gurneyi) - SA Red Data (Barnes 2000): Near-threatened.	4
Aquatic/instream biota: unique	3 Sensitive community	4
Riparian/wetland biota: unique	3 Valley forest Natal ghost frog (*Heleophryne natalensis*) - **SA endemic** Yellow-striped reed frog (*Hyperolius semidiscus*) - **SA endemic** Rattling frog (*Semnodactylus wealii*) - **SA endemic** Mountain caco (*Cacosternum nanum parvum*) - **SA endemic** Dusky-bellied water snake (*Lycodonomorphus laevissimus*) - **SA endemic** Western Natal green snake (*Philothamnus natalensis occidentalis*) - **SA endemic**	4
Aquatic/instream biota: intolerant no flow	3 (5 spp of rheophillics)	4
Aquatic/instream biota: intolerant physico-chemical changes	3 (2 *Chiloglanis, B. argenteus*)	3
Riparian/wetland biota: intolerant	2 (Matumi)	3
Aquatic/instream biota: species/ taxon richness	1 (Approx 7 fish sp.)	4
Riparian/wetland biota: species/ taxon richness	3 (6 riparian indicator species present)	4
Instream habitat: diversity of types and features	2 (Fast flowing habitat, not many slow flowing habitats: Islands, waterfalls, runs, riffles, rapids, etc. No backwaters and pools.)	4
Riparian/wetland habitat: diversity of types and features	2 (Riparian zone narrow on steep slope; mostly forested)	3
Instream habitat: refugia and critical	1 (Only deep channel with fast flow offers refuge)	3
Riparian/wetland habitat: refugia and critical	3 (Steep slopes towards river covered with dense riverine forest)	3
Instream habitat: sensitivity to flow changes	3.5 (Waterfall, cascades, riffles and rapids, overhang)	3
Riparian wetland habitat: sensitivity to flow changes	2 (Narrow macro-channel - inundation frequent, but not extensive due to slope)	3
Instream: migration route	1 (Falls a natural migration barrier)	3
Riparian: migration corridor	3 (Dense riparian forest an effective corridor)	4
Nat parks, wilderness areas, reserves, heritage sites, natural areas	1 (Conserved by farmer)	4

Table 8: The final EIS scores and overall EIS category.

Main stem	Nel's River
Median instream biota rating	3
Max instream biota rating median	3
Median rating: riparian/wetland biota	3

Max rating: riparian/wetland biota	5
Median rating: instream habitat	1.5
Max rating: instream habitat	3.5
Median rating: riparian/wetland habitat	2.5
Max rating: riparian/wetland habitat	3
Instream biota flow sensitivity	3
Instream biota physico-chemical sensitivity	3
Protected and natural areas	1
Biota EIS	3
Habitat EIS	2
Overall EIS rating	2.5
Overall EIS category	HIGH

According to the EIS model, the overall EIS rating is 2.5 and thus the overall EIS category is considered to be "HIGH". Thus, the Ecological importance of this river reach presents high integrity regarding diversity, rarity or uniqueness of the habitats and biota

4.3 Aquatic surveys

4.3.1 Aquatic habitat assessment

The river reach between the Donora weir and the southern boundary of the farm is bedrock dominated and consists of fast flowing habitats due to the steep slope of the area. Rapids are abundant and a large waterfall is situated on the farm. These habitats are connected with fast-flowing runs, and where the rocky bottom dominates, cascades are visible during high flows and probably riffles during lower flow.

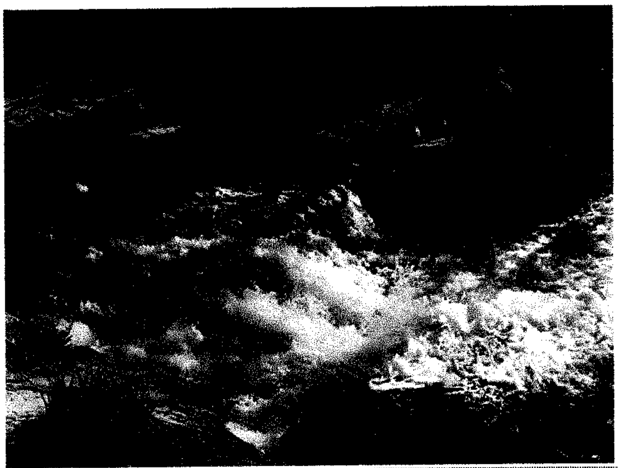


Figure 21: Rapids and cascades are abundant in this reach.

Figure 22: Due to the steep slope even the runs are fast-flowing.

During the survey the following parameters were measured - IHAS (Integrated Habitat Assessment System), HSI (Habitat Suitability Index) and HQI (Habitat Quality Index) with results summarized in Table 9.

Table 9: The habitat parameters as measured at the Donora site.

	IHAS	HSI	HQI
Upstream at weir	74%	33%	74%
Downstream at hydro outlet	77%	37%	83%

Although the IHAS and HQI were relatively high due to very good fast flowing rocky habitats, the much lower HSI (Table 10) indicated the fact that there were no slower-flowing habitats such as backwaters, pools of slower runs present in the reach, lowering the habitat availability.

Table 10: Habitat Suitability Index (HSI) scores of the different habitat types compared (maximum scores/biotope = 5).

SITE	SIC	SOOC	Bed-rock	Aquatic vegetation	MVIC	MVOOC	Gravel	Sand	Mud	Score	%
Upstream	3	0	4	3	2	0	1	2	0	15	33%
Downstream	4	1	4	3	2	0	1	2	0	17	37%

4.3.2 Aquatic invertebrate assessment

The macro-invertebrates were sampled according to SASS5 method at a site upstream at the weir, and at the hydro station release point. Table 11 summarizes the macro-invertebrates sampled and their SASS5 scores.

Table 11: SASS5 scores of the different habitat types in the Nel's River (complete table in Appendix 2).

TAXON	Upstream	Downstream
Potamonautidae 3		A
Perlidae 12	A	A
Baetidae 1 spp 4		
2 spp 6	B	
>2 spp 12		B
Heptageniidae 10		A
Oligoneuridae 15	B	A
Tricorythidae 9	B	B
Calopterydidae 10	A	A
Gomphidae 6	A	A
Libellulidae 4	A	A
Naucoridae 7		A
Pleidae 4	A	B
Veliidae 5	A	
Hydropsychidae 1= 4	B	B
Philopotamidae 10	B	
Leptoceridae 6	A	
Gyrinidae 5		A
Chironomidae 2	A	
Dixidae 13	A	
Simuliidae 5		A
SASS Score	**111**	**112**
No of families	**14**	**14**
ASPT	**7.9**	**8.0**

Estimated abundance: 1=1; A=2-10; B=11-100; C=101-1000; D=>1000

According to the Average Score per Taxon (ASPT) values (Table 11) the condition at the site are classified as "Excellent" (Table 13).

Table 12: IHAS, HIS, HQI and SASS scores at the relevant monitoring sites.

	IHAS %	**HSI %**	**HQI %**	**SASS SCORE**	**NO OF FAMILIES**	***ASPT***
Upstream at weir	74%	33%	74%	111	14	**7.9**
Downstream at hydro outlet	77%	37%	83%	112	14	**8.0**

The IHAS and HQI scores are high and reflect a "Good" class according to Table 13. The lower score for the HSI is due to the fact that there are very few slow habitats in this stretch of river, a natural phenomenon and not due to anthropological influences.

Table 13: Categories used to classify Habitat, SASS and ASPT values:

HABITAT	SASS4	ASPT	CONDITION
>100	>140	>7	Excellent
80-100	100-140	5-7	Good
60-80	60-100	3-5	Fair
40-60	30-60	2-3	Poor
<40	<30	<2	Very poor

4.3.3 Fish Response Assessment Index (FRAI)

The purpose of the Fish Response Assessment Index (FRAI) is to provide a habitat-based cause-and-effect interpretation underpinning the deviation of the fish assemblage from the reference condition.

The application of the FRAI is based on the following:

- The FRAI is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or rivers.

- These intolerance and preference attributes are categorized into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species.

- Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements. Usually the FRAI is based on a combination of fish sample data and fish habitat data.

- Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation.

Table 14 explains the 8 steps followed in the calculation of the FRAI.

Table 14: Main steps and procedures in the calculation of the FRAI

STEP	PROCEDURE
River section earmarked for assessment	As for study requirements and design
Determine reference fish assemblage: species and frequency of occurrence	Use historical data & expert knowledge Model: use eco-regional and other environmental information Use expert fish reference frequency of occurrence database if available
Determine present state for drivers	Hydrology Physico-chemical Geomorphology or Index of habitat integrity
Select representative sampling sites	Field survey in combination with other survey activities
Determine fish habitat condition at site	Assess fish habitat potential Assess fish habitat condition
Representative fish sampling at site or in river section	Sample all velocity depth classes per site if feasible Sample at least three stream sections per site
Collate and analyze fish sampling data per site	Transform fish sampling data to frequency of occurrence ratings
Execute FRAI model	Rate the FRAI metrics in each metric group Enter species reference frequency of occurrence data Enter species observed frequency of occurrence data Determine weights for the metric groups Obtain FRAI value and category Present both modelled FRAI & adjusted FRAI.

4.3.3.1 Study of the river section earmarked for assessment

The section of river between the Donora weir and proposed hydro station outlet is dominated by bedrock and the slope is steep, therefore the flow is mostly fast. This reach consists of waterfalls, cascades, rapids and riffles, all linked by fast runs. There are no areas of slower flows to create backwaters and pools, and even the overhang is located in faster flows. The bottom is very rocky, dominated by bedrock and larger boulders, no mud and some sand on the edges. The water is usually clear but becomes turbid during high flows.
The riparian zone is mostly dense with abundant larger trees that overhang the river, and marginal shrubs and forbs in the under-storey (see also Section 2.2 of this report).

4.3.3.2 Determine reference fish assemblage: species and frequency of occurrence

<u>Frequency of Occurrence (FROC)</u>

The fish reference Frequency of Occurrence (FROC) database (Kleynhans, Louw, & Moolman, 2007), which provides consistent reference frequency of occurrence for more than 700 fish sites in South Africa, was used to establish the baseline data for this report. The FROC was developed to be used in the following programmes:

- the FRAI
- procedures that requires a reference fish assemblage (e.g. extrapolation from known sites to unknown sites)

Fish is considered to be one of the important indicators of river health and their responses to modified environmental conditions are measured in terms of the Fish Response Assessment Index (FRAI) (Kleynhans 1999; Kleynhans *et al.* 2005). This index is based on a combination of fish species habitat preferences as well as intolerance to habitat changes, and the present frequency of occurrence of species compared to the reference frequency of occurrence (Kleynhans, Louw, & Moolman, 2007).

The list of species is based on species that are known to be present or to have been present under close to reference habitat conditions. Species that are derived to have been present under relatively recent reference habitat conditions are also identified. The resulting species reference list is a combination of both of the above approaches.

The rating of the FROC refers to the reference fish frequency of occurrence (FROC) in a particular ecologically defined reach of a river. Ratings are scored from 1 to 5.

Rating of the reference fish FROC refers to the reference fish frequency of occurrence in a particular ecologically defined reach of a river. This means that FROC ratings are derived based on conditions at the particular site as well as the available habitat in the reach for species expected under reference conditions.

Basic habitat conditions that were considered in terms of the FROC of species are based on intolerance and preference rating as contained in the FRAI (Kleynhans *et al.* 2005). The presence and abundance of habitat features such as velocity-depth classes, cover types (including substrate) and the characteristics of the natural flow regime (especially the degree of perenniality) in a river reach under reference conditions formed the basis for the expert judgment of the FROC (Kleynhans, Louw, & Moolman, 2007).

Figure 23: The Donora site according to the FROC map.

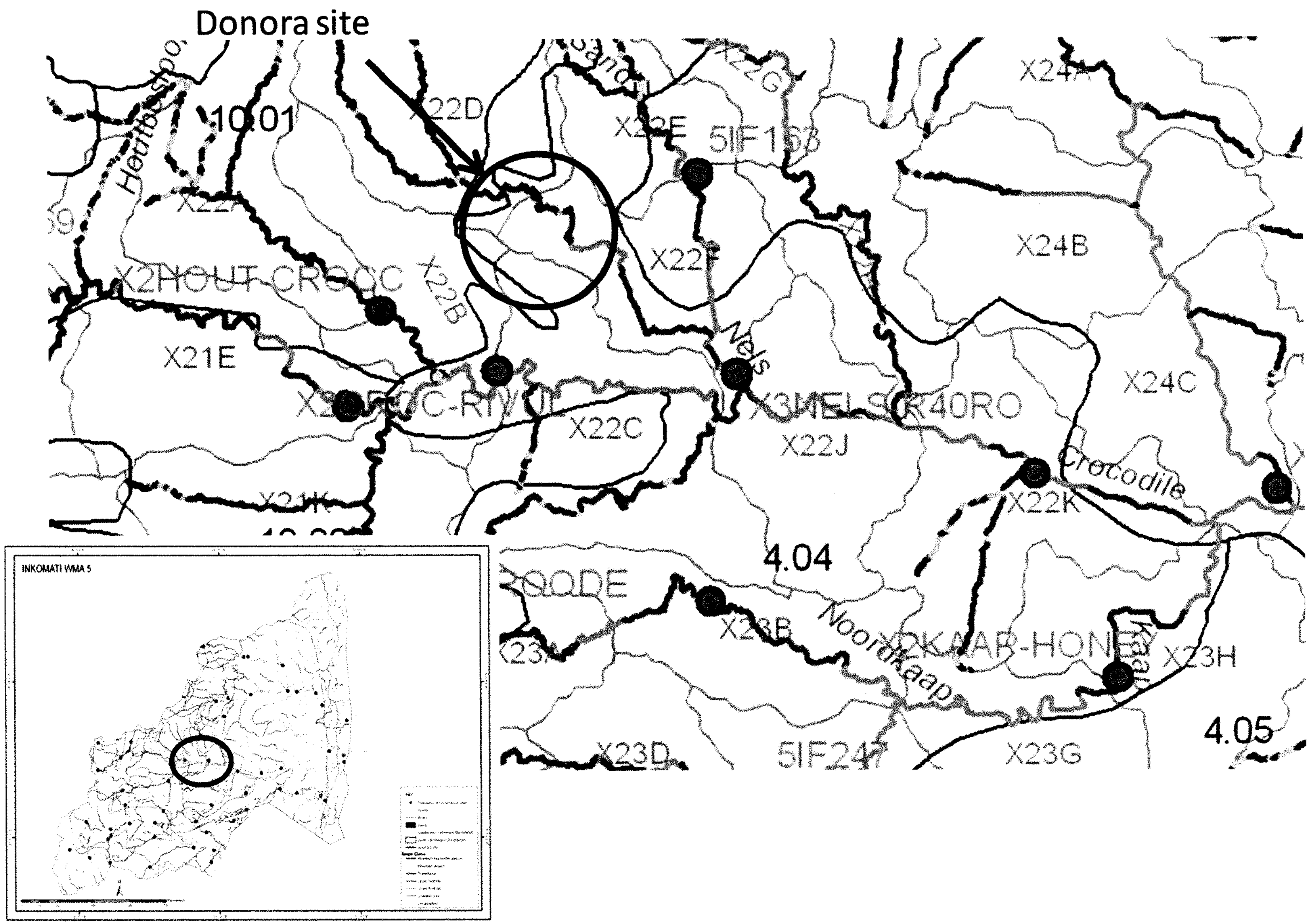


Table 15: The FROC list (and the description of the column headings) for the Nel's River at the Nel's Site (X2CROC-DNELS) downstream of the proposed hydro development (Figure 23). The freshwater fish species scientific name, abbreviation and common name are summarized in Appendix 3:

FROC SITE CODE	X2CROC-DNELS (5IF208, 5IF211)		
LATITUDE	-25.5020		
LONGITUDE	31.1834		
WMA	Inkomati		
QUAT	X22K		
MAJOR RIVERS	Crocodile (east)		
ECOREGION	4.04		
GEOMORPH ZONE	E		
ALTITUDE	489		
FISH SPP	**FROC**	**CONFIDENCE**	**RELATIVE ABUNDANCE**
AURA	4	3	1
BANO	3	3	1
BMAR	5	4	2
CBIF	3	3	1
CGAR	3	3	1
CPRE	5	5	3
PPHI	3	3	2

Table 16: Description of column headings in Table 15 above:

FIELD NAME (COLUMN TITLE IN SPREADSHEET)	DESCRIPTION
XSPP	Species suspected to be present under reference conditions.
FROC	Fish frequency of occurrence rating: 1=Present at very few sites (<10% of sites) 2=Present at few sites (>10-25%) 3=Present at about >25-50 % of sites 4=Present at most sites (>50- 75%) 5=Present at almost all sites (>75%)
CONFIDENCE	The confidence in the frequency of occurrence rating: 1=Low confidence 2=Low to moderate 3=Moderate 4=Moderate to high 5=High
RELATIVE ABUNDANCE	It is assumed that assessment is done during a year when a suitable base flow is present. Rating: 1=1-5 individuals 2=6-50 individuals 3 >50 individuals Or 1=Rare 2=Moderate 3=Abundant Due to the high variability in natural abundance of fish, his rating was only applied where an assessor had high confidence in the rating. The rating is not used in the FRAI and is considered as supplementary information.
COMMENT	Any comment that the assessor felt was relevant and important.

The list of species is based on species that are known to be present or to have been present under close to reference habitat conditions. This would include information from historical sites within a particular river reach.

4.3.3.3 Determine present state for drivers

The purpose is to provide information on the fish response and associated habitat condition and *vice versa* (i.e. fish responses that are possible, given certain habitat conditions). This assessment considers the whole river section to be studied. If information on the drivers is available, these should be used.

The water of the Middle Crocodile River (incorporating the Nels's River) is of reasonably good quality. The water varies from slightly acidic to alkaline and the low conductivity values show that the water is very slightly mineralized. Water quality in the Nel's River shows some deterioration during the winter months. Where very little water is available during the dry winter months, there is a corresponding decrease in residual assimilative capacity (DWAF 1995).

4.3.3.4 Sampling site selection

A survey of the site in the Nel's River was done to establish if there could be any effects on the riverine environment due to the proposed development, and to obtain some baseline information should future monitoring be required.

A site upstream of the site was surveyed for fish presence, while the surroundings were classified according to its potential habitat biotopes as prescribed by the FRAI methodology.

Fish were monitored per habitat type and an attempt was made to establish discrepancies in population distributions, especially linked to the habitats present.

4.3.3.5 Fish habitat assessment at site

Habitat potential assessment

Habitat assessment refers to an evaluation of fish habitat potential (i.e., the potential that the habitat provides suitable conditions for a fish species to live there) at a site in terms of the diversity of velocity-depth classes present and the presence of various cover types at each of these velocity-depth classes. This provides a framework within which the presence, absence and frequency of occurrence of species can be interpreted. Habitat assessment includes a general consideration of impacts that may influence the condition or integrity of fish habitat at a site (Kleynhans, Louw, & Moolman, 2007).

Upstream and downstream sites were surveyed for fish, and although the river was flowing high during the time of sampling, shallow areas supplied a good indication of the fish present. The aquatic and instream environments consist mainly of two habitat assemblages which contain the following:

- Upstream bedrock-dominated section
    - Fast flowing river above the waterfall, side channel with sandy bottom and some overhanging vegetation.
    - Some riffles and rapids below the weir with abundant bedrock.
- Downstream bedrock-dominated section
    - A side channel with rocky and sandy areas, some marginal vegetation and root wads.
    - Riffles over cobble and rapids over boulders and stones.

Table 17: Fish velocity-depth classes and cover present in the Nel's River (project area).

FISH VELOCITY-DEPTH CLASSES AND COVER PRESENT AT SITE (Abundance: 0=absent; 1=rare; 2=sparse; 3=moderate; 4=abundant; 5=very abundant)			
SLOW DEEP: 0	SLOW SHALLOW: 1	FAST DEEP: 5	FAST SHALLOW: 3
Overhanging vegetation: 0	Overhanging vegetation: 2	Overhanging vegetation: 3	Overhanging vegetation: 3
Undercut banks & root wads: 0	Undercut banks & root wads: 1	Undercut banks & root wads: 2	Undercut banks & root wads: 2
Substrate: 0	Substrate: 1	Substrate: 3	Substrate: 3
Aquatic macrophytes: 0	Aquatic macrophytes: 0	Aquatic macrophytes: 0	Aquatic macrophytes: 0
Water Column: 0	Water Column: 1	Water Column: 4	Water Column: 4
Remarks: No slow deep habitats due to slope of reach	Remarks: Little slow shallow habitats due to slope of reach	Remarks: Dominating habitat in river	Remarks: Mostly in side channels and on edges of river.

Habitat Condition

The purpose is to provide an indication of the deviation of the habitat from the reference condition. In contrast to the assessment of driver conditions or the IHI in a river section, fish habitat condition assessment is done for the site and modifications that have a direct influence on fish habitat at the site are considered.

Fish sampling

Sampling effort and results are reported per velocity-depth class sampled.

- **Fast-deep:** An electrical shocking apparatus, one operator and two dip net handlers are used in such habitat types. Capture results are recorded as number of fish caught per time unit (minutes).
- **Fast-shallow:** Capture results are recorded as number of fish caught per time unit (minutes) with an electrical shocker.
- **Slow-deep:** A large seine net can be used. A cast net, (diameter = 1.85 m, mesh size = 2.5 cm) can be used in pools. In this case, the river was flowing too fast for the use of the large seine method; however the cast net was used.
- **Slow-shallow:** A small seine net (5 m long, 1.5 m deep, mesh size = 1 mm) can be used to sample fish. An electrical shocking apparatus should preferably be used. Capture results are recorded as number of fish caught during each effort with a net, or the number of fish caught per time unit (minutes) with an electro-shocker. Both the electrical shocking apparatus and small seine net were used in this case.

Table 18: Habitats sampled and the sampling effort made during survey

SPECIES SAMPLED	SLOW DEEP	SLOW SHALLOW	FAST DEEP	FAST SHALLOW
AURA				5
BANO				2
BMAR			1	3
BARG				1
CPRE			2	3
PPHI				5

Table 19: Fish sampled during the survey (habitats). The freshwater fish species scientific name, abbreviation and common name are summarized in Appendix 3.

HABITATS SAMPLED AND EFFORT

SAMPLING EFFORT	SLOW DEEP	SLOW SHALLOW	FAST DEEP	FAST SHALLOW
Electro shocker (min)			20 minutes	35 minutes
Small seine (mesh size, length, depth, efforts)				
Large seine (mesh size, length, depth, efforts)				
Cast net (dimensions, efforts)			10 casts	10 casts
Gill nets (mesh size, length, time)				

Table 20: A comparison between the reference frequency of occurrence and the present frequency of occurrence.

ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	REFERENCE FREQUENCY OF OCCURRENCE CATEGORY A	FREQUENCY OF OCCURRENCE: EC
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	4	4
BANO	BARBUS ANOPLUS WEBER, 1897	3	3
BMAR	LABEOBARBUS MAREQUENSIS SMITH, 1841	5	5
CBIF	CHILOGLANIS BIFURCUS JUBB & LE ROUX, 1969	3	1
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	3	3
CPRE	CHILOGLANIS PRETORIAE VAN DER HORST, 1931	5	5
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	3	3

During the EWR sampling, the only fish caught at the EWR site E5Nels (-25.28945; 30.76464) was *Chiloglanis pretoriae* (72 individuals), *Barbus argenteus* (72 individuals) and *Amphilius uranoscopus* (3 individuals).

Collate and analyze fish sampling data per site

All the information collected during the survey are then collated in the tables of the FRAI model and analyzed throughout the database spreadsheets. The FRAI model calculates the ranks, weights and ratings to eventually provide an Ecological Class for the Nel's River site.

According to Table 19, six species of fish was sampled at the Donora site. Since only a few biotopes in the study area was available for sampling due to high flows and habitat constraints (deep runs over bedrock habitats, waterfalls), these sampled fish will serve as a indication of the potential the site has for the species assemblages present.

The presence of two very sensitive fish species, *Amphilius uranoscopus* and *Barbus argenteus* (not expected by the FROC), is an indication of the following: good water quality, favourable fast flows, and good overhanging vegetation habitats. On these grounds the fish list in Table 20 was completed, assisted by additional habitat data (Table 19).

EXECUTE THE FRAI MODEL

The FRAI model makes use of the fish intolerance and preference database that was compiled in 2001 (Kleynhans 2003). This information was built into the FRAI. The approach followed included the ranking, weighting and rating of metric groups. A large component of the FRAI is based on an automated calculation of ranks, weights and ratings.

Table 21 indicates the weights of the different metric groups. According to this, the flow modification metric group carries the most weight followed by the velocity-depth and cover metric groups. The first two have a strong link with flow, and this also have an influence on the physico-chemical metric. No introduced species are present.

Table 21: The weight allocated to the different metric groups in the model.

WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	100.00
COVER	83.58
FLOW MODIFICATION	95.52
PHYSICO-CHEMICAL	100.00
MIGRATION	52.24
IMPACT OF INTRODUCED	7.46

Table 22: The final score as calculated by the FRAI model.

PES/REC %	82.2
PES/REC CATEGORY	B

The relative FRAI score of this stretch of the river falls within the limits of an ecological state category Class B (82.2%), which means this reach is "largely natural with few modifications" (Table 22). The Class ratings are explained in Table 26.

Table 23: Ratings for the fish integrity classes

	FRAI ASSESSMENT CLASSES	
Class rating	Description of generally expected conditions for integrity classes	Relative FRAI score (% of expected)
A	Unmodified, or approximate natural conditions closely	90 to 100
B	Largely natural with few modifications. A change in community characteristics may have taken place but	80 to 89

	species richness and presence of intolerant species indicate little modification.	
C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at lower limits of this class.	60 to 79
D	Largely modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderate intolerant species. Impairment of health may become more evident at the lower limit of this class.	40 to 59
E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become very evident.	20 to 39
F	Critically modified. An extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a loss of species at the lower limit of the class. Impairment of health generally very evident.	0 to 19

4.4 Riparian habitat surveys

Riparian vegetation is described in the Water Act (Act No 36 of 1998) as follows:"Riparian habitat" includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

4.4.1 VEGRAI model

VEGRAI has a spreadsheet model component that is composed of a series of metrics and metric groups each of which is rated in the field with the guidance of data collection sheets (referred to as field forms).

The metrics in VEGRAI first describe the status of riparian vegetation in both its current and reference states and second, compare differences between the two states as a measure of vegetation response to an impact regime.

The riparian vegetation zones (Marginal, Lower and Upper) are used as the metric groups. For the simplified Level 3 version, the Lower and Upper zones were combined to form the Non-Marginal metric group (zone).

A range of metrics for each metric group is selected of which some are essential for both Levels 3 and 4 (Abundance and Cover) and the others are optional (Species Composition, Population Structure and Recruitment). The metrics are then rated and weighted and an Ecological Category (A-F) determined which represents the Ecological Category for the riparian vegetation state.

4.4.2 Impact evaluation on riparian zone and interpretation

The purpose is to evaluate and interpret the observed impacts at a site in terms of its relative influence on the riparian vegetation according to vegetation removal, alien vegetation invasion, water quantity and quality. The approach followed is that each of these four broad causes of modification relates to and is associated with particular human-related activities that would change the riparian vegetation characteristics directly or indirectly. Some of these changes may occur rapidly while others will occur gradually and only become evident through time.

This approach relates to the National Water Act which aims to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. The protection of water resource quality is essential to achieve this:

``Resource quality" means the quality of all the aspects of a water resource including,

- the quantity, pattern, timing, water level and assurance of instream flow;
- the water quality, including the physical, chemical and biological characteristics of the water;
- the character and condition of the instream and riparian habitat; and
- the characteristics, condition and distribution of the aquatic biota
- considering the functions of the riparian vegetation, these have been summarized as:

  - Sediment trapping,
  - Nutrient trapping
  - Bank stabilization and bank maintenance,
  - Contributes to water storage,
  - Aquifer recharge,
  - Flow energy dissipation,
  - Maintenance of biotic diversity,
  - Primary production.

Most of these functions relate to instream habitat conditions and it follows the basic consideration when assessing the condition of the riparian vegetation, and thus impacts should be interpreted in terms of the influence on the instream habitat.

The riparian marginal zone consists of shrubs and forbs, sometimes very dense; some reeds in level areas and abundant root wads of riparian trees. Some of these riparian trees are in the marginal zone and overhang the river. The riparian non-marginal zone consists of larger trees and marginal shrubs and forbs in the under-storey.

Table 24: A comparative description related to reference and present state of the proposed bridge project site.

Zones	Impacts	Response Metrics	Description of PRESENT STATE	Description of REFERENCE STATE
Marginal	Vegetation Removal Exotic Vegetation Water Quantity Water Quality	Cover Abundance Species Composition	This reach is bedrock-dominated and the marginal zone have scattered woody species between the rocks. Alluvial sandy areas are covered with shrubs, forbs and reeds, especially on islands in the upstream area. Selective removal of species for local use influences the abundance and species composition of this assemblage.	This reach is bedrock-dominated and the marginal zone have scattered woody species between the rocks. Alluvial sandy areas are covered with shrubs, forbs and reeds, especially on islands in the upstream area.
Non-marginal	Vegetation Removal Exotic Vegetation Water Quantity Water Quality	Cover Abundance Species Composition	True non-marginal riparian zone only occur on the upper shelf of the macro-channel since floods scour the marginal bedrock area and thus the only large trees occur in the upper zone. The strip of non-marginal riparian woody vegetation has partially been removed to make place for agriculture further away from the river.	True non-marginal riparian zone only occur on the upper shelf of the macro-channel since floods scour the marginal bedrock area and thus the only large trees occur in the upper zone. The strip of non-marginal riparian woody vegetation is gradually replaced by terrestrial components further away from the river.

TABLE 25: EVALUATION OF THE MARGINAL ZONE INTEGRITY (VEGRAI MODEL).

	MODIFICATION RATINGS			
CAUSES OF MODIFICATION	**INTENSITY**	**EXTENT**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**
REMOVAL	1.0	1.5	4.0	Some marginal vegetation was removed when the Donora recreation facilities were built.
EXOTIC INVASION	1.0		4.0	Few species including Lantana, mulberry and jacaranda.
WATER QUANTITY	1.5	1.5	4.0	Relatively high up in catchment, fewer impacts.
WATER QUALITY	0.5	0.5	4.0	Good; relatively high up in catchment, fewer impacts.
AVERAGE			4.0	

		RESPONSE METRIC RATINGS			
VEGETATION COMPONENTS	**RESPONSE METRIC**	**CONSIDER? (Y/N)**	**RATING**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**
WOODY	COVER	Y	1.0	4.0	Some marginal trees were removed when the Donora recreation facilities were built.
	ABUNDANCE	Y	0.5	4.0	Still very dense and natural apart from recreation area.
	SPECIES COMPOSITION	Y	0.0	4.0	No impact
			0.5	4.0	
NON-WOODY	COVER	Y	1.0	4.0	Some marginal forbs and shrubs were removed when the Donora recreation facilities were built.
	ABUNDANCE	Y	0.0	4.0	Still very dense and natural apart from recreation area.
	SPECIES COMPOSITION	Y	0.0	4.0	No impact
			0.3	2.7	

VEGETATION COMPONENTS	**CONSIDER? (Y/N)**	**RANK**	**WEIGHT**	**RATING**	**WEIGHTED RATING**	**MEAN CONFIDENCE**	**NOTES: (give reasons for each assessment)**

WOODY	Y	1.0	100.0	0.5	0.50	4.0	Slow-growing and long living
NON-WOODY	Y	2.0	80.0	0.3	0.27	2.7	Recover rapidly
					0.77	3.3	

CHANGE (%) IN MARGINAL ZONE CONDITION	**8.5%**

TABLE 26: EVALUATION OF THE NON-MARGINAL ZONE INTEGRITY (VEGRAI MODEL).

	MODIFICATION RATINGS			
CAUSES OF MODIFICATION	**INTENSITY**	**EXTENT**	**CONFIDENCE**	**NOTES: (give reasons for each assessment)**
REMOVAL	1.0	0.5	4.0	Some marginal vegetation was removed when the Donora recreation facilities were built.
EXOTIC INVASION	0.5		4.0	Few species including Lantana, mulberry and jacaranda.
WATER QUANTITY	0.5	0.5	4.0	Relatively high up in catchment, fewer impacts. Non-marginal zone narrow, thus close to river.
WATER QUALITY	0.0	0.0	4.0	No impact
AVERAGE			4.0	

		RESPONSE METRIC RATINGS			
VEGETATION COMPONENTS	RESPONSE METRIC	CONSIDER? (Y/N)	RATING	CONFIDENCE	NOTES: (give reasons for each assessment)
WOODY	COVER	Y	1.0	4.0	Some marginal trees were removed when the Donora recreation facilities were built.
	ABUNDANCE	Y	0.5	4.0	Still very dense and natural apart from recreation area.
	SPECIES COMPOSITION	Y	0.0	4.0	No impact
			0.5	4.0	
NON-WOODY	COVER	Y	1.0	4.0	Some marginal forbs and shrubs were removed when the Donora recreation facilities were built.
	ABUNDANCE	Y	0.5	4.0	Still very dense and natural apart from recreation area.
	SPECIES COMPOSITION	Y	0.0	4.0	No impact
			0.5	2.7	

VEGETATION COMPONENTS	CONSIDER? (Y/N)		WEIGHT	RATING	WEIGHTED RATING	MEAN CONFIDENCE	NOTES: (give reasons for each assessment)
WOODY	Y	1.0	100.0	0.5	0.50	4.0	Slow-growing and long living
NON-WOODY	Y	2.0	75.0	0.5	0.38	2.7	Recover rapidly
					0.88	3.3	

CHANGE (%) IN MARGINAL ZONE CONDITION	10.0%

TABLE 27: THE VEGETATION INTEGRITY EVALUATION OF THE PROPOSED BRIDGE CONSTRUCTION SITE (VEGRAI MODEL).

LEVEL 3 ASSESSMENT						
METRIC GROUP	**CALCULATED RATING**	**WEIGHTED RATING**	**CONFIDENCE**	**RANK**	**% WEIGHT**	**NOTES: (give reasons for each assessment)**
MARGINAL	91.5	48.1	3.3	1.0	100.0	Shading river and good corridor.
NON MARGINAL	90.0	42.6	3.3	2.0	90.0	Narrow but close to river.
	2.0				190.0	
LEVEL 3 VEGRAI (%)				90.8		
VEGRAI EC				A		
AVERAGE CONFIDENCE				3.3		

Finally, mainly due to the fact that only a small portion of non-marginal riparian vegetation was removed for the recreation facilities, the change in the non-marginal zone condition is only 8.5% (Table 25), and due to the same cause, the marginal zone change is only 10.0% (Table 26). The final riparian vegetation integrity described by the Ecological Class of this reach, resulted in a Class A (90.8%) which reflects a "High" vegetation integrity (Table 27).

Table 28: Generic ecological categories for EcoStatus components (modified from Kleynhans 1996 & Kleynhans 1999).

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

4.5 Ecological Category (EC)

EcoStatus Definition: "totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services". This ability relates directly to the capacity of the system to provide a variety of goods and services.

The driver components are assessed separately (i.e. an EC for each driver) and not integrated at a driver level to provide a driver-based indication of the EcoStatus. However, the individual metrics of all the driver components are assessed in a combined fashion that allows some comparison between metrics of all drivers. This facilitates deriving the cause-and-effect relationship that is required in the interpretation and assessment of particular biological responses.

The biological responses are assessed separately, but the resulting fish and macro-invertebrate ECs are integrated to provide an indication of the instream EC (Table 31 & 32). Logically, the integration of the riparian vegetation EC and the instream EC would provide the EcoStatus. The influence of the riparian vegetation on the instream habitat is used to interpret the biological responses and endpoints. This means that in some cases, the integrated instream biological responses are deemed to provide a reasonable indication of the EcoStatus.

Table 29: The Ecostatus and Ecoclassification of the river at the Donora site.

INSTREAM BIOTA	**Importance Score**	**Weight**	**EC %**	**EC**
FISH				
1.What is the natural diversity of **fish** species with different flow requirements	4.5	95		
2.What is the natural diversity of **fish** species with a preference for different cover types	3	75		
3.What is the natural diversity of **fish** species with a preference for different flow depth classes	3	90		
4. What is the natural diversity of **fish** species with various tolerances to modified water quality	5	100		
FISH ECOLOGICAL CATEGORY	15.5	360	**85.0**	**B**
AQUATIC INVERTEBRATES				
1. What is the natural diversity of **invertebrate** biotopes	3.5	80		
2. What is the natural diversity of **invertebrate** taxa with different velocity requirements	3.5	90		
3. What is the natural diversity of **invertebrate** taxa with different tolerances to modified water quality	5	100		
AQUATIC INVERTEBRATE ECOLOGICAL CATEGORY	**12**	270	**90.0**	**A/B**
INSTREAM ECOLOGICAL CATEGORY (No confidence)		630	**87.9**	**A/B**

INSTREAM ECOLOGICAL CATEGORY WITH CONFIDENCE	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for **fish** information	4.5	0.50	42.50
Confidence rating for **macro-invertebrate** information	4.5	0.50	45.00

	9	1.00	87.50
INSTREAM ECOLOGICAL CATEOGORY	**EC**		**A/B**

RIPARIAN VEGETATION	**EC %**	**EC**
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**90.8**	**A**

ECOSTATUS	**Confidence rating**	**Proportions**	**Modified weights**
Confidence rating for instream biological information	4.5	0.53	46.32
Confidence rating for riparian vegetation zone information	4	0.47	42.73
	8.5	1.00	89.05
ECOSTATUS	**EC**		**A/B**

In the case of the Donora site (Table 29), the instream ecological category (EC) is A/B (89.0%), indicating the high level of aquatic integrity. Due to the equally high riparian EC (C A=90.8%), the overall EC for the reach is a reach a high A/B (89.0%).

Therefore, even though the conservation value does not come out as high (Section 4.2.2), the Nel's River is a very important river with a high integrity, and the intact riverine vegetation plays a definite role in habitat corridors for migrating animal species. These corridors act as migration routes for fauna along the river, connecting the Drakensberg Escarpment with the Lowveld, as well as radiating from the river into the terrestrial areas, especially along drainage lines with intact vegetation.

Table 30: Generic ecological categories for EcoStatus.

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions are extensive.	20-39
F	Critical/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

4.6. Weir and abstraction – riverine (aquatic & riparian)

Raising of Donora weir

The Donora Weir will be raised 500mm where applicable, thus increasing the height of a potential migration barrier for fish. The reason why it is flagged as a potential barrier, is the fact that it is upstream of a series of major natural fish barriers, the Donora water fall (Figure 6) and a large cascade (Figure 21 & 32). These natural instream structures are considerably higher than the 1.5 m weir, while the weir will have a number of places where bedrock are incorporated in the structure, thus creating potential cross-over points (Figure 28 & 29).

The fact that all but 2 expected fish species were found upstream of the Donora water fall, indicate that there is a population of these fish upstream. However, the chances are remote that these fish scaled the falls, and must be relicts of original distribution. Despite this fact, it is recommended that the small weir will be made fish migration friendly and basic but effective fishways be established at the weir.

The water that will be channelled away will reduce the flow in the area between the weir and the hydro station outlet. This issue is discussed under 5.2.1.

Figure 24: The Donora weir and downstream area.