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Water Affairs
REPUBLIC OF SOUTH AFRICA

**REPORT NO.:P 02/B810/00/0608/02: Annexure A**

# GROOT LETABA RIVER WATER DEVELOPMENT PROJECT (GLeWaP)

# Environmental Impact Assessment

# (DEA Ref No 12/12/20/978)

ANNEXURE A: WATER QUALITY SPECIALIST REPORT

**MARCH 2010**


*Compiled by: ILISO Consulting (Pty) Ltd*

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## DECLARATION OF CONSULTANTS' INDEPENDENCE

Dr Martin van Veelen, who conducted the water quality specialist study, is an employee of ILISO Consulting (Pty) Ltd who are independent consultants appointed by the Department of Water Affairs and Forestry. He has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialist who performed the work.

# REPORT DETAILS PAGE

| | |
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***Environmental Assessment Practitioner***
*Approved for ILiSO Consulting (Pty) Ltd by:*

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*Project Director*

# EXECUTIVE SUMMARY

*On 1 June 2006 the Department of Water Affairs and Forestry (DWAF), Directorate: National Water Resource Planning commissioned the study titled the* ***Groot Letaba River Water Development Project (GLeWaP)****. The DWAF appointed ILISO Consulting (Pty) Ltd as the lead Professional Environmental Service Provider with specialist sub-consultants. The study area covers the B8 catchment. The urgent need for the study was identified by DWAF's Internal Strategic Perspective for the Luvuvhu/ Letaba Water Management Area completed in December 2004. The study estimates, at a cursory level, a significant shortfall in water supply which can be attributed to the substantial growth in water usage, as well as the impact on the catchment over the years.*

*This report examines the water quality situation in the study area. However, it is not intended to provide a detailed analysis of the water quality problems and their causes, but rather to provide a broad overview of the water quality situation and the possible need for an additional water system. The water quality data provided by DWAF from 72 of their stations was systematically analysed to determine which of the data sets were complete enough to base an interpretation on. A total of 5 stations situated around the study area were selected.*

*The water quality is assessed in terms of electrical conductivity, ammonium, orthophosphate, chloride, sulphate, nitrate/nitrite and pH. Water quality data was assessed according to a fitness for use range (water quality criteria), which was based on the Department of Water Affairs and Forestry water quality guidelines.*

*A non-parametric statistic analysis was used to calculate the variability in water quality data from the river flow stations and the boreholes. With non-parametric statistics the interquartile range, which lies between the 25th and the 75th percentile, is generally used to describe the central tendency or average conditions. For the purposes of this study the 95th percentile was included as it provides an indication of variability and can be used to assess the frequency of excursions into higher and possibly unacceptable water quality conditions.*

*On the whole the surface water quality is still good and fit for all uses. Of concern, however, are the consistently high concentrations of chloride, nitrate/nitrite and electrical conductivity in the boreholes from which water is supplied to some of the communities.*

*The water quality situation in the catchment of the proposed new dam is such that no water quality problems are expected to occur. The dam will be able to provide water of an acceptable quality to a community that is at present reliant on water from boreholes of which some of the water is not fit for human consumption. The requirements in terms of the Reserve for water quality can be met.*

*The only possible effect, in terms of water quality, is the release of cold and anaerobic bottom water during periods when the dam becomes stratified. This can effectively be mitigated by the installation and correct operation of multiple level outlets.*

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

*There is some risk of contamination by herbicides and pesticides during the filling of the dam, as well as anoxic conditions due to the decomposing of organic material. This can effectively be mitigated by clearing the dam basin and preventing the use of herbicides and pesticides once the construction of the dam starts.*

*In terms of water quality there is therefore no significant effect on the environment from either the construction of the proposed new dam, or the raising of the Tzaneen Dam wall.*

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# ABBREVIATIONS

| | |
|---|---|
| Cl | Chloride |
| DWAF | Department of Water Affairs and Forestry |
| DEAT | Department of Environmental Affairs and Tourism |
| EMP | Environmental Management Plan |
| EIA | Environmental Impact Assessment |
| EMP's | Environmental Management Plans |
| EIR | Environmental Impact Report |
| EMS | Environmental Management System |
| EC | Electrical Conductivity |
| GLeWaP | Groot Letaba River Water Development Project |
| GLEMPF | Groot Letaba Environmental Management Plan Framework |
| MAR | Mean Annual Runoff |
| NEMA | National Environmental Management Act |
| $NH_4$ | Ammonia |
| $N0_2 + N0_3$ | Nitrite and Nitrate |
| PSP | Professional Service Provider |
| $PO_4$ | Phosphate |
| $SO_4$ | Sulphate |

# 1. STUDY INTRODUCTION

## 1.1 BACKGROUND TO PROJECT

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

Dr Martin van Veelen of ILISO Consulting undertook the Water Quality specialist report as part of the EIA.

## 1.2 BACKGROUND

The National Water Act, 1998 (Act 36 of 1998) (NWA) prescribes that all catchments where there are licensed and/or registered water users are to comply with all of the following conditions:

- The absence of "water stress", i.e. where the demand exceeds the supply, or where water quality is a problem;
- the need to achieve equity in water allocation;
- the need to promote beneficial water use;
- the need to facilitate efficient water management; and
- The need to protect water resource quality.

The Groot Letaba Catchment unfortunately has not been able to comply with all of these requirements due to the increasing severity in water shortages. This has resulted in the main consumptive users (domestic, irrigation, industrial, and forestry) competing for this vital resource during winter months (the low flow period), and resorting to expensive alternative measures for survival.

## 1.3 PURPOSE OF THE REPORT

This report provides an assessment of the water quality within the Groot Letaba Catchment in terms of electrical conductivity (EC), ammonium ($NH_4$), pH, nitrite and nitrate ($N0_2$ / $N0_3$), sulphate, phosphorous ($P0_4$) and chloride (Cl). The purpose of the water quality investigation is to determine the current water quality situation and the trend, and then to determine how this could be affected by the planned project. Should there be any detrimental effects, mitigation measures are suggested.

## 1.4 STRUCTURE OF THIS REPORT

This specialist study has been undertaken in compliance with regulation 33(2) of GN 385. The report would thus be structured accordingly **(Table 1.1).**

**Table 1.1: Report Structure**

| Regulatory Requirements | Section of Report |
|---|---|
| (a) The person who prepared the report; and the expertise of that person to carry out the specialist study or specialised process. | Chapter 2 |
| (b) a declaration that the person is independent | Page i |
| (c) an indication of the scope of, and the purpose for which, the report was prepared | Chapter 3 |
| (d) a description of the methodology adopted in preparing the report or carrying out the specialised process | Chapter 4 |
| (e) a description of any assumptions made and any uncertainties or gaps in knowledge | Chapter 5 |
| (f) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment | Chapter 6 |
| (g) recommendations in respect of any mitigation measures that should be considered by the applicant and the competent authority | Chapter 7 |
| (h) a description of any consultation process that was undertaken during the course of carrying out the study | Chapter 8 |
| (i) a summary and copies of any comments that were received during any consultation process | Chapter 9 |
| (j) any other information requested by the competent authority. | Chapter 10 |

# 2. PROJECT TEAM

ILISO Consulting has been appointed as Independent Environmental Assessment Practitioner (EAP) to undertake the EIA. Dr Martin van Veelen is the Project Leader and also the water quality specialist.

**Dr Martin van Veelen** is a professional engineer with a Ph D in aquatic health. He is the Managing Director of the ILISO Environmental Management Division and a certified Environmental Assessment Practitioner with 30 years experience. He specialises in project management, environmental impact assessments and water resource planning. He specifically has extensive experience in water quality, especially water quality management, water quality monitoring and water quality assessment.

# 3. PURPOSE OF THE REPORT AND SCOPE OF WORK

The information provided by the Letaba Catchment Reserve Determination Study (DWAF, 2006) and the water quality data from the river flow stations and reservoirs stations that fall within the study area were used to:

- Determine the impact of the dam on the quality of the water that will be stored in the proposed new dam, and in the Groot Letaba River downstream of the dam, and

- To compile a pre-construction and construction Environmental Management Plan (EMP) for the water quality associated with the proposed dam.

# 4. METHODOLOGY

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

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

The following criteria will be used to evaluate significance:

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

**Extent and location**
Magnitude of the impact and is classified as:

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

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

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

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

**Intensity**

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

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

**Probability**

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

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

**Confidence**

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

- **Low**: the judgement is based on intuition and not on knowledge or information.
- **Medium**: common sense and general knowledge informs the decision.
- **High**: Scientific and or proven information has been used to give such a judgement.

### Significance

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

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

### Cumulative Impacts

The possible cumulative impacts will also be considered.

### Mitigation

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

**Table 4.1: Example of Impact Assessment Table**

| | | |
|---|---|---|
| Description of potential impact | | |
| Nature of impact | | |
| Legal requirements | | |
| Stage | Construction and decommissioning | Operation |
| Nature of Impact | | |
| Extent of impact | | |
| Duration of impact | | |
| Intensity | | |
| Probability of occurrence | | |
| Confidence of assessment | | |
| Level of significance before mitigation | | |
| Mitigation measures (EMP | | |

| | | |
|---|---|---|
| requirements) | | |
| Level of significance after mitigation | | |
| Cumulative Impacts | | |
| Comments or Discussion | | |

# 5. ASSUMPTIONS, UNCERTAINTIES AND GAPS IN KNOWLEDGE

## 5.1 SOURCE OF DATA

Water quality data from the selected water quality monitoring stations that fall within the study area **(Figure 5.1)** were obtained from the DWAF. The data sets include results from the late 1960's to 2007 as listed in **Table 5.1.**

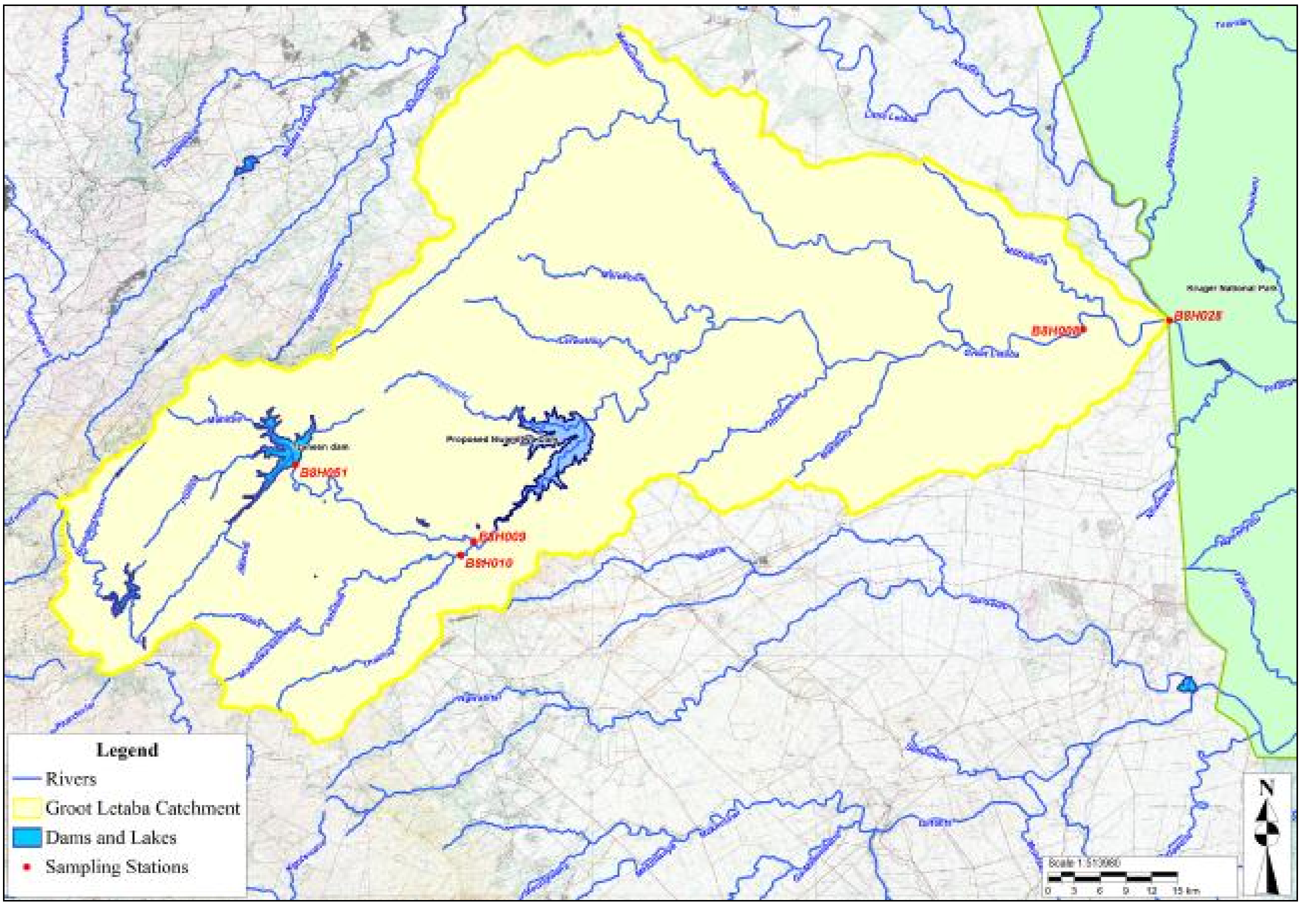


**Figure 5.1: Location of River Stations**

**Table 5.1: Water quality monitoring stations used in study**

| Drainage Region | Station No. | Station Name | Date of First Sample | Date of Last Sample | No of Samples taken |
|---|---|---|---|---|---|
| **B81 D** | B8H010 | Letsitele River | 1969/11/20 | 2007/04/26 | 1011 |
| **B81 C** | B8H051 | Tzaneen Dam - Outlet | 1985/01/30 | 2007/01/22 | 423 |
| **B81 E** | B8H028 | Letaba River at the Kruger National Park | 1983/11/29 | 2007/06/20 | 282 |
| **B81 E** | B8H009 | Groot Letaba at The Junction | 1969/11/20 | 2007/04/25 | 973 |
| **B81 J** | B8H008 | Groot Letaba at Letaba Ranch | 1977/09/21 | 2007/04/24 | 1324 |

## 5.2 REASON FOR SELECTION

The river flow stations used in this study have been selected for the following reasons:

- They are within close proximity to the proposed dam at the site known as Nwamitwa;
- They are within close proximity to the Tzaneen Dam; or
- They are close to possibly impacted areas, for example the Kruger National Park.

## 5.3 DATA MANIPULATION

In order to analyse the water quality data provided by DWAF the data had to be prepared and any missing values had to be estimated. This was conducted using a systematic approach. The first step was to extract data for the study period (January 2003 to December 2007). This study period was chosen as being representative of the current water quality situation, but long enough to detect trends. In the second step, the datasets were filtered to monthly values in order to remove any bias due to periods of intensive sampling. In this step the first sample taken in a month was used. The third step involved calculating values missing for incomplete datasets using one of the following two methods:

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

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

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

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

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

## 5.4 COMPLETENESS OF DATA

To evaluate the completeness of the data sets from each river flow station over the 5 year period of 2003 to 2007, the percentage of completeness was calculated. The percentage of completeness reflects the number of measured values after data sets have been filtered to monthly values and missing values had been filled in (see the discussion on data manipulation above describing how the data was filtered to monthly values and missing values filled in).

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

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

After determining the completeness of the data sets, the following rules were applied to determine whether or not a dataset could be used:

1. Only data sets that were at least 70% complete were considered,
2. Only data sets that complied with the first rule and had data from at least 2000 onwards were selected.

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

## 5.5 DATA ANALYSIS

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

To answer the questions “what is the water quality” and “how has the water quality changed” non-parametric statistics were used to calculate the variability, which is a measure of how water quality may differ over time. With non-parametric statistics the interquartile range, which lies between the 25$^{th}$ and the 75$^{th}$ percentile, is generally used to describe variability, while the median value (50$^{th}$ percentile is an indication of the central tendency or average. For the purposes of this study the 95$^{th}$ percentile was included as it can be used to assess the frequency of excursions into higher and possibly unacceptable water quality conditions.

Only data over the last five years (January 2003 to December 2007) was used to determine the current water quality. This was done in order to have a reasonable number of data points on which to base the calculated statistics, but not going back too far in time to have the assessment influenced by any trends that may be present.

The current water quality was based on the calculation of the median, 75th percentile and the 95th percentile.

## 5.6 WATER QUALITY ASSESSMENT

### 5.6.1 Variables of Concern

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

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

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

- **Nitrate/Nitrite ($NO_3$/$NO_2$)**: Has a health effect on humans (particularly babies), and is also an indication of contamination from human activities in the catchment, notably the discharge of treated waste water. Nitrite has a toxic effect on aquatic organisms, particularly those organisms that use gills to breathe under water.

- **Phosphate ($PO_4$)**: Has no direct effect on the use of water, but is an indicator of contamination from activities in the catchment such as waste water discharge and fertilisers from agricultural activities. Elevated concentrations of phosphate can lead to algal blooms in standing water which affect users and the aquatic ecosystem negatively.

- **Sulphate ($S0_4$):** Occurs naturally and is widely distributed in natural waters. Levels should not be more that 250mg/L in drinking water. When Sulphate levels are higher than 500mg/l it is know to contribute to the unpleasant taste of water. Sensitive users may experience diarrhoea, but most people can adapt after a period of use.

- **Ammonia ($NH_4$):** Ammonia is toxic to aquatic life, especially in the unionised form ($NH_3$). The ratio between $NH_3$ and $NH_4$ is dependent on the temperature and pH. For this reason guidelines are normally stated as total ammonia. Ammonia is reduced by natural processes to nitrate/nitrite and is therefore not persistent. Ammonia seldom occurs in concentrations that are high enough to affect human health, and as it is a fertiliser, does not affect agriculture.

- **Chloride (Cl):** Is an indicator of the nature of salinity. It is an indicator of salty taste, and also corrosivity with respect to household appliances and irrigation equipment. In some water bodies sulphate has the same effect as chloride and the two should be assessed in conjunction with each other. However, sulphate concentrations in the study area are very low, and in this case can be ignored. Effects on the aquatic ecosystem as a result of salinity will be detected long before chloride in itself becomes problematic, and chloride can therefore be ignored when assessing water quality in this respect. Some crops, specifically deciduous trees such as citrus, are sensitive to chloride as it builds up in the leaves and causes leave sclerosis. This is probably the most sensitive use with respect to chloride.

- **Pesticides and Herbicides:** There is some evidence (Heath and Claassen, 1999 and Vosloo and Bouwman, 2005) that filling of the dam could lead to contamination by pesticides and herbicides that were used in the dam basin. Pesticides and herbicides that can be legally used have a relatively short half life, and should not be a problem as long as the use of these are stopped some time before the dam is completed and filling commences. However, it is not known whether or not more persistent pesticides or herbicides were used in the past. An example would be DDT that is used against malaria. This is mostly used in and around dwellings, especially thatched roof houses. Unfortunately there is no readily available data to assess this risk quantitatively.

### 5.6.2 Water Quality Criteria, Guidelines and Fitness for Use

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

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

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

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

The fitness-for-use range is also colour coded for ease of interpretation of information (**Table 5.2**).

**Table 5.2: Colour codes assigned to fitness for use ranges**

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

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

### 5.6.3 Fitness for use categories

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

The DWAF guidelines are user-specific, making it possible to have many different guidelines for each of the water quality variables (depending on how many user groups are affected by the same variable). For each user group a particular set of guidelines for water quality is relevant (developed by DWAF). The guidelines provide a description of the effect that changes in water quality will have on the user, and not an interpretation of whether this is acceptable or not. From these guidelines the cut-off values for the different fitness-for-use categories have been set. A breakdown of these values is given in **Table 5.3.**

The cut-off values for the fitness for use categories are per user and per variable and can be used to assess the fitness for use of the Groot Letaba study area for individual users or user categories such as domestic, agriculture, industry, recreation and the aquatic ecosystem. The study focused on domestic and agriculture water uses. In order to determine the fitness for use of the Groot Letaba study area as a whole, the different fitness for use categories for different users affected by the same variable have been reconciled. This was done by selecting the most stringent value for each cut-off value in order to arrive at the management levels. A summary of these values are given in **Table 5.4**

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

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

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

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

d) Ammonia ($NH_3/NH_4$): Total Ammonia is used as an indicator of the presence of $NH_3$ which is highly toxic to aquatic life even in low concentrations, and is therefore difficult to measure. In most cases ammonia has no effect on human consumption or on irrigation in the concentrations in which it occurs in rivers and streams. The guideline for aquatic use therefore determines the cut-off values for the fitness for use range.

e) Sulfate ($S0_4$): The norm used on sulfate is based on human health and aesthetic effect. The domestic guideline for consumption is the most stringent. The ideal range is between 200mg/l 0 400 mg/l.

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

g) Chloride (Cl): The most stringent guideline is for agricultural irrigation; this guideline will be carried over to the fitness-for-use categories because it is necessary to protect the crops farmed from toxic levels of chloride.

### Table 5.3: User specific guidelines

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

**Table 5.4: Combined fitness for use categories**

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

### 5.6.4 Fitness for use assessment

In the foregoing chapters the fitness-for-use categories have been developed. What is now needed is to assess the water quality on the basis of the statistical distribution of the measurements over the various categories. Obviously, if all the statistics (median, 75th percentile and 95th percentile) fall in the "ideal" range, then the water is ideal. The same is true for the other categories.

The rules for determining the overall fitness for use are shown in **Table 5.5** below.

**Table 5.5: Fitness for use assessment criteria**

| Fitness for use range in which the variable falls | | | Water quality assessment category | Colour code |
|---|---|---|---|---|
| Median | 75th percentile | 95th percentile | | |
| Ideal | Ideal | Ideal | Ideal | Blue 1 |
| Ideal | Ideal | Acceptable | Acceptable | Green 2 |
| Ideal | Acceptable | Acceptable | | |
| Acceptable | Acceptable | Acceptable | | |
| Ideal | Ideal | Tolerable | | |
| Ideal | Acceptable | Tolerable | Tolerable | Yellow 3 |
| Acceptable | Acceptable | Tolerable | | |
| Acceptable | Tolerable | Tolerable | | |
| Tolerable | Tolerable | Tolerable | | |
| Any other combination | | | Unacceptable | Red 4 |

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

# 6. RESULTS

## 6.1 CURRENT WATER QUALITY

The data set used to calculate the values in **Table 6.1** to **Table 6.4** are based on monthly data over a period of 5 years (2001 – 2005).

**Table 6.1: Water quality assessment for the median of stations analysed**

| Station Name | Station No. | EC | pH | Cl | $SO_4$ | $NO_3$+$NO_2$ -N | $NH_4$ -N | $PO_4$-P |
|---|---|---|---|---|---|---|---|---|
| Tzaneen Dam | B8H051 | 8 | 7.5 | 5 | 3 | 0.12 | 0.147 | 0.013 |
| Grt Letaba @ The Junction | B8H009 | 11 | 7.6 | 10 | 3 | 0.27 | 0.020 | 0.016 |
| Letsitele | B8H010 | 28 | 8.0 | 20 | 6 | 0.61 | 0.020 | 0.153 |
| Grt Letaba @ Letaba Ranch | B8H008 | 58 | 8.2 | 89 | 18 | 0.06 | 0.020 | 0.024 |
| Grt Letaba @ KNP | B8H028 | 71 | 8.3 | 102 | 19 | 0.04 | 0.020 | 0.022 |

**Table 6.2: Water quality for the 75th percentile of stations analysed**

| Station Name | Station No. | EC | pH | Cl | $SO_4$ | $NO_3$+$NO_2$ -N | $NH_4$ -N | $PO_4$-P |
|---|---|---|---|---|---|---|---|---|
| Tzaneen Dam | B8H051 | 8 | 7.6 | 6 | 6 | 0.19 | 0.270 | 0.018 |
| Grt Letaba @ The Junction | B8H009 | 12 | 7.7 | 12 | 7 | 0.39 | 0.044 | 0.021 |
| Letsitele | B8H010 | 37 | 8.1 | 33 | 9 | 1.19 | 0.051 | 0.242 |
| Grt Letaba @ Letaba Ranch | B8H008 | 81 | 8.3 | 131 | 25 | 0.17 | 0.041 | 0.035 |
| Grt Letaba @ KNP | B8H028 | 92 | 8.4 | 153 | 27 | 0.06 | 0.045 | 0.035 |

**Table 6.3: Water quality for the 95th percentile of stations analysed**

| Station Name | Station No. | EC | pH | Cl | $SO_4$ | $NO_3+NO_2$ - N | $NH_4$ -N | $PO_4$-P |
|---|---|---|---|---|---|---|---|---|
| Tzaneen Dam | B8H051 | 9 | 7.8 | 8 | 10 | 0.29 | 0.468 | 0.028 |
| Grt Letaba @ The Junction | B8H009 | 23 | 7.9 | 21 | 11 | 0.66 | 0.072 | 0.036 |
| Letsitele | B8H010 | 47 | 8.3 | 60 | 15 | 2.91 | 0.140 | 0.998 |
| Grt Letaba @ Letaba Ranch | B8H008 | 102 | 8.6 | 194 | 36 | 0.38 | 0.059 | 0.082 |
| Grt Letaba @ KNP | B8H028 | 123 | 8.5 | 243 | 33 | 0.25 | 0.090 | 0.062 |

**Table 6.4** depicts the fitness for use category for each of the sampling points that was analysed. The water quality falls mostly in the ideal range, except in terms of phosphate. This is probably due to activities in the catchment, such irrigation return flow and treated domestic waste discharge. The lower reaches of the river are clearly more saline than the upper reaches.

**Table 6.4: Concluding water quality assessment**

| Station Name | Station No. | EC | pH | Cl | $SO_4$ | $NO_3+NO_2$ - N | $NH_4$ -N | $PO_4$-P |
|---|---|---|---|---|---|---|---|---|
| Tzaneen Dam | B8H051 | B | B | B | B | B | Y | Y |
| Grt Letaba @ The Junction | B8H009 | B | B | B | B | B | B | Y |
| Letsitele | B8H010 | G | B | B | B | B | G | R |
| Grt Letaba @ Letaba Ranch | B8H008 | Y | G | Y | B | B | B | Y |
| Grt Letaba @ KNP | B8H028 | Y | G | Y | B | B | B | Y |

## 6.2 TRENDS

A time series for the different variables at the different monitoring points is included as **Appendix A**. A summary of the trends is shown in the table below. A “1” denotes a decrease in concentration or value, while a “2” denotes an increase or positive trend. A “0” means that there is no change over the period under review.

**Table 6.5: Trend analysis**

| Station Name | Station No. | EC | pH | Cl | $SO_4$ | $NO_3$+$NO_2$ -N | $NH_4$ -N | $PO_4$-P |
|---|---|---|---|---|---|---|---|---|
| Tzaneen Dam | B8H051 | 2 | 1 | 2 | 1 | 1 | 2 | 2 |
| Grt Letaba @ The Junction | B8H009 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Letsitele | B8H010 | 2 | 1 | 2 | 2 | 0 | 1 | 2 |
| Grt Letaba @ Letaba Ranch | B8H008 | 2 | 0 | 2 | 2 | 1 | 1 | 1 |
| Grt Letaba @ KNP | B8H028 | 2 | 1 | 2 | 2 | 2 | 0 | 1 |

On the whole the water quality of the catchment is improving in terms of nutrients, but there is an increasing trend in salinity. The changes in water quality are however small, and not significant in terms of fitness for use. Even at the 95$^{th}$ percentile value, the water quality still falls mostly in the ideal range in the upper reaches.

Station B8H051 represents the Tzaneen Dam. The slight positive trend is not significant in terms of fitness for use, but is highly significant in terms of indicating that there are processes in the catchment of the dam that are causing changes in water quality.

## 6.3 BOREHOLE WATER QUALITY

Water quality data for boreholes was obtained from the DWAF database. The different boreholes were grouped according to the quaternary drainage region in which they occur, and the data analysed. The results are shown in **Table 6.6**.

**Table 6.6: Borehole water quality in catchment B8**

| Variable | | B8H008 | B8H009 | B8H010 | B8H014 | B8H018 | B8H050 | B8H051 | B8H064 |
|---|---|---|---|---|---|---|---|---|---|
| Chloride (mg/l Cl) | Median | 10.7 | 22.3 | 28.2 | 46.4 | 113 | 16.4 | 16.4 | 23.3 |
| | 75th Perc | 12.7 | 29.7 | 60.8 | 252 | 125 | 19.4 | 19.4 | 29.7 |
| | 95th Perc | 20.6 | 120 | 269 | 409 | 402 | 29.5 | 29.5 | 34.8 |
| Electrical Conductivity (mS/m) | Median | 40.0 | 36.9 | 58.9 | 112 | 113 | 18.7 | 18.7 | 78.2 |
| | 75th Perc | 42.3 | 48.4 | 96.6 | 219 | 118 | 20.6 | 20.6 | 81.1 |
| | 95th Perc | 45.8 | 124 | 194 | 391 | 237 | 37.0 | 37.0 | 83.5 |
| NO3+NO2 (mg/l N) | Median | 3.58 | 0.040 | 10.8 | 18.9 | 3.88 | 0.02 | 0.02 | 10.0 |
| | 75th Perc | 5.73 | 1.36 | 15.5 | 20.0 | 4.75 | 4.10 | 4.10 | 10.49 |
| | 95th Perc | 9.08 | 20.0 | 46.8 | 101 | 5.98 | 0.08 | 0.08 | 10.8 |
| NH4 (mg/l N) | Median | 0.03 | 0.02 | 0.02 | 0.02 | 0.07 | 0.02 | 0.02 | 0.02 |
| | 75th perc | 0.05 | 0.03 | 0.05 | 0.02 | 0.06 | 0.03 | 0.03 | 0.05 |
| | 95th Perc | 1.17 | 0.01 | 0.11 | 0.04 | 0.02 | 0.08 | 0.08 | 0.08 |
| PO4 (mg/l P) | Median | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.05 | 0.05 | 0.02 |
| | 75th Perc | 0.06 | 0.02 | 0.03 | 0.03 | 0.02 | 0.08 | 0.08 | 0.03 |
| | 95th Perc | 0.02 | 0.05 | 0.12 | 0.06 | 0.07 | 0.33 | 0.33 | 0.04 |
| S04 (mg/l) | Median | 5.8 | 7.53 | 10 | 33.8 | 8.20 | 2 | 2 | 8.01 |
| | 75th Perc | 8.36 | 12.2 | 14.6 | 49.5 | 9.92 | 4.11 | 4.11 | 9.23 |
| | 95th Perc | 9.28 | 22.1 | 62.7 | 78.0 | 74.8 | 10.7 | 10.7 | 10.21 |
| pH | Median | 7.53 | 8.08 | 7.95 | 8.18 | 8.51 | 7.41 | 7.41 | 8.23 |
| | 75th Perc | 7.70 | 8.22 | 8.06 | 8.13 | 8.62 | 7.65 | 7.65 | 8.32 |
| | 95th Perc | 7.84 | 8.46 | 8.26 | 9.33 | 8.88 | 8.23 | 8.23 | 8.40 |

The salinity of the borehole water is such that in most areas it is unfit for human consumption due to the high salinity, or will impart an unpleasant taste to the water. Of most concern is the elevated nitrate/nitrite concentration in the water of some of the boreholes. This is indicative of serious contamination, and it can be expected that there will be some bacterial pollution as well. The borehole water is also not suitable for irrigation of citrus, except in an emergency over a short period of time.

## 6.4 ASSESSMENT OF POTENTIAL IMPACTS

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

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

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

### 6.4.1 Expected water quality in the dam

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

The proposed dam will have a capacity of more than the mean annual runoff of the river, and the quality of the water in the dam can therefore be expected to be equal to the median value of the river water. This is a conservative assumption, as most of the inflow (in terms of volume) into the dam occurs during flood events when the concentrations are low. However, the median value makes provision for prolonged periods of low flow and the concentrating effect of evaporation losses.

The water quality in the dam will be a combination of the water quality at B8H009 and B8H010. According to the hydrological analysis the present day flow at B8H009 represents 58% of the flow below the confluence of the Groot Letaba River and the Letsitele River, and the flow at B8H010 represents 42%. The contribution from the Nwanedzi is relatively small (11% of the flow at the dam site) and as it can be accepted that it does not differ significantly from the rest of the catchment, will therefore have very little effect on the overall quality. The values depicted in **Table 6.7** were calculated from the observed values at B8H009 and B8H010 as the predicted 95$^{th}$ percentile concentrations in the dam.

**Table 6.7: Predicted water quality in the dam (95th percentile)**

| EC | pH | Cl | $SO_4$ | $NO_3 + NO_2$ - N | $NH_4$ - N | $PO_4$ - P |
|---|---|---|---|---|---|---|
| 18 | 7.8 | 14 | 4 | 0.41 | 0.020 | 0.074 |

Apart from phosphate, the water quality falls in the ideal range. In terms of domestic use it represents a vast improvement over the borehole quality, while it is also eminently suitable for irrigation.

The water quality in the dam will represent a significant improvement in the water quality that is currently available, especially for domestic users that are currently dependent on borehole water. No mitigation is required.

The trophic classification is determined by the mean annual concentration of TP (Total phosphate) and chlorophyll (Walmsley and Butty, 1980). **Table 6.8** below demonstrates the different trophic classification and **Table 6.9** provides a definition of each trophic level.

**Table 6.8: Trophic Classification**

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

Source: (Walmsley and Butty, 1980)

**Table 6.9: Trophic Definition**

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

Source: http://www.dwaf.gov.za/iwqs/eutrophication/NEMP/nempdam.htm (DWAF 2002)

The predicted phosphate concentration is 0.074 mg/l P (74 µg/ℓ). This puts it in the eutrophic range, but as a concentration of less than 0.16 mg/l P will result in nuisance conditions occurring for less than 20% of the time, this is seen as tolerable. Nonetheless, the situation will warrant close monitoring at the least.

The predicted phosphate concentration in the dam will put it in the range of eutrophic. This means that nuisance conditions with respect to algal blooms will occur, but for less than 20% of the time. No mitigation is required, but it is suggested that the source of phosphate in the catchment is located and reduced.

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

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

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

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

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

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

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

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

Stratification is predicted to occur in the proposed new dam, and the release of cold, anoxic bottom water will have a detrimental effect on the aquatic life up to a distance of about 15 km below the dam wall. To overcome the effect it is recommended to install a multiple level outlet structure, with oulets at approximately 5 meter intervals from 6 meters below the full supply level of the dam, to be confirmed in the design phase.

**Table 6.10: Impact assessment table for water quality (users)**

| | | |
|---|---|---|
| Description of potential impact | Better quality water for users | |
| Nature of impact | Positive | |
| Legal requirements | | |
| Stage | Construction and decommissioning | Operation |
| Nature of Impact | | Positive |
| Extent of impact | | Regional |
| Duration of impact | | Long term |
| Intensity | | Medium |
| Probability of occurrence | | High |
| Confidence of assessment | | High |
| Level of significance before mitigation | | High |
| Mitigation measures (EMP | | None, the impact is positive and |

| | | |
|---|---|---|
| requirements) | | desired |
| Level of significance after mitigation | | |
| Cumulative Impacts | | |
| The water from the dam will obviate the current situation where people are dependent on borehole water that is not always fit for human consumption. | | |

### Table 6.11: Impact assessment table for water quality (downstream effects)

| | | |
|---|---|---|
| Description of potential impact | Water quality changes (temperature and oxygen) in the river downstream of the proposed dam. | |
| Nature of impact | Negative | |
| Legal requirements | | |
| Stage | Construction and decommissioning | Operation |
| Nature of Impact | | Negative |
| Extent of impact | | Regional |
| Duration of impact | | Long term |
| Intensity | | Medium |
| Probability of occurrence | | High |
| Confidence of assessment | | Medium |
| Level of significance before mitigation | | Medium |
| Mitigation measures (EMP requirements) | | Multiple level outlets at the dam |
| Level of significance after mitigation | | Low (totally mitigated) |
| Cumulative Impacts | | |
| The installation of multiple level outlets and proper operation will completely mitigate the effect of water quality changes downstream of the proposed dam. | | |

The raising of the Tzaneen Dam will have no water quality effects with respect to the current situation.

### 6.4.2 Impacts during construction

Some impacts on water quality may occur during construction. These have to do with possible contamination of the river by construction materials, as well as the discharge of waste from the construction site. These occurrences are governed by the National Water Act, and as long as this is adhered to, the effect will be minimal. This applies at both sites, namely the proposed new dam as well as the possible raising of the Tzaneen Dam.

**Table 6.12: Water quality impacts during construction**

| | | |
|---|---|---|
| Description of potential impact | Contamination of river water from construction materials and the discharge of waste from the construction site. | |
| Nature of impact | Negative | |
| Legal requirements | National Water Act | |
| Stage | Construction and decommissioning | Operation |
| Nature of Impact | Negative | |
| Extent of impact | Regional | |
| Duration of impact | Short | |
| Intensity | Low | |
| Probability of occurrence | Medium | |
| Confidence of assessment | Medium | |
| Level of significance before mitigation | Medium | |
| Mitigation measures (EMP requirements) | Adhere to requirements of the National Water Act, and good house-keeping on site. | |
| Level of significance after mitigation | Low | |

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

### 6.4.3 Impacts during filling of the dam

As mentioned before, there is some concern that there may be some contamination by pesticides and herbicides that were used in the dam basin, and that this could pose a threat to human health as well as the aquatic ecology. Although the effect would last only for a short period of time (the pesticides and herbicides would be leached out and effectively diluted by the inflow into the dam once it is full), it does pose a risk should the dam only fill slowly over the initial years after completion. The most effective way to mitigate this risk is to remove all standing crops and to break down and remove all buildings in the dam basin before filling commences.

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

For the above reasons, it is strongly recommended that the dam basin is cleared, and that the use of pesticides and herbicides is stopped when dam construction commences, irrespective of whether or not the present land owners are allowed to continue farming until the dam starts filling up.

**Table 6.13: Water quality impacts during filling of the dam**

| | |
|---|---|
| Description of potential impact | Contamination of water by pesticides and herbicides, and the creation of anoxic conditions due to decomposition of organic material. |
| Nature of impact | Negative |
| Legal requirements | National Water Act |

| | | |
|---|---|---|
| Stage | Construction and decommissioning | Operation (Filling of dam) |
| Nature of Impact | | Negative |
| Extent of impact | | Local |
| Duration of impact | | Short term |
| Intensity | | Low/Medium (depends on how fast the dam fills up) |
| Probability of occurrence | | Medium |
| Confidence of assessment | | Medium |
| Level of significance before mitigation | | Medium |
| Mitigation measures (EMP requirements) | | Clear the dam basin<br>Prevent the use of herbicides and pesticides in the dam basin once construction starts |
| Level of significance after mitigation | | Low |
| Cumulative Impacts | | |
| | | |

## 6.5 COMPLIANCE TO THE RESERVE

Information regarding the Reserve was obtained from the Department of Water Affairs and Forestry (File Reference 26/8/3/3/190, 332, 659, 334, 1049, 1050, 1051).

The Preliminary Reserves for each of seven Ecological Water Requirement (EWR) sites in the Groot Letaba River and its main tributaries were determined during 2006. The Reserve was duly signed off by the Director-General: Water Affairs and Forestry on 27 December 2006. It thereby is applicable to the authorization of all water use activities in the Groot Letaba River Catchment, which includes the storing of water.

Nine ecologically distinct Resource Units (RUs) were identified in the Letaba River catchment. However, eco-classification was conducted only for the 7 EWR sites selected in the study area (**Figure 6.1**). The Ecological Importance and Sensitivity and Socio-cultural Importance of these EWR sites are provided in **Table 6.13**. They range from low to high importance at EWR4, on the Groot Letaba River, as it enters the KNP.

The Present Ecological State (PES) of each EWR site is also given in **Table 6.13** and ranges from category C at EWR 1 (upper catchment of Groot Letaba River), EWR 5 (Klein Letaba) and EWR 6, and 7 (in the KNP) to category D in the Letsitele River. The Recommended Ecological Category for each EWR site is to remain unchanged from the PES.

The EWR site that will be applicable to the proposed new dam is EWR Site 3 (Groot Letaba River at Die Eiland). Although this site is somewhat downstream from the proposed dam site, there are no significant inflows that could influence the water quality along this stretch of the river. It can therefore be accepted that, as long as the requirements of the Reserve are met in the proposed new Dam, they can be met at EWR Site 3 as well. This would then constitute compliance with the Reserve.

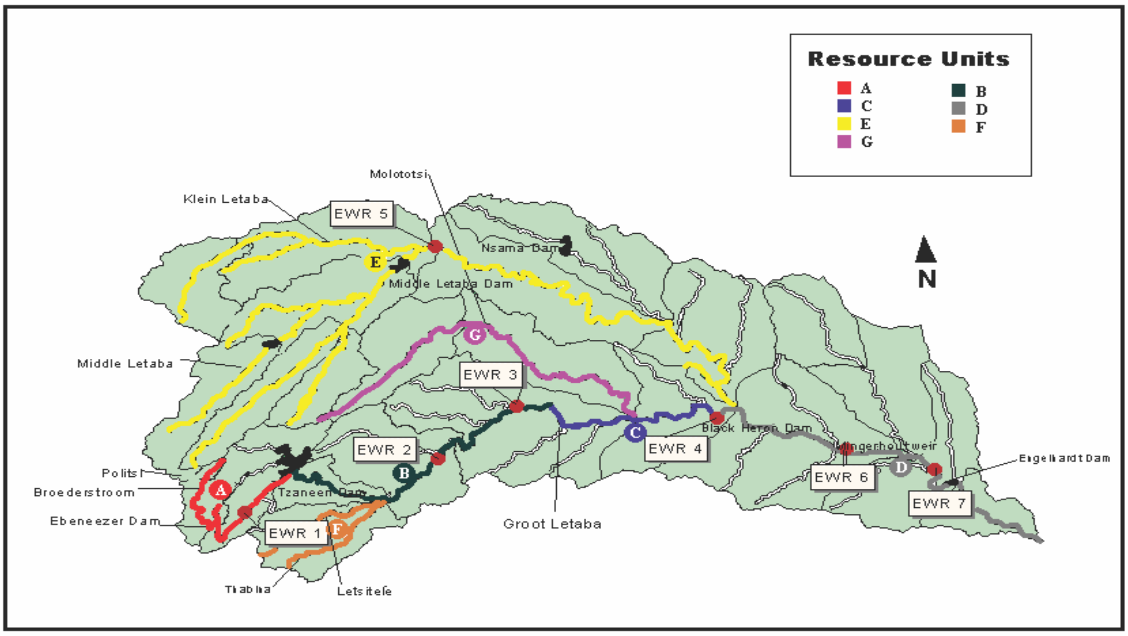


**Figure 6.1: EWR Sites in the Groot Letaba River Catchment**

**Table 6.5: Summary of the Present Ecological Status (PES), Ecological Importance and Sensitivity (EIS) and Socio-cultural Importance (SI) of each Site in the Letaba River Catchment, the Recommended Ecological Category (REC) suggested by the specialists and used to determine the EWR, and the most likely alternative ECs, where applicable.**

| Site | PES | Importance | | Ecological Category | | |
|---|---|---|---|---|---|---|
| | | EIS | SI | REC | Alternatives | |
| 1 | C | Mod | Low | C | N/A | D |
| 2 | D | Mod | Low | D | N/A | N/A |
| 3 | C/D | High | Mod | C/D | C | D |
| 4 | C/D | High | High | C/D | N/A | D |
| 5 | C | Mod | Mod | C | D | N/A |
| 6 | C | High | Low | C | D | B |
| 7 | C | High | Low | C | D | B |

Quality ecospecs are related to attaining the recommended water quality category of the overall Recommended Ecological category (REC), and are presented as 95th percentiles, i.e. values not to be exceeded more than 5% of the time, for inorganic salts, physical variables and toxics; and 50th percentiles for nutrients, i.e. TIN and SRP (**Table 6.14**). Biotic community composition (invertebrates) should not drop below the indicated values. Percentiles should be calculated within the framework of the current assessment method, i.e. using the PES monitoring point as shown on the table for the relevant EWR site, and the most recent 3 to 5 years of data, equivalent to a minimum of 60 data points. This approach is consistent with that to be used for the design of a monitoring programme for water quality.

### Table 6.6: EWR 3: Die Eiland on the Groot Letaba River

| **River** | Groot Letaba River | **DWAF Water Quality Monitoring points** | | |
|---|---|---|---|---|
| **WQSU** | 4 | **RC** | B8H009Q01 (1976 – 1977) | |
| **EWR Site** | 3 | **PES** | B8H009Q01 (2000 - 2004) | |
| **Water quality constituents** | | **Present state** | **Quality ecospecs** | **Improvements required** |
| Inorganic salts | $MgSO_4$ | B | 23 mg/L | N/A |
| | $Na_2SO_4$ | A | 20 mg/L | N/A |
| | $MgCl_2$ | A | 15 mg/L | N/A |
| | $CaCl_2$ | A | 21 mg/L | N/A |
| | NaCl | B | 191 mg/L | N/A |
| | $CaSO_4$ | A | 351 mg/L | N/A |
| Nutrients | SRP | B (0.019) | 0.015 mg/L | N/A |
| | TIN | A/B - B (0.416) | 0.79 mg/L (B category) | N/A |
| Physical variables | pH (pH units) | A | 5thpercentile: 6.5 to 8.0 | N/A |
| | Temperature | Impacts expected due to low flows for 4 months of the year. | Moderate change allowed. Vary by no more than 2°C (Rating of 2, C category). | N/A |
| | Dissolved oxygen | | Moderate change allowed: 6 – 7 mg/L (Rating of 2, C category) | |
| | Turbidity (NTU) | High turbidities temporary | Small change allowed – largely natural and related to natural catchment processes such as rainfall runoff (Rating of 1, B category). | N/A |
| Response variables | Chl-a: periphyton | C – C/D: WQ Site 6: 45.77 WQ Site 7: 31.71 | **21 mg/m² (C category)** | **Slight improvement required** |
| | Chl-a: phytoplankton | - | 20 µg/L (C category) | No data |
| | Biotic community composition - macroinvertebrate | D (habitat + flow related) | **ASPT: 5 (C category)** | **Moderate improvement requited** |
| | In-stream toxicity | Evidence of acute and sub-lethal toxicity | In-stream toxicity may occur **(Rating of 2, C category)** | **Improvements required** |
| | Fluoride | A | 1500 µg/l (A category) | N/A |
| | Al | - | 20 µg/l (A category) | No information |

| | | | | |
|---|---|---|---|---|
| | Ammonia | - | 15 µg/l (A category) | No information |

| **River** | Groot Letaba River | **DWAF Water Quality Monitoring points** | | |
|---|---|---|---|---|
| **WQSU** | 4 | **RC** | B8H009Q01 (1976 – 1977) | |
| **EWR Site** | 3 | **PES** | B8H009Q01 (2000 - 2004) | |
| **Water quality constituents** | | **Present state** | **Quality ecospecs** | **Improvements required** |
| Toxics | As | - | 20 µg/l (A category) | No information |
| | Atrazine | - | 19 µg/l (A category) | No information |
| | Cd soft* | - | 0.2 µg/l (A category) | No information |
| | Cd mod** | - | 0.2 µg/l (A category) | No information |
| | Cd hard*** | - | 0.3 µg/l (A category) | No information |
| | Chorine (free) | - | 0.4 µg/l (A category) | No information |
| | Cr(III) | - | 24 µg/l (A category) | No information |
| | Cr(VI) | - | 14 µg/l (A category) | No information |
| | Cu soft* | - | 0.5 µg/l (A category) | No information |
| | Cu mod** | - | 1.5 µg/l (A category) | No information |
| | Cu hard*** | - | 2.4 µg/l (A category) | No information |
| | Cyanide | - | 4 µg/l (A category) | No information |

Unfortunately the quality ecospecs are not translated into concentrations of the individual ions. Nonetheless, the predicted sulphate and chloride concentrations in the dam (**Table 6.6**) are so low, that the requirements of the ecospecs can be easily met. The same is true for the total inorganic nitrogen (TIN) concentration and the pH.

The only variable that remains is the phosphate. The predicted value of .074 mg/l P in the dam exceeds the 0.015 mg/l that is required at Site 3. However, on the basis of the analysis performed as part of this study, the reported concentration of 0.019 mg/l at Site 3 is questioned. It is suspected that the PES is far higher than determined as part of the Reserve study, and consequently that the quality ecospec is not correct. The earlier conclusion with respect to the condition of the dam, namely that the situation will be acceptable, is therefore maintained.

The construction of the dam will therefore not compromise the reserve in terms of quality.

# 7. RECOMMENDED MITIGATION MEASURES

## 7.1 WATER QUALITY FROM THE PROPOSED DAM

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

## 7.2 WATER QUALITY EFFECTS DOWNSTREAM OF THE DAM

Some effects as a result of stratification, namely the release of cold and anaerobic water, can be expected. This can effectively mitigated by the installation of a multiple level outlet structure. It is recommended that the outlets are positioned at 4 meter intervals, starting 6 meters below full supply level.

## 7.3 IMPACTS DURING CONSTRUCTION

Baseline monitoring

- Water samples for water quality analysis will be taken weekly for the first four weeks before construction is initiated, thereafter, and during construction a sample will be taken once a month. The samples will be analysed for all substances that can be expected to emanate from the construction site and/or the construction activities.

Washing

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

Instrumentation

- Water samples must be analysed in a recognised, accredited laboratory.

Data recording

- All water quality and quantity data must be recorded at a central point together with the sampling positions and the dates and times of the sampling.

Reporting

- Water quality and quantity data must be presented in a report, which will include an overview of the state of all water courses, including water quality and hydrological integrity.

Waste discharge

- Water quality results from all waste discharge must comply with and shall be compared to the “GA general limit” and a compliance report prepared.

## 7.4 IMPACTS DURING FILLING OF THE DAM

The water quality in the dam may be affected by the presence of herbicides and pesticides in the dam basin. The water quality will also be affected by decomposing vegetation once the dam starts to fill. Both these problems can be effectively mitigated by clearing the dam basin of all vegetation and structures, and by prohibiting the use of pesticides and herbicides in the dam basin once construction starts.

The water in the dam must be monitored for DDT and its derivatives, as well as the presence of Lindane, Mercaption, Pirimiphos and Aldicarb on a monthly basis over the first three years of operation.

# 8. CONSULTATION PROCESS

## 8.1 PUBLIC PARTICIPATION

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

The proposed project was announced in July 2007 to elicit comment from and register I&APs from as broad a spectrum of public as possible. The announcement was done by the following means:

- the distribution of Background Information Documents (BIDs) in four languages,
- placement of site notices in the project area,
- placement of advertisements in regional and local newspapers,
- publishing information on the DWAF web site,
- announcement on local and regional radio stations; and
- hosting five focus group meetings in the project area.

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

The availability of the Final Environmental Impact Assessment Report, its summary (translated in four languages), the various specialist studies, the Environmental Management Plans and Programmes will be announced by way of personalized letters to stakeholders and the placement of advertisements in regional and local newspapers. The Draft documents was made available to I&APs for their inputs and comments. Two stakeholder meetings were planned and presented the contents of the documents and to discuss the findings of the study.

The Draft Environmental Impact Assessment Report, its summary (translated in four languages), the various specialist studies, the Environmental Management Plans and Programmes were made available for a period of thirty (30 days) for stakeholders to comment. Stakeholder comments were taken into consideration with the preparation of the final documents. The availability of the final documents will be announced prior to submission to the decision-making authority.

# 9. COMMENTS RECEIVED

The following issues were sourced from the Issue and Response Report (Version 2) as submitted to the Department of Environmental Affairs and Tourism with the Scoping Report.

## 9.1 ISSUES RELATED TO THE ECOLOGICAL RESERVE AND WATER QUALITY

| Issue | Person submitted by | When received | Response |
|---|---|---|---|
| That the ecological Reserve is immediately implemented and monitored – pre, during and post development monitoring of the water quality and riverine ecology both up and downstream of the dam. | MK (Mick) Angliss, Limpopo Dept Economic Dev, Env & Tourism.<br><br>CA (Chantal) Matthys, DWAF: WA&IU (Environment & Recreation). | Written submission (BID comment sheet).<br><br>Written submission (BID comment sheet). | The Reserve in terms of water quality will not be compromised by the proposed dam. See Section 6.5 of the specialist report. |
| That all parties recognise from the outset that it is insufficient to state that the "ecological Reserve will be maintained". Clarity must be obtained on why existing ecological reserves of water are not being maintained (e.g. in the Olifant's River system even before construction of the De Hoop Dam, and in the Nyl River system and if this cannot be undertaken then this must be regarded as a fatal flaw. | Luke Perkins, Wildlife and Environment Society of SA (WESSA). | Written submission (BID comment sheet). | The Reserve in terms of water quality will not be compromised by the proposed dam. See Section 6.5 of the specialist report. |
| That the ecological Reserve and downstream users be considered. | Dr TK (Thomas) Gyedu-Ababio | Written submission (BID comment sheet) | The Reserve in terms of water quality will not be compromised by the proposed dam. See Section 6.5 of the specialist report. |
| That pollution of the water from the squatter area runs into the river through the Tzaneen Dam and it is affecting the quality of the existing water. | Jan de Lang, Greater Tzaneen Chamber of Business. | Attended meeting at Fairview Country Lodge, 31 July 2007, Tzaneen. | The contamination of water in the catchment area was taken into account when determining the quality of the water in the dam. Although not ideal, the water quality will not be affected unduly by the current situation. |

# 10. OTHER INFORMATION REQUESTED BY THE AUTHORITY

No other information was requested by the Authority.

# 11. CONCLUSION

The water quality situation in the catchment of the proposed new dam is such that no water quality problems are expected to occur. The dam will be able to provide water to a community that is at present reliant on water from boreholes of which some of the water is not fit for human consumption. The requirements of the Reserve in terms of water quality can be met.

The only possible effect, in terms of water quality, is the release of cold and anaerobic bottom water during periods when the dam becomes stratified. This can effectively be mitigated by the installation and correct operation of multiple level outlets.

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

There is some risk of contamination by herbicides and pesticides during the filling of the dam, as well as anoxic conditions due to the decomposing of organic material. This can effectively be mitigated by clearing the dam basin and preventing the use of herbicides and pesticides once the construction of the dam starts.

In terms of water quality there is therefore no significant effect on the environment from either the construction of the proposed new dam, or the raising of the Tzaneen Dam wall.

# 12. REFERENCES

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Heath, RGM and Claassen, M. 1999*. An Overview of the Pesticide and Metal Levels Present in Populations of the Larger Indigenous Fish Species of Selected South African Rivers*. Water Research Commission Report No: 428/1/99. ISBN No: 186845 5807. 1999.

Rossouw, N. *The development of Management orientated models for Eutrophication control.* Division of Water Technology, CSIR. P.O.Box 395, Pretoria, 0001

Van Veelen, M, 2007. *Assessment of the Water Availability in the Crocodile (west) River Catchment: water Quality Assessment*, 2007.

Van Veelen, and Maree, D, 2007. *Outeniqua; Water Quality; Water Situation Study; Gouritz Water Management Area*, 2007.

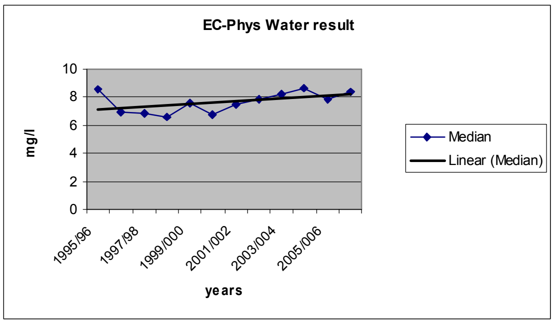
Vosloo, R and Bouwman, H, 2005. *Survey of certain Persistent Organic Pollutants in Major South African Waters*. Water Research Commission Report No: 1215/1/5, ISBN No: 1-77005-245-3. June 2005

# Appendix A: Graphs

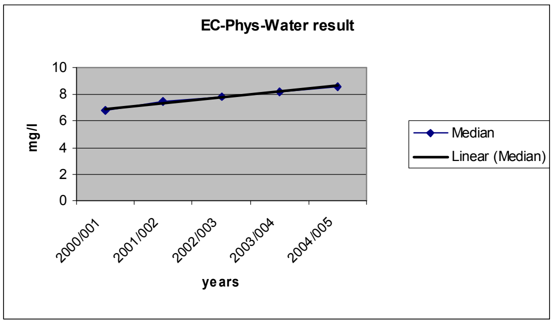
- **Time series: 2003 – 2005**
- **Annual Median Concentration vs Time (Yearly)**

## B8H051 Tzaneen Dam on Great Letaba River Left canal

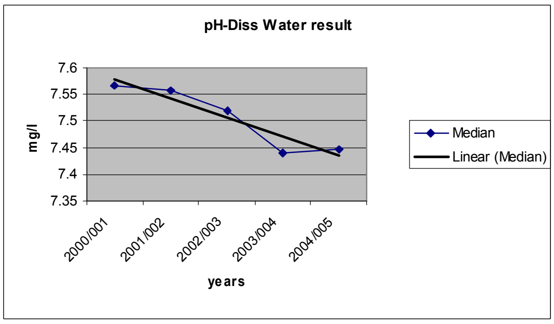
**$NH_4$ 2000 - 2005**



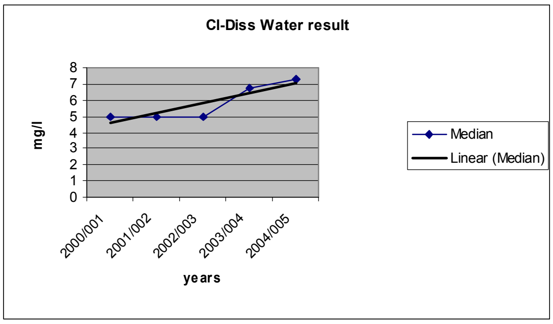

**Long Term EC**



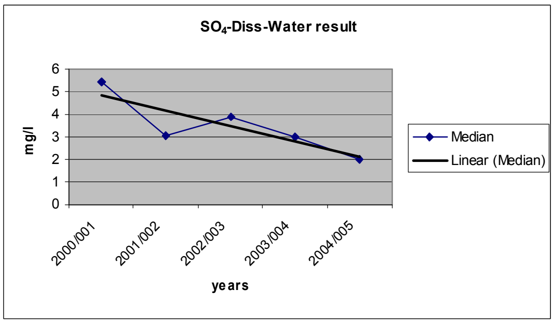

**EC 2000 - 2005**



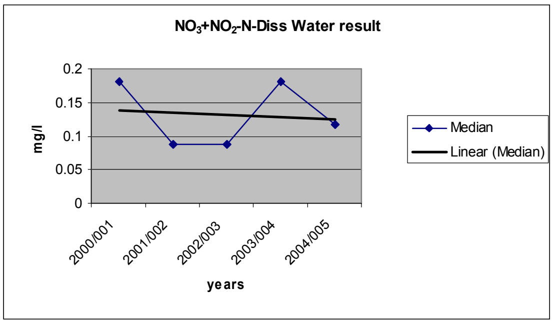

**pH 2000 - 2005**



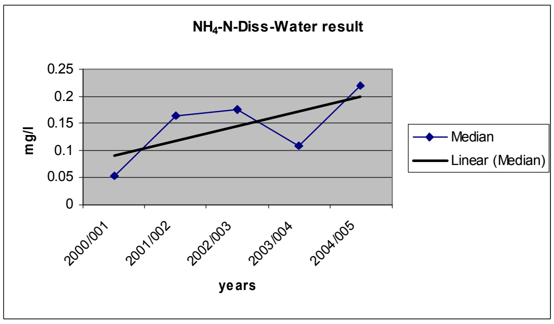

**Cl 2000 – 2005**

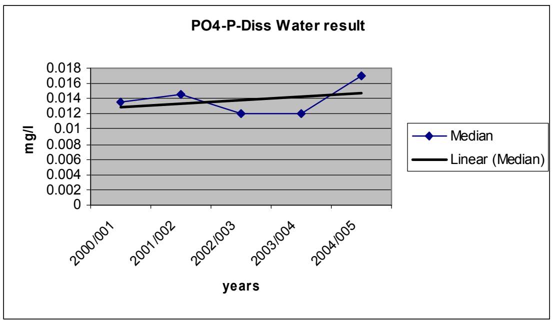



**$SO_4$ 2000 - 2005**



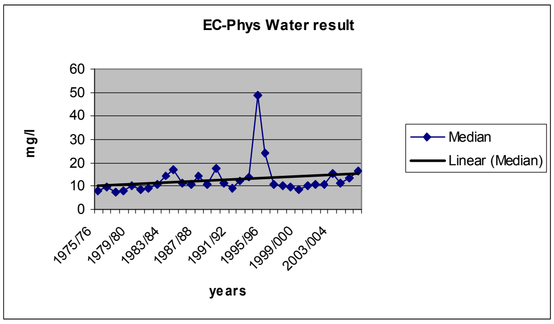

**$NO_2$/$NO_3$ 2000 - 2005**



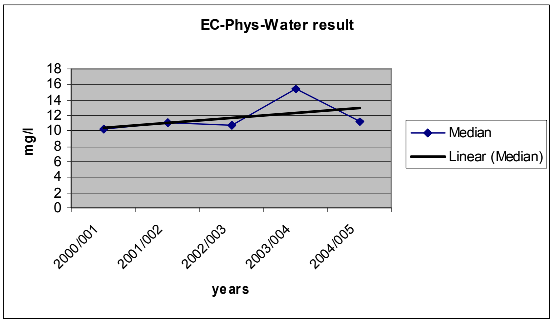




**$PO_4$ 2000 – 2005**

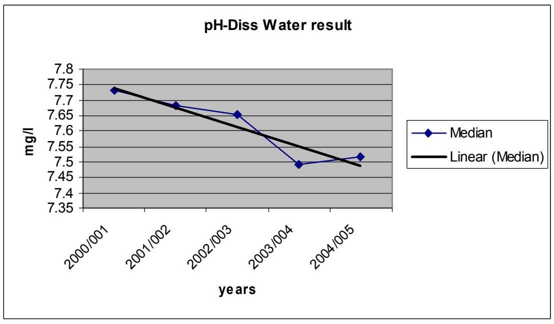
## B8H009 @ Letaba on Groot Letaba



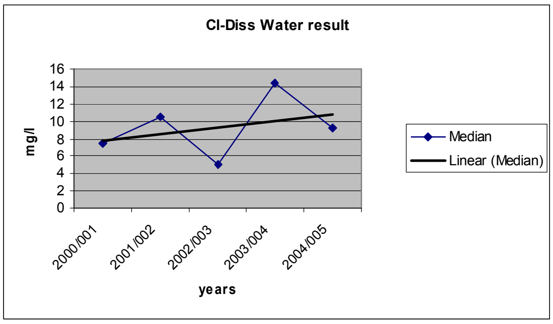

**Long Term EC**




**EC 2000 – 2005**




**pH 2000 - 2005**

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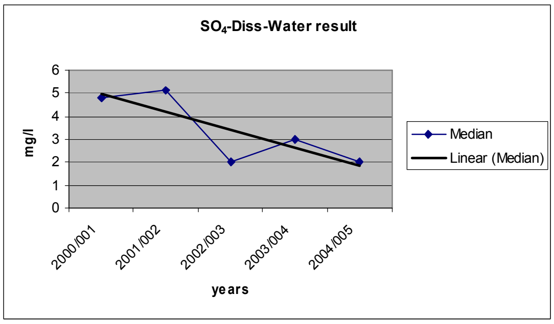
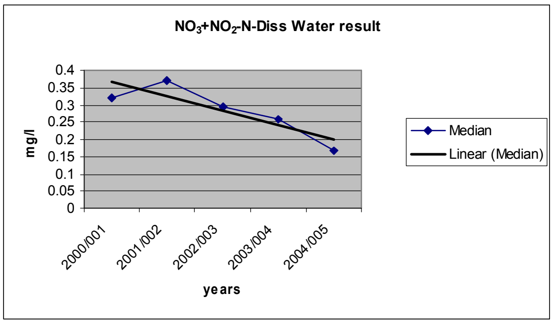
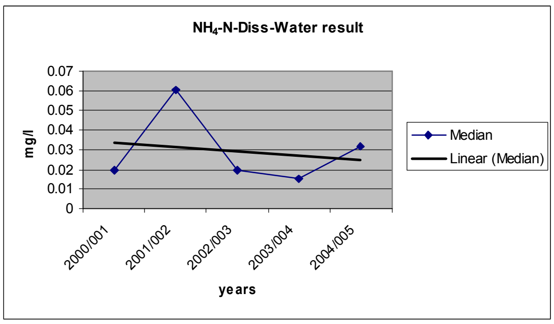


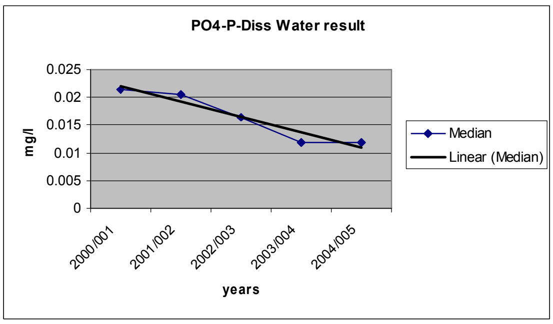

**$SO_4$ 2000 – 2005**




**$NO_3$/$N0_2$ 2000 - 2005**

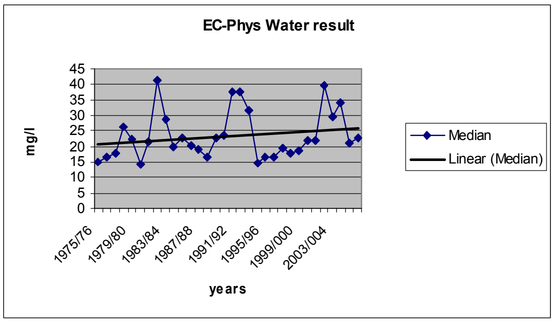



**$NH_4$ 2000 - 2005**

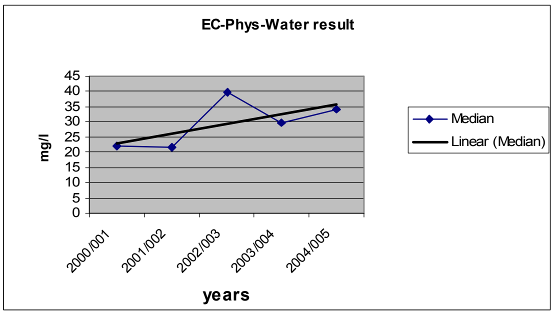



**$PO_4$ 2000 - 2005**

## B8H010 Letsitele River @ Mohlaba's Reserve




**EC Long Term**

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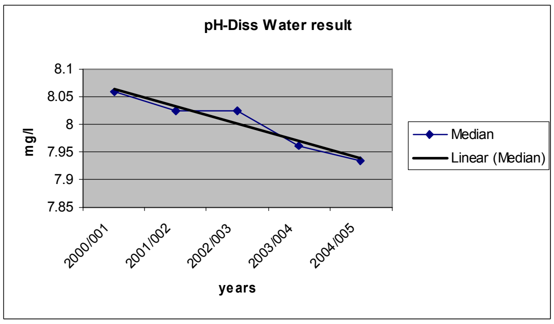
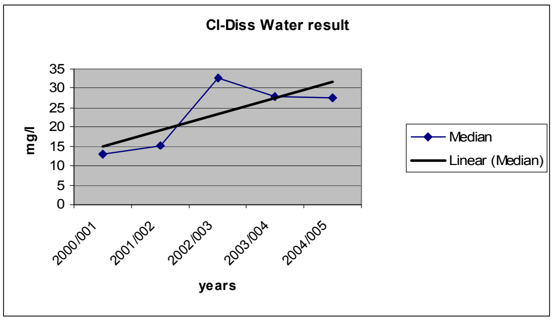
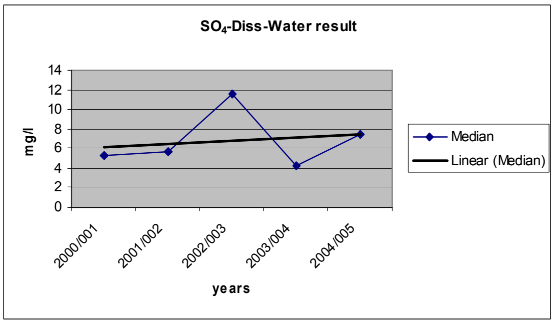


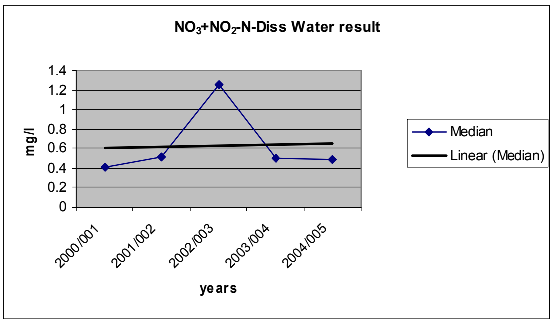

**pH 2000 - 2005**




**Cl 2000 – 2005**




**$SO_4$ 2000 - 2005**

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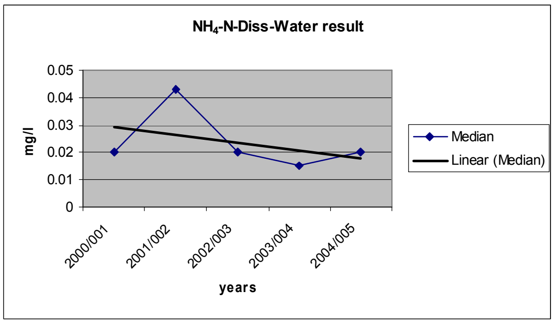
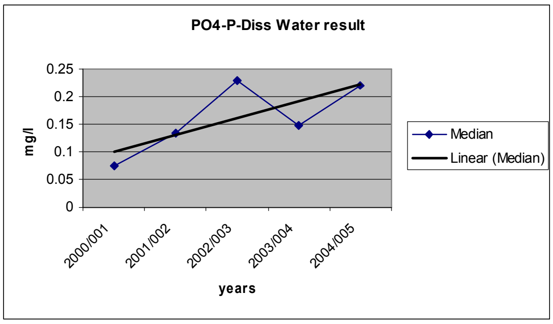
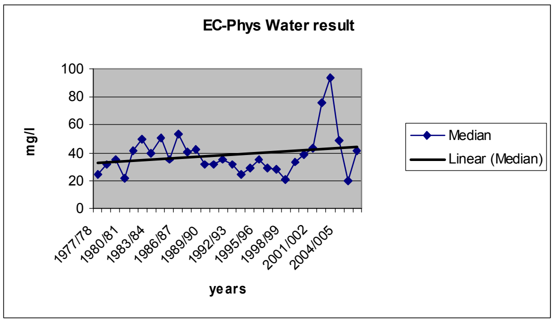


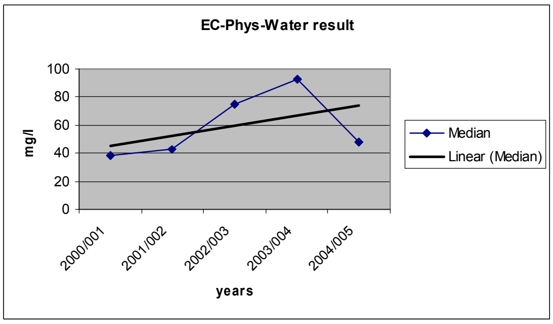




**$PO_4$ 2000 - 2005**

## B8H008 @ Letaba Ranch on Groot Letaba




**Long Term EC**

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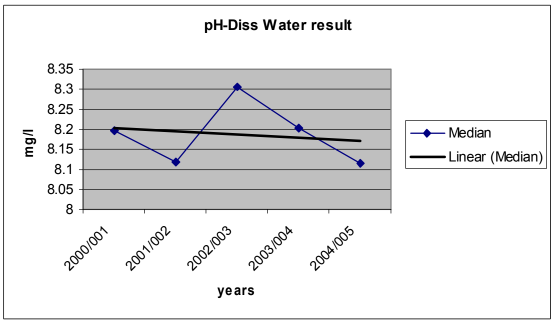


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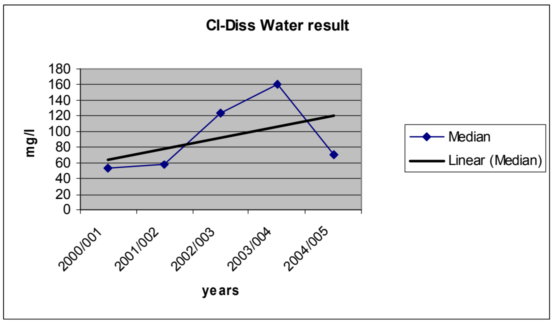
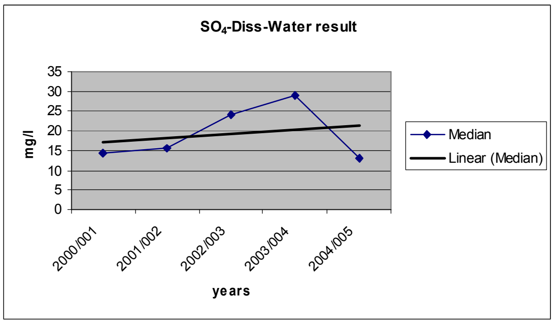



**Cl 2000 - 2005**

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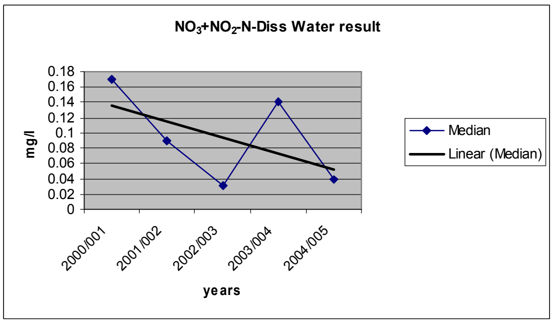


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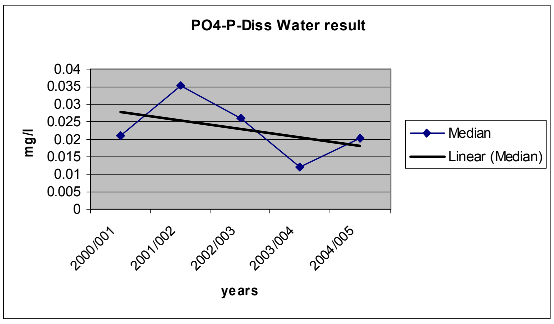


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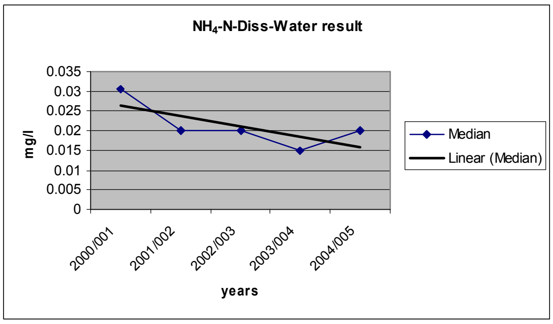
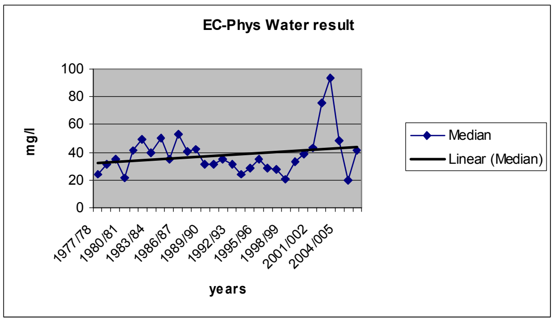
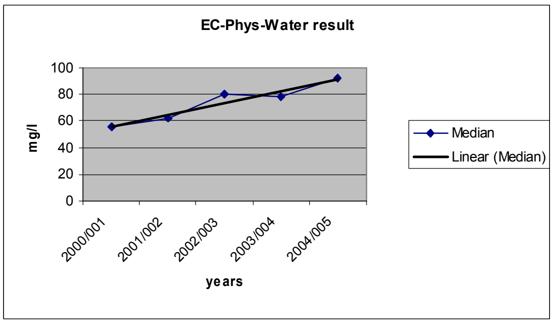



**$NH_4$ 2000 - 2005**

## B8H028 Great Letaba @ Mahlangene/Kruger Nat Park




**Long Term EC**

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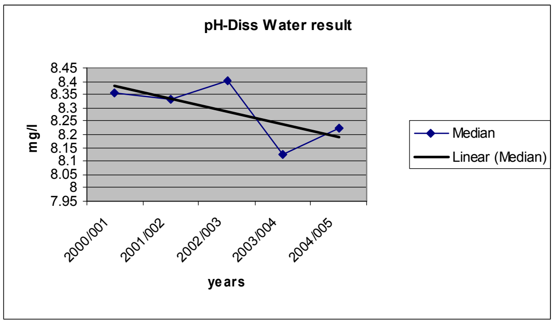
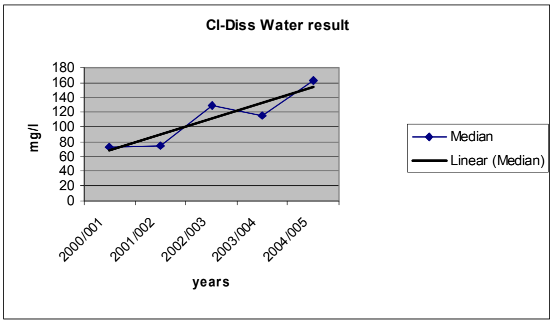
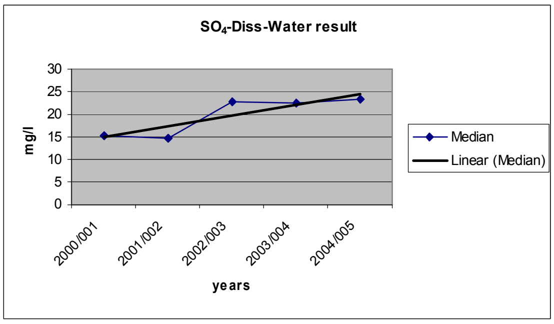



**pH 2000 - 2005**




**Cl 2000 - 2005**

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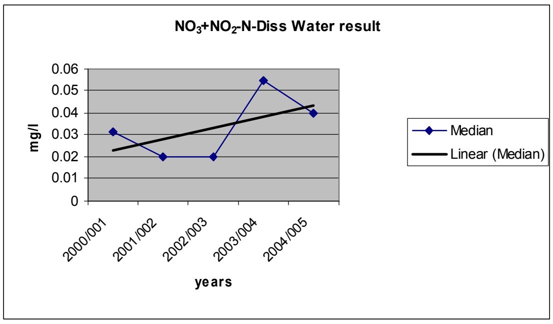
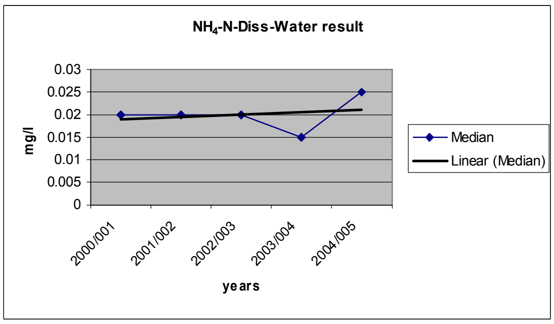



**$NO_3/NO_2$ 2000 - 2005**

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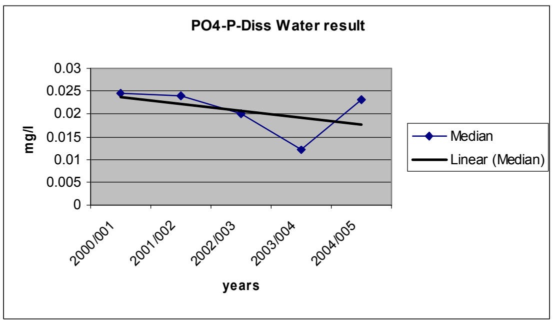


**$PO_4$ 2000 - 2005**