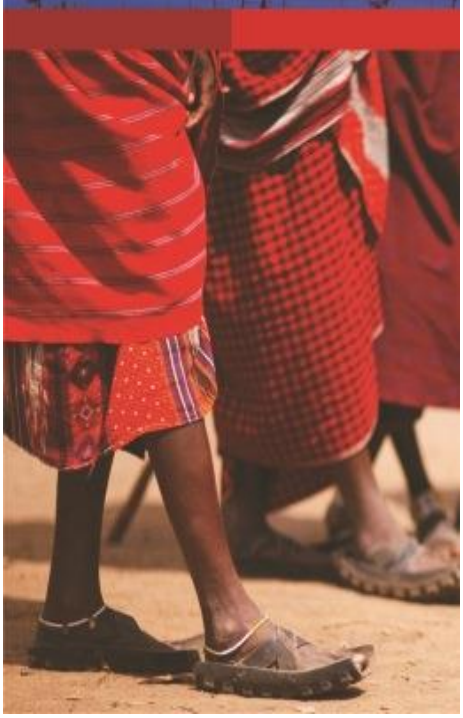


DIGBY WELLS
ENVIRONMENTAL

Sun City Resort Complex: Proposed Expansion

Aquatic Biodiversity and Impact Assessment

Project Number:

SUN4642

Prepared for:

Sun International (Pty) Ltd.

June 2018

Digby Wells and Associates (South Africa) (Pty) Ltd
Co. Reg. No. 2010/008577/07. Turnberry Office Park, 48 Grosvenor Road, Bryanston, 2191. Private Bag X10046, Randburg, 2125, South Africa
Tel: +27 11 789 9495, Fax: +27 11 069 6801, info@digbywells.com, www.digbywells.com

This document has been prepared by Digby Wells Environmental.

Report Type:	**Aquatic Biodiversity and Impact Assessment**
Project Name:	**Sun City Resort Complex: Proposed Expansion**
Project Code:	**SUN4642**

Name	Responsibility	Signature	Date
Nathan Cook Cand.Sci.Nat. (Pending)	Fieldwork/Reporting		May 2018
Byron Bester Pr.Sci.Nat.	Technical Review		June 2018

EXECUTIVE SUMMARY

Digby Wells Environmental has been appointed by Sun International (Pty) Ltd. to undertake an Environmental Impact Assessment (EIA) in relation to the proposed future developments within the Sun City Resort Complex. Subsequently, the aim of this study was to assess the aquatic systems associated with the proposed developments in order to classify the current ecological state of said systems and provide an environmental biomonitoring programme for their conservation.

The assessed tributaries included three unclassified tributaries of the Elands River (A22F-00869 Sub-Quaternary Reach), namely the Western Tributary, the Central Tributary and the Eastern Tributary (also known as the Letholenoga River). A total of two aquatic biomonitoring surveys were conducted to best categorise the aquatic conditions of the aforementioned tributaries and to determine any aquatic related potential impacts the proposed developments may cause. The findings from the study classified the tributaries into the following states:

- **Western Tributary:** Category D (largely modified). This assessment was based solely on the riparian vegetation findings due to the dry nature of the tributary observed throughout the study. The modified status can be attributed to vegetation clearing observed in the lower section of the tributary as a result of surrounding urbanisation.
- **Central Tributary:** Category C/D (moderately to largely modified). This modified state of the reach can be attributed to poor water quality findings, which were possibly attributed to discharge from the Resort's nursery area and further compounded by the poor biotic habitat available at the monitoring sites. Riparian habitat was also impacted on due to urbanisation occurring in the lower reaches and also grazing of habitat inside the Resort's boundary.
- **Eastern Tributary:** Category D (largely modified). This modified state can mainly be attributed to flow modifications and sedimentation, which is possibly linked with impacts from the upstream recreational dam and further compounded by a number of impoundments in the form of weirs along the tributary. This ultimately modifies aquatic habitat through fragmentation, resulting in the loss of selected biota from the system.

Findings from the impact assessment show that the largest threat of the proposed future developments upon on the ecology of the associated tributaries (or watercourses), is the increase in surface runoff, which will further facilitate erosion and sedimentation of the already modified systems. Furthermore, an increase in contaminant and hazardous chemicals entering the associated tributaries is expected, especially due to the predicted runoff associated with the Project. Physical alterations to riparian habitat is also suspected to occur due to proposed developments within the 32 m buffer zones as stipulated by the North West Biodiversity Act.

Management actions against the aforementioned potential impacts have been provided for and include, but are not limited to, the proposed mitigation actions in the report. Unplanned events for the proposed project were also determined and include the potential of chemical / contaminant spills from the developments as well as possible spills and leakages from the proposed pipeline.

As previously stated, the largest concern with the Sun International Project, in terms of aquatic ecology, is suspected to be the potential increase in surface runoff from the proposed developments which has a number of indirect impacts itself. Aquatic ecology is suspected to be negatively influenced as a result of the aforementioned concern through the deterioration of water quality, the degradation of habitat and alteration of hydrology. However, as observed in this study the Project area is generally dry with periodic rainfall events and as such, it is predicted that if Sun International remain outside of the 32m buffer zone from aquatic systems and implement the proposed mitigation measures where necessary, the impact on aquatic ecology will be negligible.

Therefore, authorisation of the Project with regards to the aquatic environment of the area is acceptable provided that the following terms are met:

- Adhere to the North West buffer zones of 32 m from all aquatic resources as indicated in Figure 9-1; and
- Ensure that the provided Aquatic Biomonitoring Programme is followed on an annual basis by a suitably Department of Water Affairs approved aquatic ecologist.

TABLE OF CONTENTS

1 Introduction 9
1.1 Project Background 9
1.2 Legislative Content 13
2 Details of the Specialist 14
2.1 Declaration of the Specialist 15
3 Conditions of this Report 16
4 Scope and Methodology of the Study 17
4.1 Details of the site visit 17
4.1.1 Baseline Determination 18
4.1.1.1 Water Quality 18
4.1.1.2 Habitat Quality 18
4.1.1.2.1 Intermediate Habitat Integrity Assessment 18
4.1.1.3 Aquatic Macroinvertebrate Assessment 21
4.1.1.3.1 Integrated Habitat Assessment System 21
4.1.1.3.2 South African Scoring System 22
4.1.1.3.3 Macroinvertebrate Response Assessment Index 23
4.1.1.4 Ichthyofaunal Assessment 23
4.1.1.4.1 Fish Response Assessment Index 24
4.1.1.5 Present Ecological Status 24
4.1.2 Impact Assessment 24
5 Existing Environment 2
5.1 Ecological Importance and Sensitivity 6
5.2 Current Aquatic Related Impacts 6
6 Limitations to the Study 7
7 Results and Discussion 8
7.1 Water Quality 8
7.2 Intermediate Habitat Integrity Assessment 10
7.3 Macroinvertebrate Assessment 13

7.3.1 Integrated Habitat Assessment System 13
7.3.2 South African Scoring System 14
7.3.3 Macroinvertebrate Response Assessment Index 16
7.4 Ichthyofauna Assessment 17
7.4.1 FRAI Assessment 20
8 Present Ecological Status 22
9 Impact Assessment 23
9.1 Construction Phase 23
9.1.1 Impact Description: Water and Habitat Quality Deterioration 23
9.1.2 Management Objectives 24
9.1.3 Management Actions 24
9.1.3.1 Buffer zone establishment 24
9.1.4 Impact Ratings 28
9.2 Operational Phase 31
9.2.1 Impact Description: Water and Habitat Quality Deterioration 32
9.2.2 Management Objectives 32
9.2.3 Management Actions 32
9.2.4 Impact Ratings 33
9.3 Decommissioning Phase 38
9.4 Unplanned and Low Risk Events 38
10 Aquatics Biomonitoring Programme 39
11 Conclusion 39
12 Reference List 41

LIST OF FIGURES

Figure 1-1: Localities of proposed developments 12
Figure 4-1: Annual Rainfall Trend for the North West Province (DWS, 2018) 17
Figure 4-2: Guidelines Used for the Interpretation and Classification of the SASS5 Scores (Dallas, 2007) 23
Figure 5-1: Wetland Delineation 3

Figure 5-2: Sampling Site Localities in Relation to the Tributaries of Concern 4
Figure 7-1: Water Observed from the Nursery Located Upstream from Site CT1 10
Figure 9-1: Aquatic 32 m Buffer Zones 27

LIST OF TABLES

Table 1-1: Summary of Projects 9
Table 1-2: Structure of this report in accordance with the EIA Regulations 13
Table 2-1: Details of the Specialist(s) who prepared this Report 15
Table 4-1: Criteria in the Assessment of Habitat Integrity 19
Table 4-2: Table giving Descriptive Classes for the Assessment of Modifications to Habitat Integrity 20
Table 4-3: Criteria and Weights Used for the Assessment of Habitat Integrity 20
Table 4-4: Intermediate Habitat Integrity Categories (Kleynhans, 1996) 21
Table 4-5: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat 22
Table 4-6: Impact Assessment Parameter Ratings 26
Table 4-7: Probability/Consequence Matrix 30
Table 4-8: Significance Rating Description 1
Table 5-1: Coordinates and Descriptions of the Selected Monitoring Sites 5
Table 5-2: Desktop Information for the Central and Eastern tributaries 6
Table 7-1: Water Quality Results Recorded During the Study 8
Table 7-2: Western Tributary Riparian Intermediate Habitat Integrity Assessment 10
Table 7-3: Central Tributary Instream Intermediate Habitat Integrity Assessment 11
Table 7-4: Central Tributary Riparian Intermediate Habitat Integrity Assessment 12
Table 7-5: Eastern Tributary Instream Intermediate Habitat Integrity Assessment 12
Table 7-6: Intermediate Habitat Integrity Assessment for Riparian Habitat 13
Table 7-7: IHAS Results Recorded for the Study 13
Table 7-8: SASS5 Result Recorded During the Study 14
Table 7-9: Sampled Macroinvertebrates at Site CT3 15
Table 7-10: MIRAI Scores for the Central Tributary based on Site CT1 Findings 16
Table 7-11: MIRAI Scores for the Eastern Tributary 17

Table 7-12: Sampled, Observed and Expected Fish Species during the Study 17
Table 7-13: Site Locations and Photographs of Sampled Fish Species..... 18
Table 7-14: Central Tributary FRAI Results..... 20
Table 7-15: Eastern Tributary FRAI Results..... 21
Table 8-1: The Present Ecological Status of the Western Tributary..... 22
Table 8-2: The Present Ecological Status of the Central Tributary 22
Table 8-3: The Present Ecological Status of the Eastern Tributary..... 23
Table 9-1: Potential Surface Runoff Impacts of the Construction Phase 28
Table 9-2: Potential Chemical Impacts of the Construction Phase 30
Table 9-3: Increased Runoff and Erosion from Impermeable Surfaces and Beach Expansion 33
Table 9-4: Potential Chemical Impacts associated with the Operational Phase..... 34
Table 9-5: Potential Erosion Impacts associated with the Culverts..... 36
Table 9-6: Unplanned Events and Mitigation Measures 38
Table 10-1: Biomonitoring Programme..... 39

LIST OF APPENDICES

Appendix A: Site Photographs
Appendix B: CV's

1 Introduction

Digby Wells Environmental (*hereafter Digby Wells*) has been appointed by Sun International (Pty) Ltd. (*hereafter the Resort*) to undertake an Environmental Impact Assessment (EIA) in relation to proposed future developments within the Sun City Resort Complex (*hereafter the* Project) located near Rustenburg, North West Province.

1.1 Project Background

Table 1-1 below presents an overview of the proposed activities and developments for the Project.

Table 1-1: Summary of Projects

Category	No.	Project Name	Project Summary
Resort Expansion Projects (REP)	REP1	Eco-Lodge	Development of a Bush Lodge / Eco-Lodge at Gary Player Golf Course Workshop.
	REP2	Driving Range Road	Construct a Road to connect the Driving Range at Lost City Golf Course (LCGC) to the Gary Player Golf Course (GPGC) via the Palace garden road and Valley of Waves (VOW) road.
	REP3	Kwena Gardens Expansion	Construct 20 additional Rustic Chalets at Kwena Gardens.
	REP4.1	Vacation Club (VC) Phase 3	Construct an additional 150 simplex units, 2- 3 bed units and associated infrastructure to expand capacity at the VC. The site identified for the expansion currently houses the Helipad and Nursery.
	REP4.2	Vacation Club (VC) Phase 4	Construct an additional 150 simplex units, 2- 3 bed units and associated infrastructure to expand capacity at the VC. The VC Phase 4 area occupies a total footprint of 82 ha and is located between the decommissioned landfill site and Bakubung Gate. This area falls within the undeveloped area of the resort which is not fenced, therefore fencing of this area will be required as part of its establishment.
	REP5	Recreational Lake Beach Expansion	Expand the existing artificial beach at the Lake and construct an additional shallow swimming pool at Waterworld Beach
	REP6	Helipad relocation and expansion	Decommission the existing helipad, to make space for VC Phase 3, and construct a new helipad with increased bays closer to the Palace.
	REP7	Additional Parking Garage, Convention	Construct an additional parking garage, Convention Centre and Hotel (250 rooms)

		Centre and Hotel	including a bridge link from Sun Central to the new Hotel.
	REP8	Soccer Fields	Develop 2 soccer fields at the Warehouse
Utilities and Services Projects (USP)	USP1	Stormwater culverts at Golf Course Roads	Install Stormwater pipes / culverts at Golf Course Roads to allow water to flow under the roads and maintain the road surface for fence inspections by security (prevent floods washing away the road).
	USP2	Additional Reservoirs to Supplement existing water storage capacity	Construct 2 x 10Ml reservoirs or alternatively 1x 20Ml Reservoir on Telkom Hill next to existing Upper Reservoir.
	USP3	Effluent transfer line replacement	Currently there is an effluent transfer line (old asbestos line) through Sunset Drive to Hole 2. This line will be decommissioned (shut down) but remain in place. A new line will then be installed against the fence of Letsatsing.
	USP4	Sunset-Sky-train Fresh Water Line	Construct a main water line from the Welcome Centre to Sky-train (pipe will be attached to sky-train route)
	USP5	Ledig Sewer Line decommissioning, New WWTW for VC and Palace	Currently the sewer line running through Ledig (old asbestos line). The line will be decommissioned (shut down but remain in place).
	USP6	South Village Pipeline	Construct an additional pipeline for water supply to South Village
	USP7	Generator Park	Consolidate the generators throughout the site into one area for effective monitoring and control, or establish a generator park to service the east side business units.
Maintenance Projects (MP)	MP1	Clearance of Fence Roads	Vegetation Clearance at perimeter fences to serve as maintenance roads and Fire Breaks (25 km)
	MP2	Sun Park Culverts	The bottom access road to Sun City crosses a watercourse at two points downstream of the Sun City Recreational Lake. There are a number of culverts, allowing water to flow underneath the road. The culverts in question are pairs of culverts at two sites close to the Sun Park. These culverts have not been cleaned out in recent years and have begun to silt up with soil, vegetation and litter. Sun City wishes to establish an access road to

			the Culverts to enable regular maintenance of the culverts, and periodically clean the culverts as necessary. This is considered an ongoing maintenance project and not a once-off activity.

The localities of the proposed future developments are illustrated in Figure 1-1 below.

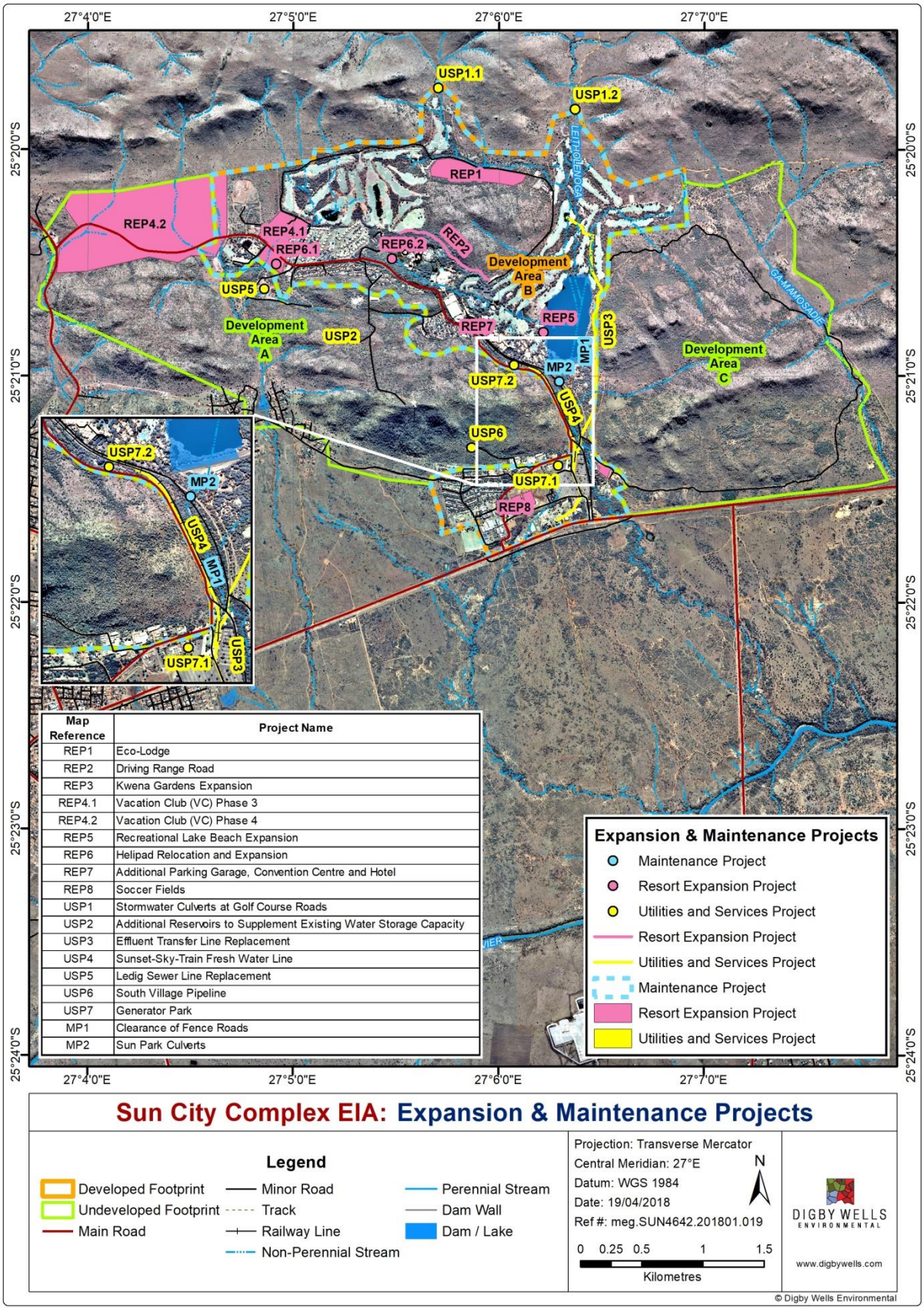


Figure 1-1: Localities of proposed developments

1.2 Legislative Content

Activities that are listed in terms of the Environmental Impact Assessment (EIA) Regulations[1] require environmental authorisation prior to commencing. The proposed Projects at Sun City constitutes Listed Activities in terms of GN R 983 (Listing Notice 1); GN R 984 (Listing Notice 2) and GN R 985 (Listing Notice 3) as amended.

This specialist aquatics report has been compiled in terms of Appendix 6 of the NEMA EIA Regulations, 2014, (as amended) in terms of the Scoping and EIA process which is being followed in applying for Environmental Authorisation.

The requirements of Appendix 6 are presented in Table 1-2 below and cross-referenced to the relevant sections of this report.

Table 1-2: Structure of this report in accordance with the EIA Regulations

Regulatory Requirement for EIA Reports	Relevant Section of this report
1. (1) A specialist report prepared in terms of these Regulations must contain -	
(a) details of— (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Please refer to Section 2 and Appendix B of this Report
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Please refer to Section 2 of this report: Details of the Specialist
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Please see Section 4: Scope and Methodology of the Study
(cA) an indication of the quality and age of base data used for the specialist report;	Please see Section 5.1: Ecological Importance and Sensitivity and Section 12: Reference List
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Please see Section 5: Existing Environment

[1] As published in Government Notices R982; 983; 984 and 985 on 4 December 2014, as Amended 7 April 2017.

(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Please see Section 4.1: Details of the site visit
(e) a description of the methodology adopted in preparing the report inclusive of equipment and modelling used;	Please see Section 4: Scope and Methodology of the Study
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Please see Section 9: Impact Assessment
(g) an identification of any areas to be avoided, including buffers;	
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Please see Section 6: Limitations to the Study
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Please see Section 9: Impact Assessment
(k) any mitigation measures for inclusion in the EMPr;	Please see Section 11: Conclusion
(l) any conditions for inclusion in the environmental authorisation;	
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	
(n) a reasoned opinion— (i) whether the proposed activity, activities or portions thereof should be authorised; (i) (A) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	
(q) any other information requested by the competent authority.	

2 Details of the Specialist

This Specialist Report has been compiled by the following specialists (CVs of the Project Team are included in Appendix B).

Table 2-1: Details of the Specialist(s) who prepared this Report

Responsibility	**Field work and report compilation**
Full Name of Specialist	Nathan Gerard Cook
Highest Qualification	BSc in Environmental Sciences
Years of experience in specialist field	1
Registration	South African Council for Natural Scientific Professionals: *Candidate Natural Scientist* (Reg. No. 119160- Pending)
Responsibility	**Report review**
Full Name of Specialist	Byron Bester
Highest Qualification	MSc in Aquatic Health
Years of experience in specialist field	7
Registration	South African Council for Natural Scientific Professionals: *Professional Natural Scientist* (Reg. No. 400662/15)

2.1 Declaration of the Specialist

I Nathan Cook, as the appointed specialist hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent:
  - other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity; or
  - am not independent, but another specialist that meets the general requirements set out in Regulation 13 have been appointed to review my work (Note: a declaration by the review specialist must be submitted);
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to

influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application;

- have ensured/will ensure that information containing all relevant facts in respect of the application was/will be distributed or was/will be made available to interested and affected parties and the public and that participation by interested and affected parties was/will be facilitated in such a manner that all interested and affected parties were/will be provided with a reasonable opportunity to participate and to provide comments;
- have ensured/will ensure the inclusion of inputs and recommendations from the specialist reports in respect of the application, where relevant; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist:

Nathan Gerard Cook

Full Name and Surname of the specialist:

Digby Wells Environmental

Name of company:

24/04/2018

Date:

3 Conditions of this Report

Findings, recommendations and conclusions provided in this report are based on the best available scientific methods and the author's professional knowledge and information at the time of compilation. Digby Wells employees involved in the compilation of this report, however, accepts no liability for any actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, and by the use of the information contained in this document.

No form of this report may be amended or extended without the prior written consent of the author and/or a relevant reference to the report by the inclusion of an appropriately detailed citation.

Any recommendations, statements or conclusions drawn from or based on this report must clearly cite or make reference to this report. Whenever such recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety.

4 Scope and Methodology of the Study

As a part of the Environmental Authorisation process for the proposed future developments at the Resort Complex, an aquatic impact assessment was required to be undertaken within the surrounding aquatic ecosystems, in order to establish baseline conditions prior to the commencement of the Project. Furthermore, this study aims to determine the current aquatic biodiversity, aquatic ecological integrity and identify any potential aquatic-related impacts through two aquatic surveys detailed below.

4.1 Details of the site visit

In order to best understand the variable conditions of the aquatic ecology associated with the Project area, the surveys were selected during a low flow/rainfall period and during a high flow/rainfall period. These selections were based on average rainfall data gathered from provincial rainfall trend data provided by the Department of Water and Sanitation (DWS, 2018) as illustrated in Figure 4-1 below. According to the gathered data, the onset of the North West rainy season occurs during the months of October to November with the highest average monthly rainfall occurring during the month of January. As a result of these findings, the low flow survey was conducted in November 2017, in order to characterise conditions after the dry season (May-September), with the high flow survey falling in the month of January aligning with the highest average monthly rainfall.

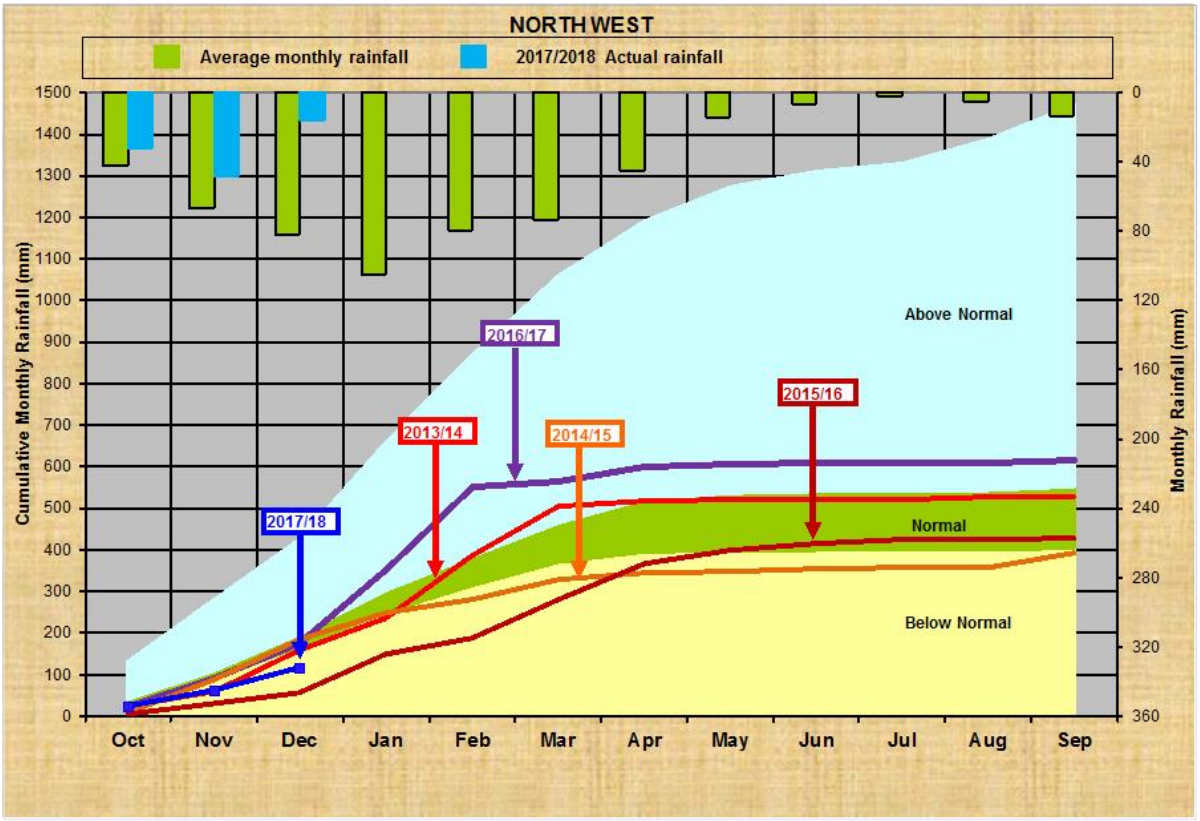


Figure 4-1: Annual Rainfall Trend for the North West Province (DWS, 2018)

4.1.1 Baseline Determination

In order to complete this study and to enable an adequate description of the representative status of the aquatic biodiversity associated with the affected aquatic ecosystems, the following indicators were evaluated as part of the assessment:

- Stressor Indicators:
  - *In situ* water quality.
- Habitat Indicators:
  - Instream and riparian habitat integrity.
- Response Indicators:
  - Aquatic macroinvertebrates assemblages; and
  - Ichthyofaunal assemblages.

The following assessments were conducted in order to best characterise the aforementioned aquatic indicators associated with the Project.

4.1.1.1 Water Quality

Selected *in situ* water quality variables were measured at each of the selected sampling sites using water quality meters manufactured by Extech Instruments, namely an ExStik EC500 Combination Meter and an ExStik DO600 Dissolved Oxygen Meter. Constituents considered include temperature (C^{o}), pH, electrical conductivity (µS/cm), dissolved oxygen concentration (mg/l) and saturation percentage. Water quality guidelines used in this report are for Aquatic Ecosystems (DWAF, 1996).

4.1.1.2 Habitat Quality

The availability and diversity of aquatic habitat is important to consider in assessments due to the reliance and adaptations of aquatic biota to specific habitats types (Barbour *et. al*., 1996). Habitat quality and availability assessments are usually conducted alongside biological assessments that utilise fish and macroinvertebrates. Aquatic habitat (habitat) was assessed through visual observations on each river system considered.

4.1.1.2.1 Intermediate Habitat Integrity Assessment

To define a general habitat, for baseline purposes, the instream and riparian habitat was assessed and characterised according to “Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems (Section D).

The Intermediate Habitat Integrity Assessment (IHIA) model was used to assess the integrity of the habitats from a riparian and instream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996). The criteria utilised in the assessment of habitat integrity in the current study are presented in Table 4-1.

Table 4-1: Criteria in the Assessment of Habitat Integrity

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et. al*., 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or alternatively agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et. al*., 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et. al*., 1992). Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

The relevant criteria is then weighted and scored according to Kleynhans (1996), as seen in the tables below (Table 4-2) and Table 4-3).

Scores are calculated based on ratings received from the assessment. The estimated impacts of the criteria are summed and expressed as a percentage to arrive at a provisional habitat integrity assessment. The scores are placed into the IHIA categories (Kleynhans, 1996) as seen in Table 4-4.

Table 4-2: Table giving Descriptive Classes for the Assessment of Modifications to Habitat Integrity

Impact Category	Description	Score
None	No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

Table 4-3: Criteria and Weights Used for the Assessment of Habitat Integrity

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		

Instream Criteria	Weight	Riparian Zone Criteria	Weight
TOTAL	**100**	**TOTAL**	**100**

It should be noted that the IHIA was based on regions assessed in the current studies and therefore may only constitute the assessment of conditions within the considered Sub-Quaternary Reach (SQR) length.

Table 4-4: Intermediate Habitat Integrity Categories (Kleynhans, 1996)

Category	Description	Score
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.	80-90
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 has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	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

It should be noted that the IHIA was based on regions assessed in the current study and therefore the above habitat integrity categories and the assessment itself may only constitute the assessment of conditions within the considered SQR length.

4.1.1.3 Aquatic Macroinvertebrate Assessment

The subsections below outline the different macroinvertebrate associated assessments utilised in the study.

4.1.1.3.1 Integrated Habitat Assessment System

Due to the reliance and adaptations of aquatic biota to specific habitats, the availability and diversity of habitats is important to consider in aquatic assessments (Barbour et al., 1998). Assessment of the available habitat for aquatic macroinvertebrate colonisation at each of the sampling sites is vital for the correct interpretation of results obtained following biological assessments. It should be noted that the available methods for determining habitat quality are not specific to rapid biomonitoring assessments and are inherently too variable in their approach to achieve consistency amongst users.

Nevertheless, the Invertebrate Habitat Assessment System (IHAS) has routinely been used in conjunction with SASS as a measure of the variability of aquatic macroinvertebrate biotopes available at the time of the survey (McMillan, 1998). The scoring system was traditionally split into two sections, namely the sampling habitat (comprising 55% of the total score) and the general stream characteristics (comprising 45% of the total score), which were summed together to provide a percentage and then categorised according to the values in Table 4-5.

Table 4-5: Adapted IHAS Scores and associated description of available aquatic macroinvertebrate habitat

IHAS Score (%)	Description
>75	Excellent
65-74	Good
55-64	Adequate / Fair
<55	Poor

However, the lack of reliability and evidence of notable variability within the application of the IHAS method has prompted further field validation and testing, which implies a cautious interpretation of results obtained until these studies have been conducted (Ollis et al., 2006). In the interim and for the purpose of this assessment, the IHAS method was adapted by excluding the assessment of the general stream characteristics, which resulted in the calculation of a percentage score out of 55 that was then categorised by the aforementioned Table 4-5. Consequently, the assessment index describes the quantity, quality and diversity of available macroinvertebrate habitat relative to an “ideal” diversity of available habitat.

4.1.1.3.2 South African Scoring System

The South African Scoring System Version 5 (SASS5) is the current index being used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Chironomidae) to highly sensitive families (e.g. Perlidae). SASS results are expressed both as an index score (SASS Score) and the Average Score Per Taxon (ASPT value).

Sampled invertebrates were identified using the “Aquatic Invertebrates of South African Rivers” (Gerber and Gabriel, 2002). Identification of organisms was made to family level (Thirion *et. al.*, 1995; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Bushveld Basin lower relief ecoregion (Figure 4-2). This method seeks to develop biological bands depicting the various ecological states and is derived from data

contained within the Rivers Database and supplemented with other data not yet in the database.

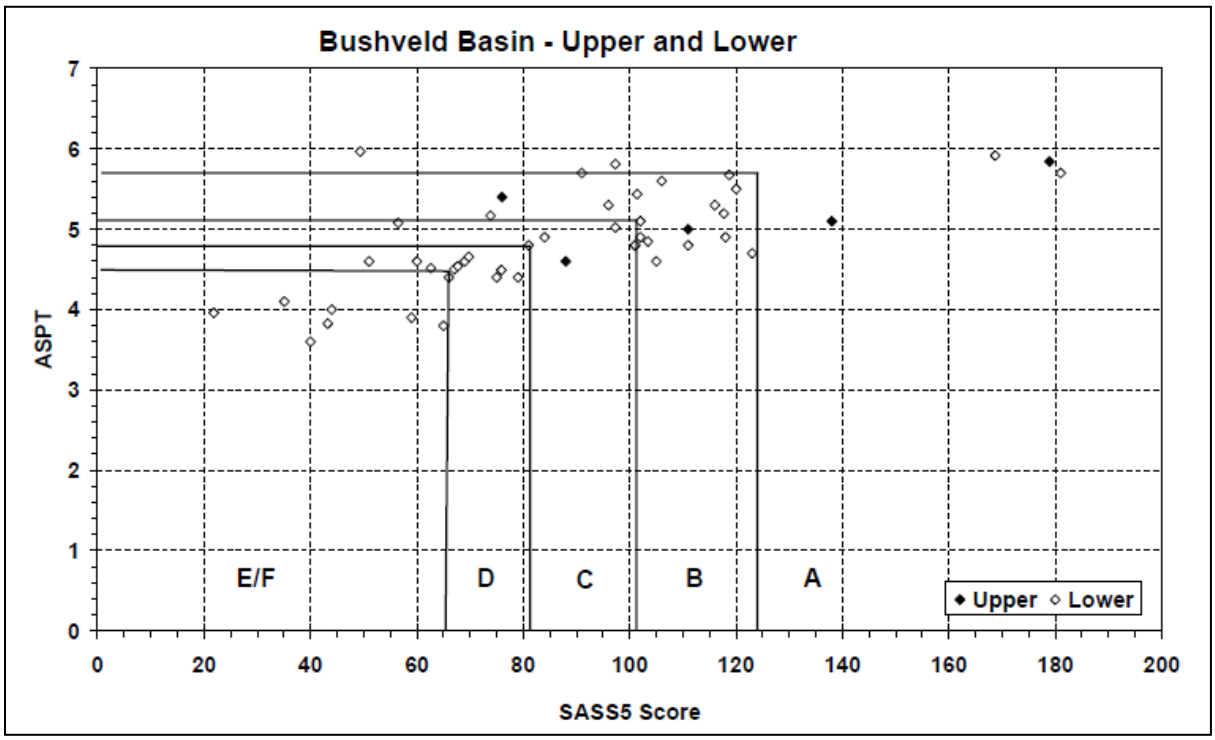


Figure 4-2: Guidelines Used for the Interpretation and Classification of the SASS5 Scores (Dallas, 2007)

4.1.1.3.3 Macroinvertebrate Response Assessment Index

The Macroinvertebrate Response Assessment Index (MIRAI) was used to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community from the calculated reference conditions for the Bushveld Basin. This does not preclude the calculation of SASS5 scores if required (Thirion, 2007). The four major components of a stream system that determine productivity for aquatic macroinvertebrates are as follows:

- Flow regime;
- Physical habitat structure;
- Water quality; and
- Energy inputs from the watershed riparian vegetation assessment.

The results of the MIRAI will assist in the determination of the Present Ecological Status (PES) of the assessed reaches.

4.1.1.4 Ichthyofaunal Assessment

Fish sampling was conducted by means of various techniques including electroshocking with a Smith and Root LR-24 unit as well as the use of cast nets and conventional angling

techniques at applicable sites with sufficient water depth. All fish were captured, identified and counted in the field and released alive at the point of capture. Fish species were identified using the "Complete Guide to the Freshwater Fishes of Southern Africa" (Skelton, 2001).

4.1.1.4.1 Fish Response Assessment Index

The purpose of the Fish Response Assessment Index (FRAI) is to provide a habitat-based cause-and-effect underpinning to interpret the deviation of the fish assemblages from the identified reference conditions. The information gained using the FRAI provides an indication of the PES of the river based on the fish assemblage structures observed. It must be noted that a reach based FRAI assessment was completed utilising only sampling sites in the upper reaches of the three tributaries of concern. These findings should be interpreted with caution as the assumption was made that the fish assemblages were homogenous throughout the assessed reaches. In order to obtain more accurate FRAI results, sites need to be assessed along the entirety of each SQR of concern instead of only the upper reaches.

4.1.1.5 Present Ecological Status

Ecological classification refers to the determination and categorisation of the integrity of the various selected biophysical attributes of ecosystems compared to the natural or close to natural reference conditions (Kleynhans and Louw, 2007). For the purpose of this study the Present Ecological Status (PES) of tributaries considered in the study was derived through the characterisation of the various biophysical attributes as described in the above sections. The River Eco-status Monitoring Programme (REMP) Ecological Classification manual by Kleynhans and Louw (2007) was used in order to accomplish this task.

It is important to note that an adapted version of the Riparian Ecological Category surrogate (Dr. C.J. Kleynhans, *pers. comm.*, 2015) will be used in this assessment as follows:

*Riparian Vegetation EC = 100-(((IHIA 'Natural vegetation removal')+(IHIA 'Exotic Vegetation Encroachment'))/50*100)*.

4.1.2 Impact Assessment

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts.

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 4-8. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 4-7, which is extracted from Table 4-6. The description of the significance ratings is discussed in Table 4-8.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 4-6: Impact Assessment Parameter Ratings

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 4-7: Probability/Consequence Matrix

Significance																																						
Probability 7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Consequence																																					

Table 4-8: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

5 Existing Environment

The study area is located within the Limpopo Water Management Area (WMA) within the A22F quaternary catchment. This places the watercourses of concern within the Bushveld Basin freshwater ecoregion. As delineated in the Wetland Assessment by Digby Wells (2018a), the project area consists of three main watercourses (Figure 5-1). These watercourses are unclassified tributaries of the Elands River (also referred to as Sub-Quaternary Reach SQR A22F-00869). Furthermore, the gathered National Freshwater Ecosystem Priority Area (NFEPA) data (Nel *et al*., 2012) indicates that the project area does not fall within a NFEPA catchment or near any flagship free-flowing rivers.

For the purpose of the study these tributaries have been named as illustrated in Figure 5-2 and are described below with their monitoring points in Table 5-1. Furthermore, it is important to note that the HGM unit 7 (Figure 5-1) was not included in the aquatic assessment as no developments are planned to occur in proximity to the wetland.

- **Western Tributary**: This tributary is located in the far western section of the project area. It is characterised by alluvial substrates and large sections of bedrock. However, this system was observed as dry throughout the aquatic study. A drainage line of this tributary is situated within the proposed development area for Vacation Club Phase 4, as indicated by HGM unit 1 in Figure 5-1.
- **Eastern Tributary**: This tributary is unnamed according to DWS. However, based on the information stipulated in the approved WUL, the watercourse is identified as the Letholenoga River. The Resort's recreational dam is situated along this watercourse and has subsequently resulted in an expression of a perennial nature along the downstream reach. Discharge from the Resort's Waste Water Treatment Works (*hereafter WWTW*) has also contributed to consistent flow. The channel bed is predominantly characterised by fine mud-like sediment, which has accumulated within the downstream reaches, possibly due to the construction of weirs and erosion caused by the recreational dam.
- **Central Tributary**: This tributary is located between the Western and Eastern tributaries. It was assessed from the Resort's nursery area to a downstream impoundment located outside the project boundary near an informal settlement (see Site CT3 in Figure 5-2). Major impacts associated with this system comprised of solid waste dumping and free-roaming livestock activity observed along the entirety of the assessed reach. The current Vacation Club facilities, as well as the golf course, appear to have altered the flow for this tributary as they fall directly in the upper eastern catchment area. The proposed Vacation Club Phase 4 development falls within the upper western catchment area of this reach. Both the aforementioned drainage lines can be observed in Figure 5-1 and Figure 5-2, where they extend northwards from Site CT1 outside the project boundary.

Please refer to Section 8 in the document for the ecological PES determined for each of the tributaries.

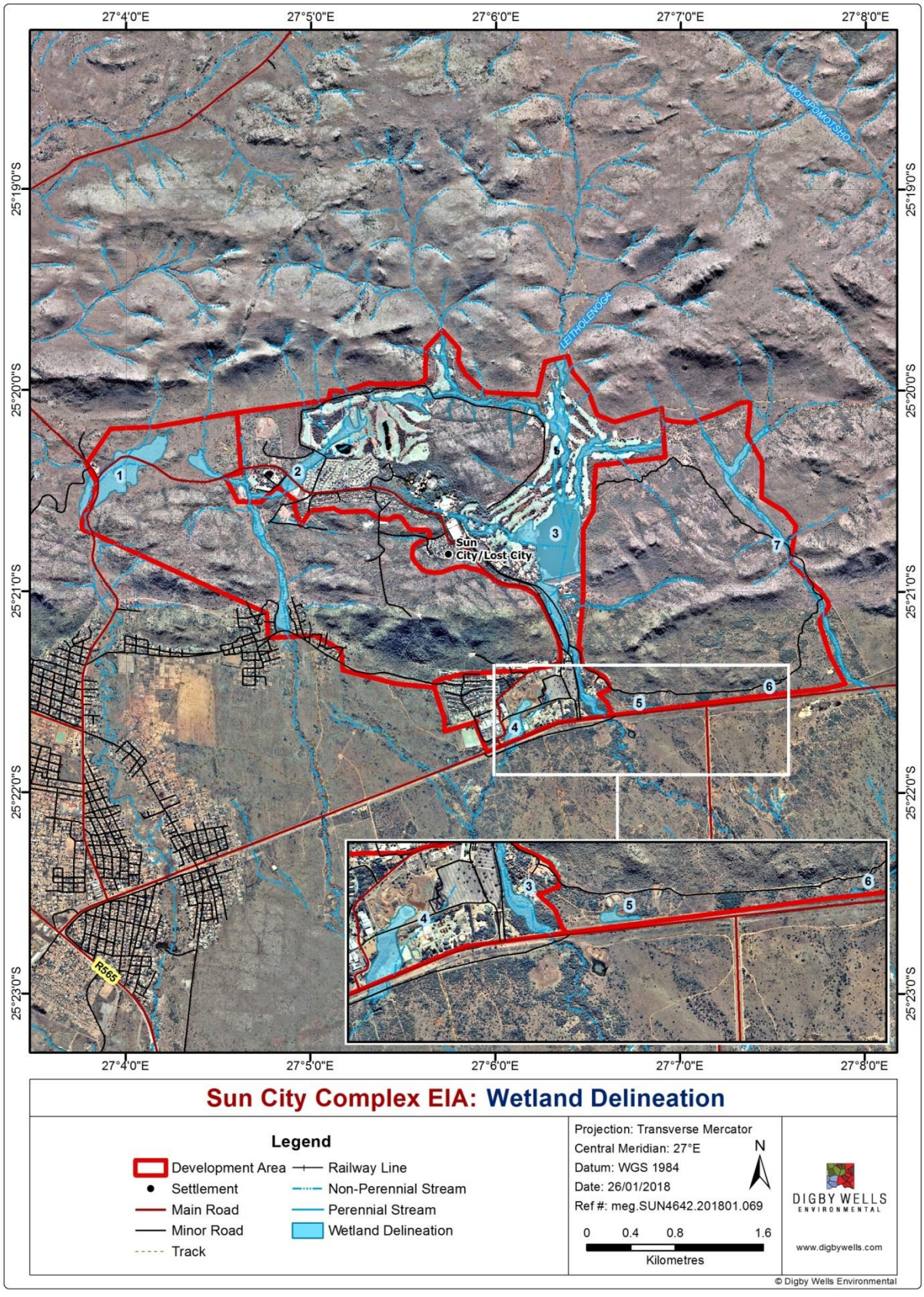


Figure 5-1: Wetland Delineation

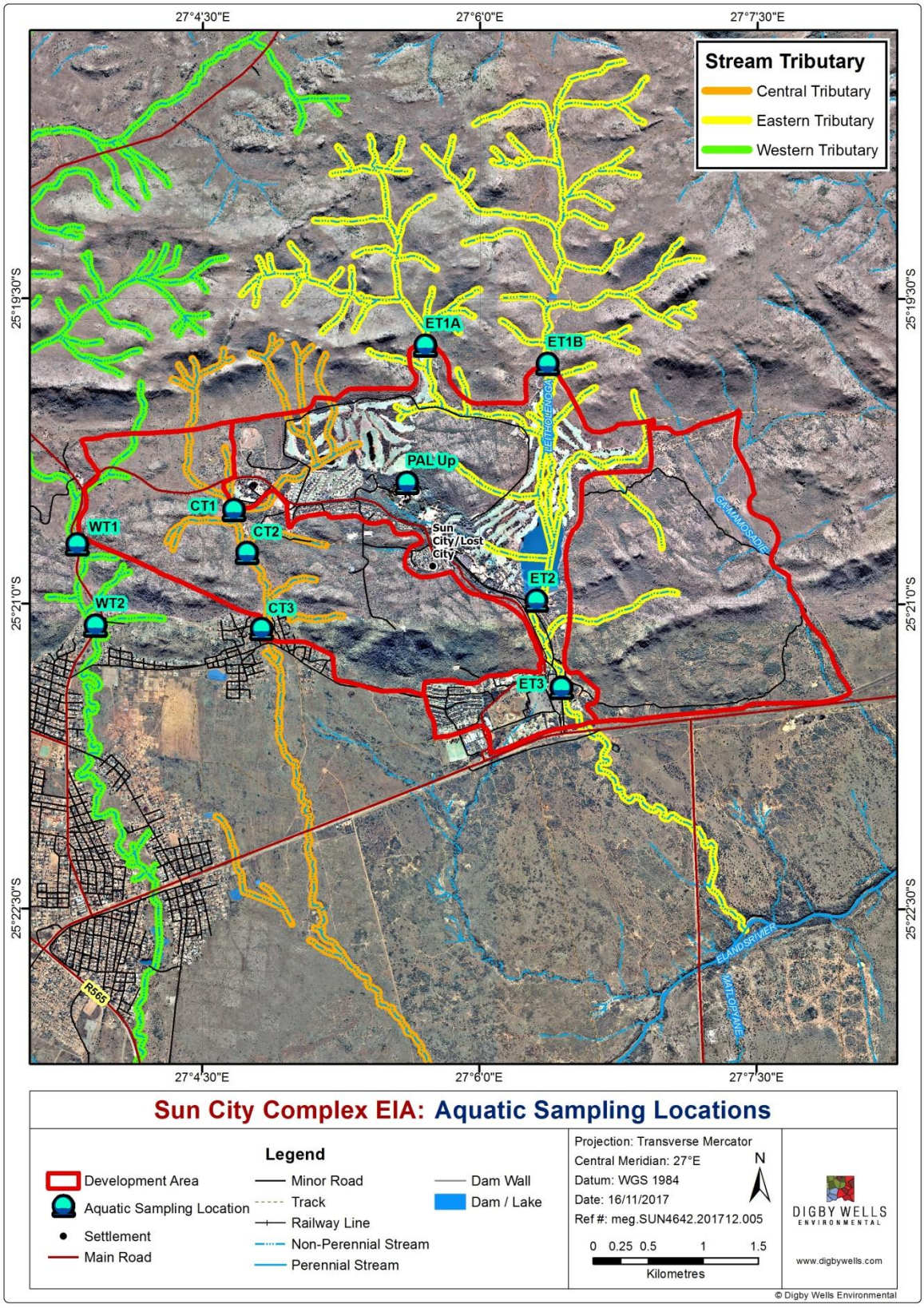


Figure 5-2: Sampling Site Localities in Relation to the Tributaries of Concern

Table 5-1: Coordinates and Descriptions of the Selected Monitoring Sites

Site Name	Coordinates	Description
WT1	25°20'42.47"S 27° 3'49.33"E	The upper most site situated on the Western Tributary acting as a reference site for the tributary.
WT2	25°21'6.43"S 27° 3'55.27"E	This site is the most downstream site on the tributary, containing solid waste possibly resulting from nearby rural settlements.
CT1	25°20'32.30"S 27° 4'40.10"E	This site is situated in the upper reaches of the Central Tributary below the resort's nursery. It is characterised by a small stream flowing into a pool before going over a road crossing.
CT2	25°20'45.01"S 27° 4'44.33"E	This site is located in approximately the middle of the tributary and was selected to monitor any potential impacts that might be related to the proposed Waste Water Treatment Works (WWTW) and from the proposed vacation club phase 3 development.
CT3	25°21'7.49"S 27° 4'49.08"E	Due to site CT2 being dry during the low flow survey, this downstream impounded site was selected to obtain downstream aquatic data. During the survey large amounts of cattle and algae was observed at this site.
ET1A	25°19'43.78"S 27° 5'42.29"E	This is the first of two river crossing sites on the Eastern Tributary also known as the Letholenoga River. Data from this site can be used as a reference before entering the Project area.
ET1B	25°19'49.18"S 27° 6'21.95"E	This is the second river crossing site located east of ET1A and will be utilised in the same manner as the first river crossing site.
ET2	25°20'59.02"S 27° 6'18.37"E	This site is characterised by a deep pool with large amounts of planted vegetation surrounding the banks. It is situated immediately downstream from the resort's recreational dam and is monitored in relation to the proposed effluent line construction.
ET3	25°21'24.76"S 27° 6'26.51"E	This site is situated adjacent to the proposed rustic chalet expansion and will be used to obtain data for the expansion as well as a final source for impacts from the effluent line crossing.
PAL UP	25°20'24.30"S 27° 5'36.30"E	Due to the fact that new development is proposed to take place around the resort's palace artificial wetland area, this site was selected to monitor any changes any water quality. It is important to note that this is an isolated system and appears to not impact any of the tributaries of concern.

5.1 Ecological Importance and Sensitivity

As a result of the assessed tributaries being unclassified (DWS, 2018), only data from the adjoining SQR (i.e. Elands River) could be obtained. This data was used to get an indication of the Ecological Importance and Sensitivity (EIS) of the Central and Eastern tributaries. The findings are presented in Table 5-2 below and supplemented with data gathered from Digby Wells (2016) and findings from the current study.

Table 5-2: Desktop Information for the Central and Eastern tributaries

Component	Central Tributary	Eastern Tributary
Present Ecological Status	C/D	D
Species of conservation concern	*Oreochromis mossambicus* expected	*Oreochromis mossambicus* sampled
Fish and invertebrate physiochemical sensitivity	High	
Fish no flow sensitivity	High	
Invertebrate velocity sensitivity	High	
Protected wetland vegetation expected	3 species	
Endemic wetland vegetation expected	4 species	
Ecological Importance (EI)	Moderate	
Ecological Sensitivity (ES)		

Based on the above components, the EIS for both the Central and Eastern tributaries can be categorised as moderate.

It is important to note that due to the dry nature of the Western Tributary limited aquatic related data could be obtained. Therefore, closer attention should be paid to the findings from the wetland assessment conducted by Digby Wells (2018a).

5.2 Current Aquatic Related Impacts

According to the DWS (2018) gathered data for the catchment, the tributaries face the following impacts: The following impacts/activities were identified:

- Small: agricultural fields, algal growth, bed and channel disturbance, low water crossings, roads and urbanisation;

- Moderate: water abstraction, small farm dams, exotic vegetation, inundation, mining related impacts and vegetation removal;
- Large: erosion, livestock impacts (overgrazing and trampling of vegetation), effluent from mining activities and urban areas and sedimentation of the rivers; and
- Serious: grazing.

Findings from the current study show that the assessed tributaries face the following impacts:

Western Tributary:

- Road crossings;
- Urban development in the downstream sections resulting in vegetation clearing.

Central Tributary:

- Urban development in the downstream sections resulting in vegetation clearing; and
- Increased dissolved solids, possibly from the Resort's Nursery discharge observed.

Eastern Tributary:

- Flow modifications from the Resort's recreational dam and weirs;
- Sedimentation of the tributary (especially in the mid reaches);
- Interference with biotic migratory pathways as determined in the Digby Wells aquatic monitoring study for the Resort (Digby Wells, 2016); and
- Invasive biota (i.e. *Cyprinus carpio*).

6 Limitations to the Study

The timing of both surveys coincided with a below normal rainfall event experienced during the 2017/2018 period in the North West Province (Figure 4-1). As a result, water courses associated with the study area were uncharacteristically low with a majority of the monitoring sites observed as dry throughout the study. Thus, limited aquatic data could be recorded where only selected parameters could subsequently be measured and a limited number of assessment indices could be applied in the study.

The dry conditions experienced throughout the study have most likely negatively influenced the aquatic baseline data presented in this report. Consequently, the findings expressed in this report should not be considered as conclusive baseline representations of the overall aquatic ecology in the associated watercourses. Rather, the atypical dry nature of the water courses should be taken into account when interpreting the baseline findings which are most likely below the normal aquatic conditions for the area.

Additionally, as described in Dickens and Graham (2002), the SASS5 assessment is not suitable for non-perennial systems. Therefore, more attention should be paid to the

ecological categories from the MIRAI assessment instead of those determined from the SASS5 scores.

7 Results and Discussion

The sections below summarise the baseline findings from the study.

It is important to note that the monthly rainfall recorded in the North West province leading up to and during the study (October 2017-January 2018) was recorded below the monthly average (Figure 4-1). As a result a majority of the selected monitoring sites were dry and as such, application of selected indicators, assessment indices and meters could not be applied. Furthermore, the rainfall recorded during the months of December 2017 and January 2018 was lower than the recorded rainfall during the initial low flow survey month of November 2017 (Figure 4-1). Consequently, the water levels observed during, what was classified as, the high flow survey (January 2018) was lower than the observed water levels during the low flow survey. Therefore, the overall findings and ecological categorisations presented in this report should be interpreted with caution as they may not be true representations of the aquatic ecology for the assessed area.

7.1 Water Quality

The results of the *in situ* water quality assessment are provided in Table 7-1.

Table 7-1: Water Quality Results Recorded During the Study

Site	WT1	WT2	CT1	CT2	CT3	ET1A	ET1B	ET2	ET3	PAL Up	Guideline Values
Low Flow Survey (November 2017)											
Temperature (˚C)	DRY	DRY	27.6	DRY	27.8	DRY	DRY	27.6	26.9	25.4	-
pH	DRY	DRY	8.66	DRY	8.24	DRY	DRY	7.63	7.93	8.16	6.5-9
Conductivity (µS/cm)	DRY	DRY	1260	DRY	771	DRY	DRY	827	845	718	<700
Dissolved Oxygen (mg/l)	DRY	DRY	6.51	DRY	5.53	DRY	DRY	4.18	4.88	10.73	-
Saturation Percentage (%)	DRY	DRY	105.2	DRY	108.4	DRY	DRY	69.6	81.1	128.3	80-120
High Flow Survey (January 2018)											
Temperature (˚C)	DRY	DRY	DRY	DRY	31.4	DRY	DRY	31.7	31.9	26.4	-

pH	DRY	DRY	DRY	DRY	7.26	DRY	DRY	7.51	7.66	8.12	6.5-9
Conductivity (µS/cm)	DRY	DRY	DRY	DRY	744	DRY	DRY	872	832	785	<700
Dissolved Oxygen (mg/l)	DRY	DRY	DRY	DRY	5.15	DRY	DRY	4.23	3.76	4.83	-
Saturation Percentage (%)	DRY	DRY	DRY	DRY	94.4	DRY	DRY	77.2	63.6	81.3	80-120
*Red shading indicates constituents exceeding guideline values (DWAF)											

Based on the results from the *in situ* water quality assessment conducted during the study, the water quality conditions at all of the tested sites are suspected to be impacting on the natural diversity of aquatic biota in the associated river systems. This can be attributed to the elevated conductivity values recorded at all tested sites throughout the study. These recorded constituents exceeded the recommended guideline value of 700 µS/cm (DWAF, 1996), which consequently presents unfavourable conditions for aquatic biota intolerant to high dissolved solid concentrations.

During the low flow survey, water emanating from the Resort's nursery located upstream from Site CT1 was observed (Figure 7-1). The exact chemistry of this water is not yet fully described as only *in situ* testing was conducted. However, it is suspected that this water is contributing to the elevated conductivity value of 1260 µS/cm recorded at Site CT1 as no other potential upstream sources of this contamination could be defined during the survey. Attention was to be paid at this site during the high flow survey in order to better understand the high conductivity. However, no water quality could be recorded during the survey as the site was observed as dry.

The elevated conductivity values recorded throughout the Eastern Tributary may be attributed to the Resort's irrigation activities especially of the golf course. Constant watering of the golf course and associated evaporation is suspected to result in an increase in sodium chloride concentration in the soil which in turn might be entering into the downstream reach (i.e. Eastern Tributary). The impounded nature of the monitoring sites also may be contributing to the elevated conductivity findings as the dissolved solids in the reach will probably be concentrated at the sites whereas being diluted at flowing sites.

Figure 7-1: Water Observed from the Nursery Located Upstream from Site CT1

7.2 Intermediate Habitat Integrity Assessment

The IHIA was completed on a desktop level of the three SQR's of concern and populated with observations recorded during the various surveys.

The IHIA results for the Western Tributary are presented in Table 7-2. It is important to note that only the riparian habitat assessment could take place due to the dry nature of this tributary observed throughout the study. This assessment took place from the upper most delineated section of the reach (see Figure 5-1) to approximately 5 km downstream where the reach intersects with the R556 regional route.

Table 7-2: Western Tributary Riparian Intermediate Habitat Integrity Assessment

Riparian	Average score	Score
Indigenous vegetation removal	16.00	8.32
Exotic vegetation encroachment	5.00	2.40

Riparian	Average score	Score
Bank erosion	8.00	4.48
Channel modification	6.00	2.88
Water abstraction	4.00	2.08
Inundation	5.00	2.20
Flow modification	4.00	1.92
Water quality	0.00	0.00
Total Riparian	**75.72**	
Category	**C**	

According to the IHIA results for the Western Tributary, the riparian habitat for the assessed reach was classified as moderately modified (Category C).

Table 7-3: Central Tributary Instream Intermediate Habitat Integrity Assessment

Instream	Average score	Score
Water abstraction	11.00	6.16
Flow modification	9.00	4.68
Bed modification	10.00	5.20
Channel modification	5.00	2.60
Water quality	9.00	5.04
Inundation	8.00	3.20
Exotic macrophytes	0.00	0.00
Exotic fauna	0.00	0.00
Solid waste disposal	10.00	2.40
Total Instream	**70.72**	
Category	**C**	

The IHIA scores for the Central Tributary indicate that the instream habitat is in a moderately modified state (Category C).

Table 7-4: Central Tributary Riparian Intermediate Habitat Integrity Assessment

Riparian	Average score	Score
Indigenous vegetation removal	14.00	7.28
Exotic vegetation encroachment	3.00	1.44
Bank erosion	4.00	2.24
Channel modification	5.00	2.40
Water abstraction	9.00	4.68
Inundation	6.00	2.64
Flow modification	7.00	3.36
Water quality	8.00	4.16
Total Riparian	**71.80**	
Category	**C**	

The IHIA scores for the Central Tributary indicate that the riparian habitat is in a moderately modified state (Category C).

Table 7-5: Eastern Tributary Instream Intermediate Habitat Integrity Assessment

Instream	Average score	Score
Water abstraction	15.00	8.40
Flow modification	19.00	9.88
Bed modification	16.00	8.32
Channel modification	17.00	8.84
Water quality	11.00	6.16
Inundation	14.00	5.60
Exotic macrophytes	8.00	2.88
Exotic fauna	10.00	3.20
Solid waste disposal	7.00	1.68
Total Instream	**45.04**	

Category	D

The IHIA scores for the Eastern Tributary indicate that the instream habitat is in a largely modified state (Category D).

Table 7-6: Intermediate Habitat Integrity Assessment for Riparian Habitat

Riparian	Average score	Score
Indigenous vegetation removal	15.00	7.80
Exotic vegetation encroachment	8.00	3.84
Bank erosion	9.00	5.04
Channel modification	12.00	5.76
Water abstraction	12.00	6.24
Inundation	17.00	7.48
Flow modification	18.00	8.64
Water quality	9.00	4.68
Total Riparian	**50.52**	
Category	**D**	

The IHIA scores for the Eastern Tributary indicate that the riparian habitat is in a largely modified state (Category D).

7.3 Macroinvertebrate Assessment

The subsections below summarise the findings of the various macroinvertebrate assessments utilised in the study. It is important to note that Sites WT1, WT2, CT2, ET1A and ET1B were observed as dry throughout the study. As a result these sites were excluded from the macroinvertebrate assessment.

7.3.1 Integrated Habitat Assessment System

The results of the IHAS are presented in the table below (Table 7-7).

Table 7-7: IHAS Results Recorded for the Study

Site	CT1	CT3	ET2	ET3
Low Flow Survey (November 2017)				
IHAS	50.9	32.7	40.0	54.5
Interpretation	Poor	Poor	Poor	Poor

High Flow Survey (January 2018)				
IHAS	DRY	40.0	40.0	50.9
Interpretation	DRY	Poor	Poor	Poor

The available macroinvertebrate habitat at all of the sites applicable for the SASS5 assessment was classified as Poor. This is due to the lack of vegetation observed at Site CT1 possibly as a result of the low rainfall experienced in the North West Province leading up to the study (Figure 4-1). The monitoring sites along the Eastern Tributary are characterised by slow flowing impounded sections which appear to be severely sedimented, especially noted at Site ET3. This sedimentation appears to result from the potential loss of flow due to the number of weirs built along the tributary. This has resulted in a loss of the stones biotope which acts as a large portion of important macroinvertebrate habitat thus, contributing significantly to the poor classification as presented by the above scores.

7.3.2 South African Scoring System

The following table (Table 7-8) outlines the SASS5 scores recorded during the low flow and high flow surveys. Only three of the monitoring sites, namely Sites CT1, ET2 and ET3, fell within the defined parameters for a SASS5 assessment (i.e. sufficient water levels and flow). Site CT3 does not fall within the parameters of the SASS5 protocol due to the impounded state of the site. Therefore, the ecological category was excluded in the assessment. However, the macroinvertebrates were sampled at this site and are presented in Table 7-9. These findings can be compared with those recorded in future studies but are not a true representation of the macroinvertebrate conditions of the reach.

Table 7-8: SASS5 Result Recorded During the Study

Site	CT1	CT3	ET2	ET3
Low Flow Survey (November 2017)				
SASS5 Score	90	38	83	60
No of Taxa	20	11	19	13
ASPT	4.5	3.5	4.4	4.6
Ecological Category	**C**	**-**	**C**	**D**
High Flow Survey (January 2018)				
SASS5 Score	DRY	42	61	99
No of Taxa	DRY	12	13	21

Site	CT1	CT3	ET2	ET3
Low Flow Survey (November 2017)				
ASPT	DRY	3.5	4.7	4.7
Ecological Category	**-**	**-**	**D**	**C**

The SASS5 results recorded during the study indicate that the macroinvertebrate assemblages range from largely modified (Ecological Category D) to moderately modified (Ecological Category C). The number of sampled taxa ranged from 11 at Site CT3 during the low flow survey to 21 at Site ET3 during the high flow survey. These taxa consist predominantly of taxa tolerant to poor water quality conditions and tolerant to no-flow conditions. The lowest SASS5 and ASPT scores were recorded at Site CT3 during both surveys (to be discussed below).

Table 7-9: Sampled Macroinvertebrates at Site CT3

Taxon	Abundance		Sensitivity Score
	Low flow	High flow	
Oligochaeta	A	A	1
Baetidae 1sp	B	A	4
Baetidae 2sp	B	-	6
Coenagrionidae	B	B	4
Aeshnidae	B	1	8
Libellulidae	B	-	4
Belostomatidae*	A	A	3
Gerridae*	0	A	5
Nepidae*	B	A	3
Notonectidae*	-	B	3
Veliidae*	-	B	5
Chironomidae	B	B	2

Culicidae*	B	B	1	
Lymnaeidae*	A	-	3	
Physidae*	A	A	3	
Total Taxa	**11**	**12**	**Average**	**3.7**
A = 2-10; B = 10-100; * = air breathing taxa				

As indicated by the findings presented in Table 7-9, the average sensitivity score of the sampled macroinvertebrates was 3.7. This represents a macroinvertebrate assemblage with low sensitivity, fairly tolerant to modifications. The number of sampled taxa ranged from 11 during the low flow survey to 12 during the high flow survey where a total of eight of the 14 taxa being air breathers. These air breathing taxa tend to be more tolerant to changes, especially in the form of water quality, as they do not fully rely on *in situ* parameters for survival. It must be noted that this lowered score is however, to be expected at the monitoring site and cannot be attributed to activities of the Resort at the timing of the surveys. The impounded nature of the site has resulted in low habitat availability, expressed by the poor IHAS scores recorded for the site, which in turn results in less macroinvertebrate taxa.

7.3.3 Macroinvertebrate Response Assessment Index

The results for the MIRAI assessment conducted for the Central Tributary are presented in Table 7-10 with the results for the Eastern Tributary in Table 7-11. The Central Tributary assessment was conducted based on the SASS5 data obtained during a single survey (low flow) and at a single site only (Site CT1). Therefore, despite an accurate determination of the macroinvertebrate Ecological Category for Site CT1, the confidence of its homogeneity throughout the reach is lowered. The MIRAI assessment for the Eastern Tributary encompassed the gathered SASS5 data over both surveys (high and low flow) from both monitoring sites (Sites ET2 and ET3).

Table 7-10: MIRAI Scores for the Central Tributary based on Site CT1 Findings

Invertebrate Metric Group	Score Calculated
Flow modification	53.9
Habitat	62.0
Water Quality	47.4
Ecological Score	**54.6**
Invertebrate Category	**D**

The MIRAI results indicate that the macroinvertebrate assemblage for the reach (Central Tributary) is largely modified (Ecological Category D). It appears that poor water quality (e.g.

high conductivity recorded) is a major driver behind this categorisation compounded by flow alterations, possibly due to impoundments along the reach, and the harsh non-perennial conditions observed throughout the study.

Table 7-11: MIRAI Scores for the Eastern Tributary

Invertebrate Metric Group	Score Calculated
Flow modification	52.3
Habitat	56.6
Water Quality	57.6
Ecological Score	**55.4**
Invertebrate Category	**D**

The MIRAI results indicate that the macroinvertebrate assemblage for the reach (Eastern Tributary) is largely modified (Ecological Category D). It appears that almost equal contributions of flow, habitat and water quality modifications have contributed to this modified category. This can be attributed to impacts associated with the construction of the Resort's recreational dam compounded by a number of weirs built along the watercourse, especially in proximity to Site ET3, altering natural flow. The low rainfall experienced in the area may also partially be contributing to the flow modification score expressed by the MIRAI results. The IHAS scores recorded at the monitoring sites (i.e. Sites ET2 and ET3) indicated Poor available macroinvertebrate habitat throughout the study. As discussed in the previous IHAS section, the flow modification caused by the large number of impoundments is possibly contributing to the sedimentation observed at the monitoring sites, especially Site ET3. This has resulted in a change in the bed composition and led to a lack of cobbles in the system which in turn has resulted in fewer sampled macroinvertebrate taxa. The *in situ* water quality testing further supports the poor water quality expressed by the MIRAI findings due to the aforementioned elevated conductivity findings.

7.4 Ichthyofauna Assessment

Table 7-12 below presents the fish species collected/observed during the study.

Table 7-12: Sampled, Observed and Expected Fish Species during the Study

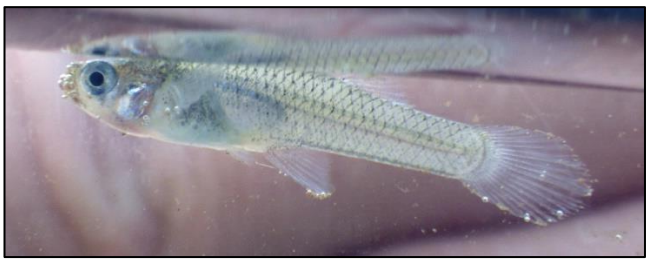
Scientific Name	Common Name	Conservation Status	Total Low Flow	Total High Flow
Enteromius mattozi	Papermouth	Least Concern	0	0
Enteromius paludinosus	Straightfin Barb	Least Concern	47	40
Enteromius trimaculatus	Threespot Barb	Least Concern	0	0

Enteromius unitaeniatus	Longbeard Barb	Least Concern	0	0
Clarias gariepinus	Sharptooth Catfish	Least Concern	40+	30+
Labeo cylindricus	Red Eyed Labeo	Least Concern	0	0
Labeo molybdinus	Leaden Labeo	Least Concern	0	0
Labeobarbus marequensis	Largescale Yellowfish	Least Concern	0	0
Engraulicypris ***(Mesobola) brevianalis***	River Sardine	Least Concern	0	0
Oreochromis mossambicus	Mozambique Tilapia	Near Threatened	13	17
Pseudocrenilabrus philander	Southern Mouthbrooder	Least Concern	30+	24
Tilapia sparmanni	Banded Tilapia	Least Concern	4	19
Cyprinus carpio*	Common Carp	Least Concern	3	5
Gambusia affinis*	Mosquito Fish	Least Concern	0	7
Exotic fish species represented with *				

A total of five of the 12 expected indigenous fish species with a total of two exotic species were recorded during the study.

Table 7-13: Site Locations and Photographs of Sampled Fish Species

Scientific Name	Photograph	Site Observed/Sampled
Enteromius paludinosus		CT3 and ET3
Clarias gariepinus		CT1, ET2 and ET3

Oreochromis mossambicus		ET3 and Recreational Dam
Pseudocrenilabrus philander		CT1, CT3 and ET3
Tilapia sparmanni		CT1 and ET3
Cyprinus carpio*		Recreational Dam
Gambusia affinis*		ET3
Exotic fish species represented with *		

All sampled fish species were observed from Site ET3 with the exception of *Cyprinus carpio*. This exotic fish species was only observed in the Resort's recreational dam and as a result

was included in the Eastern Tributary FRAI assessment below (Table 7-14). It is important to note that the sampled fish species from Site CT3 were included in the Central Tributary FRAI assessment (Table 7-14) despite the impounded nature of the site. The fish species present at this site indicate that the specific species are clearly present in the reach. However, due to the low rainfall experienced in the area (Figure 4-1), the fish in the reach have been confined to impoundment and are expected to migrate in the reach once rainfall returns to normal levels.

7.4.1 FRAI Assessment

The results from the Central Tributary FRAI Assessment are presented in Table 7-14 with the Eastern Tributary findings presented in Table 7-15.

Table 7-14: Central Tributary FRAI Results

Fish Species	Reference Frequency of Occurrence	Observed Frequency of Occurrence
Clarias gariepinus	4	3
Enteromius mattozi	1	0
Enteromius paludinosus	4	4
Enteromius trimaculatus	3	0
Enteromius unitaeniatus	3	0
Labeo cylindricus	1	0
Labeo molybdinus	1	0
Labeobarbus marequensis	1	0
Mesobola brevianalis	1	0
Oreochromis mossambicus	4	3
Pseudocrenilabrus philander	5	5
Tilapia sparmannii	4	4
FRAI (Adjusted) %		**47.8**
Ecological Category		**D**

According to the FRAI assessment the fish ecological category for the Central Tributary is largely modified (Ecological Category D). Impoundments, especially noted at Site CT3, appear to have contributed to this modified score by contributing to flow modification and the subsequent loss of flow dependent species (i.e. *Labeo molybdinus* and *Labeobarbus marequensis*).

Table 7-15: Eastern Tributary FRAI Results

Fish Species	Reference Frequency of Occurrence	Observed Frequency of Occurrence
Clarias gariepinus	5	5
Enteromius mattozi	1	0
Enteromius paludinosus	4	4
Enteromius trimaculatus	3	0
Enteromius unitaeniatus	3	0
Labeo cylindricus	1	0
Labeo molybdinus	2	0
Labeobarbus marequensis	1	0
Mesobola brevianalis	1	0
Oreochromis mossambicus	4	4
Pseudocrenilabrus philander	5	4
Tilapia sparmanni	4	4
FRAI (Adjusted) %		**44.9**
Ecological Category		**D**

The results from the FRAI assessment for the Eastern Tributary indicate that the fish assemblage for the reach is in a largely modified state (Ecological Category D). It appears that the major driver behind this categorisation can be attributed to flow modifications along the reach in the form of constructed weirs and the recreational dam. The weirs along the reach downstream from Site ET3 are most likely severely limiting on fish migration within the reach and possibly resulting in the loss of species from the study. The presence of two alien invasive fish species, namely *Cyprinus carpio* and *Gambusia affinis* are also expected to

impact on the modified Ecological Category. These species compete with indigenous species and are most likely also contributing to the loss of some of the indigenous species.

8 Present Ecological Status

The results of the ecological classification and PES for the three assessed tributaries are presented in the tables below. It is important to note that the riparian ecological category for the Western Tributary was the only ecological component used for the PES determination of the assessed reach. Therefore, interpretation of the PES for the reach should be considered with caution (Table 8-1).

Table 8-1: The Present Ecological Status of the Western Tributary

Category	Score	Ecological category
Riparian Habitat Ecological Category	58.0	D
Macroinvertebrate Ecological Category	DRY	-
Fish Ecological Category	DRY	-
Ecostatus	**58.0**	**D (Largely modified)**

The results of the PES determination indicate that the Western Tributary is in a largely modified state (Ecological Category D). This can be attributed to impacts associated with the settlements in the lower section of the assessed reach. Their influence has resulted in vegetation removal and partial encroachment of exotic vegetation in the form of subsistence crops. However, the riparian habitat in the upper reaches of this system does appear to be far more intact in comparison to the habitat associated with the settlements. As a result, the upper reach should be considered important for the conservation of the downstream impacted sections.

Table 8-2 below presents the PES findings for the Central Tributary.

Table 8-2: The Present Ecological Status of the Central Tributary

Category	Score	Ecological category
Riparian Habitat Ecological Category	66.0	C
Macroinvertebrate Ecological Category	54.6	D
Fish Ecological Category	47.8	D
Ecostatus	**58.6**	**C/D (Moderately to largely modified)**

The results of the PES determination indicate that the Central Tributary is in a moderately to largely modified state (Ecological Category C/D). This overall Ecological Category for the reach can be attributed mainly to the poor instream ecological components (i.e. macroinvertebrates and fish as a result of the low rainfall experienced) compounded by poor water quality impacts associated mainly with the low water levels and possibly due to the observed discharge from the Resort's nursery.

Table 8-3 below presents the PES findings for the Eastern Tributary.

Table 8-3: The Present Ecological Status of the Eastern Tributary

Category	Score	Ecological category
Riparian Habitat Ecological Category	54.0	D
Macroinvertebrate Ecological Category	55.4	D
Fish Ecological Category	44.9	D
Ecostatus	**52.1**	**D (Largely modified)**

The results of the PES determination indicate that the Eastern Tributary is in a largely modified state (Ecological Category D). The major driver behind this modified categorisation appears to be due to equal contributions of both modified riparian habitat and instream biological responses (i.e. macroinvertebrates and fish). Modifications to the reach from reference conditions, in the form of impoundment and weir construction, habitat removal and the presence of exotic plants and fish, have resulted in the subsequent largely modified categorisation of the tributary.

9 Impact Assessment

The potential impacts that will negatively impact aquatic ecology are listed below for the various phases of the project.

9.1 Construction Phase

Land manipulation and vegetation clearing associated with the proposed infrastructure establishment and expansion is the main foreseeable aquatic-related impact associated with the construction phase of the project. There is also a risk of contaminants associated with construction activities and machinery entering the aquatic systems from the project workings and storage sites.

9.1.1 Impact Description: Water and Habitat Quality Deterioration

Land manipulation and the clearing of vegetation for infrastructure will most likely increase surface runoff, erosion and subsequently the amount of suspended and dissolved solids as

well as pollutants (i.e. hazardous substances from the actual construction areas such as hydrocarbons, organic waste from lack of ablutions and domestic litter) entering the associated watercourses. These impacts will alter the water chemistry of the affected watercourses due to the possible increase in contaminant, dissolved salt and suspended solids concentrations and will negatively impact aquatic ecology as follows:

- Contaminant increases in watercourses will increase the potential toxicity of the water and place additional stress on the aquatic biota in the impacted systems;
- Dissolved solids concentration is one of the most influential water quality variables on aquatic biotic community structures (Dallas & Day, 2004). Thus, increases in this regard will result in loss of certain taxa if their specific salinity tolerances are exceeded;
- An increase in suspended solids will directly alter aquatic habitats after deposition (Wood & Armitage, 1997) which in turn will negatively impact biotic community structure. Suspended solids can also directly impact aquatic biota through the accumulation of silt on respiratory organs (i.e. gills) and by decreasing visibility which will affect feeding habits of specific taxa; and
- Habitat deterioration in the form of sedimentation; bed, channel and flow modification may occur due to the possible increased runoff, erosion and the physical removal / loss of aquatic habitat at construction sites (e.g. beach expansion and culverts).

9.1.2 Management Objectives

The objective for management is to preserve the PES of the various watercourses associated with the Resort and prevent further degradation of local aquatic environments. This objective can be achieved through the management of the aforementioned potential water and habitat quality related impacts as listed in the section below.

9.1.3 Management Actions

General mitigation actions provided in the wetlands and surface water studies conducted by Digby Wells (2018a & 2018b) should be used to guide the effective management of aquatic resources potentially affected by the project. However, more specific management actions / components for the Construction phase are listed below.

9.1.3.1 Buffer zone establishment

The establishment of clearly marked buffer zones, which are defined as regions of natural vegetation between watercourses / wetlands and developments or activities (WRC, 2015), is a key management action that should take place. These zones intend to provide the following aquatic related functions:

- Maintenance of aquatic processes;
- Reduction of impacts on water resources associated with upstream activities and adjoining land uses; and

- Provision of habitat.

According to the Water Research Commission (2015) the efficacy of a buffer is related to the distance between the river system and the zone of disturbance. Thus, by increasing the length of a buffer, the potential impacts related to the proposed infrastructure / activity is reduced. Furthermore, according to the North West Biodiversity Management Act (Act no 4 of 2016) (*hereafter NWBMA*), activities involving vegetation (i.e. vegetation clearing for infrastructure) should be restricted within 32 metres from the high watermark on either side of a watercourse. It was however, observed that infrastructure already exists within this zone (e.g. Rustic Chalets and Crocodile Farm).

Therefore, considering the aforementioned statements and the NWBMA, buffer zones of at least 32 metres should be placed between the proposed developments / activities and the high water mark of the associated watercourses and drainage lines as illustrated in Figure 9-1. It is important to note that the buffer zones have been applied to the watercourse situated in the far eastern section of the project area despite it not being an area of concern for this study.

It is however, predicted that the construction phase will still impact on the aquatic ecology of the associated watercourses if the 32 meter buffer is adhered to. Thus, the following additional management actions need to be implemented in order to reduce associated impacts.

- Limit vegetation removal to the infrastructure footprint area only where removed or damaged vegetation areas (riparian or aquatic related) should be revegetated as soon as possible;
- Bare land surfaces downstream of construction activities must be vegetated to limit erosion from the expected increase in surface runoff from infrastructure. It is important to note that limited chemical use, such as fertilisers, should be used in this regard as this may lead to additional pollution of the downstream systems due to possible leaching;
- Environmentally friendly barrier systems, such as silt nets or in severe cases the use of trenches, can be used downstream from construction sites to limit erosion and possibly trap contaminated runoff from construction;
- Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow (i.e. use of baffles at the end of canals or trenches);
- Water used at construction sites should be utilised in such a manner that it is kept on site and not allowed to run freely into nearby watercourses;
- Construction chemicals, such as paints and hydrocarbons, should be used in an environmentally safe manner with correct storage as per each chemical's specific storage descriptions; and

- High rainfall periods (usually December to March) should be avoided during construction in order to possibly avoid increased surface runoff in attempt to limit erosion and the entering of external material (i.e. contaminants and / or dissolved solids) into associated aquatic systems.

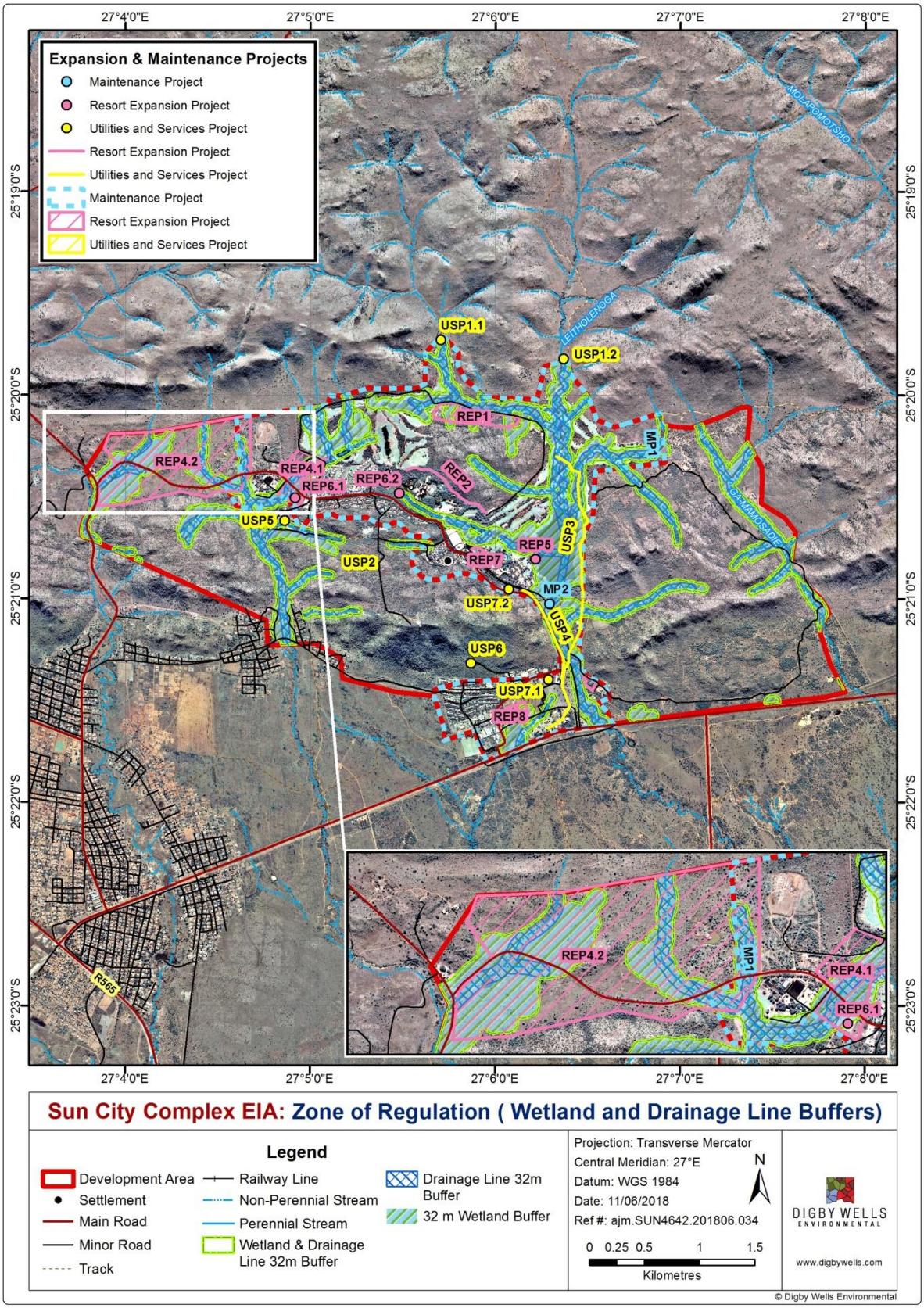


Figure 9-1: Aquatic 32 m Buffer Zones

9.1.4 Impact Ratings

Table 9-1 presents the impact ratings associated with an increase in runoff predicted for the construction phase of the project.

Table 9-1: Potential Surface Runoff Impacts of the Construction Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearance and construction of proposed infrastructure			
Impact Description: Habitat removal resulting in increased runoff and erosion in associated watercourses			
Prior to Mitigation/Management			
Duration	Project life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until removal of infrastructure or project closure.	Minor (negative) – 44
Extent	Local (3)	Due to the usual dry nature of the project area runoff is already expected to be limited. However, downstream sections of the associated flowing systems may be affected extending past the project area.	
Intensity x type of impact	Moderate - Negative (-3)	Due to the dry nature of the project area, the intensity of runoff is already expected to be limited In the already modified and sedimented systems.	
Probability	Probable (4)	The impact is likely to occur more than once during construction but limited due to periodic rainfall events.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Mitigation/Management Actions ■ ***Limit vegetation removal to the infrastructure footprint area only where removed or damaged vegetation areas (riparian or aquatic related) should be revegetated as soon as possible;*** ■ ***Bare land surfaces downstream of construction activities should be vegetated;*** ■ ***Environmentally friendly barrier systems, such as silt nets or in severe cases the use of trenches, can be used downstream from construction sites;*** ■ ***Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow (i.e. use of baffles at the end of canals or trenches);*** ■ ***Water used for construction should be kept at the construction sites and not be allowed to freely flow into nearby watercourses; and*** ■ ***High rainfall periods (usually December to March) should be avoided during construction.***			
Post-Mitigation			
Duration	Project Life (5)	Once vegetation is cleared for infrastructure, no revegetation will occur until the closure phase of the project or removal.	Negligible (negative) – 18
Extent	Limited (2)	Runoff will most likely be restricted after mitigation actions and if high rainfall periods are avoided for construction.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are all incorporated for the construction phase, the intensity of the impact should decrease significantly, especially due to the dry nature observed throughout the study.	
Probability	Improbable (2)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme cases or unexpected rainfall events.	
Nature	Negative		

The risk of contaminants entering associated watercourses via surface runoff was also taken into account with the impact ratings for this potential impact outlined in Table 9-2 below.

Table 9-2: Potential Chemical Impacts of the Construction Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Contaminants from construction sites entering associated watercourses			
Impact Description: Water quality deterioration in the various aquatic systems			
Prior to Mitigation/Management			
Duration	Medium Term (3)	It is predicted that the entry of construction related contaminants will only enter nearby watercourses during high rainfall events throughout the construction phase.	Minor (negative) – 36
Extent	Local (3)	Due to the usual dry nature of the project area runoff is already expected to be limited. However, downstream sections of the associated systems will most likely be affected when flowing and extend outside of the project area.	
Intensity x type of impact	Moderate - Negative (-3)	Due to the dry nature of the project area, the intensity of runoff is already expected to be limited. However, aquatic systems are regarded as sensitive and the entry of contaminants will result in serious aquatic related impacts.	
Probability	Probable (4)	The impact is likely to occur more than once during construction.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Mitigation/Management Actions ■ ***Bare land surfaces downstream of construction activities should be vegetated;*** ■ ***Environmentally friendly barrier systems, such as silt nets or in severe cases the use of trenches, can be used downstream from construction sites;*** ■ ***Storm water must be diverted from construction activities and managed in such a manner to disperse runoff and prevent the concentration of storm water flow (i.e. use of baffles at the end of canals or trenches)*** **which may carry contaminants from construction sites if flowing through them*;*** ■ ***Water used for construction should be kept at the construction sites and not be allowed to freely flow into nearby watercourses;*** ■ ***Construction chemicals, such as paints and hydrocarbons, should be used in an environmentally safe manner with correct storage as per each chemical's specific storage descriptions; and*** ■ ***High rainfall periods (usually December to March) should be avoided during construction.***			
Post-Mitigation			
Duration	Medium Term (3)	Duration will remain the same throughout construction.	Negligible (negative) – 14
Extent	Limited (2)	Runoff will most likely be restricted to only impact the immediate water bodies after mitigation actions.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are all incorporated for the construction phase, the intensity of the impact should decrease significantly, especially due to the dry nature observed throughout the study.	
Probability	Improbable (2)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme cases or unexpected significant rainfall events.	
Nature	Negative		

9.2 Operational Phase

A major foreseeable impact associated with the operational phase of the project is increased runoff possibly resulting in erosion and sedimentation as a consequence of constructed

impermeable surfaces, culverts and storm water pipelines. The use of chemicals, such as fertilisers and maintenance chemicals (i.e. toxic paint), in order to maintain operations might also enter into nearby watercourses throughout the operation phase of the project.

9.2.1 Impact Description: Water and Habitat Quality Deterioration

Similarly to the impacts described for the construction phase, the predicted increased runoff has the potential to increase flow rates, sediment input, erosion and contaminants in the associated water courses. These influences will directly impact on water quality and aquatic habitat which in turn will negatively affect the aquatic biota in the associated watercourses.

9.2.2 Management Objectives

The objective for management is to preserve / improve the PES of the various watercourses associated with the Resort and prevent further degradation of local aquatic environments. This objective can be achieved through the management of the aforementioned potential water and habitat quality related impacts as listed in the section below.

9.2.3 Management Actions

General mitigation actions provided in the surface water and wetlands studies conducted by Digby Wells (2017a & 2017b) should be used to guide the effective management of aquatic resources potentially affected during the operational phase of the project. However, more specific management actions / components for the conservation of aquatic ecology during the operational phase are listed below.

- During the operational phase of the project a Storm Water Management Plan (SWMP) should already be implemented. This should take into account all drainage lines associated with the new developments which should convey storm water to silt traps in order to limit erosion and an increase of suspended solids in downstream watercourses;
- Bare surfaces downstream from the developments where silt traps are not an option should be vegetated in order to attempt to limit erosion and runoff that might be carrying contaminants;
- Culverts and storm water pipelines should already be designed and built with large enough diameters to limit clogging (i.e. able to manage 50-year peak flows). Monitoring and maintenance of these structures should be an ongoing process where excess debris in the structures to be removed when noticed;
- Culvert should be designed to facilitating the movement of aquatic species up and downstream (i.e. pipe culverts should be avoided and a “stream simulation approach” should be followed). The outlets of the proposed culverts should be armoured with naturally occurring structures (i.e. rocks) in order to dissipate the predicted increase flow rates in order to limit erosion;

- Sediment / sand from the beach expansion should be restricted to the beach area with the use of barrier systems to restrict the sand from entering the recreational dam; and
- Monitoring of the pipeline and its service routes should be done by a surface water or aquatic specialist in order to determine localities of areas subjected to erosion and increased runoff where after new mitigation actions should be implemented as per the specialist's recommendations. This should take place biannually or as reported on by internal pipeline monitors.

9.2.4 Impact Ratings

Table 9-3: Increased Runoff and Erosion from Impermeable Surfaces and Beach Expansion

Dimension	Rating	Motivation	Significance
Activity and Interaction: Increased runoff and sedimentation of watercourses			
Impact Description: Increasing the erosion and turbidity in associated watercourses			
Prior to Mitigation/Management			
Duration	Project Life (5)	It is predicted that increased runoff will continue throughout the life of the project whenever rainfall events occur.	Minor (negative) – 48
Extent	Local (3)	Due to the usual dry nature of the project area runoff is already expected to be limited. However, downstream sections of the associated systems will most likely be affected when flowing and extend outside of the project area.	
Intensity x type of impact	Serious - Negative (-4)	Due to the dry nature of the project area, the intensity of runoff is already expected to be limited. However, aquatic systems are regarded as sensitive and the entry of more solid particles will result in serious aquatic related impacts.	
Probability	Probable (4)	The impact is likely to occur throughout the life of the Project but limited due to periodic rainfall events.	
Nature	Negative		

Dimension	Rating	Motivation	Significance
Mitigation/Management Actions ■ SWMP should already be implemented and take into account all drainage lines associated with the new developments which should convey storm water to silt traps; ■ Bare surfaces downstream from the developments where silt traps are not an option should be vegetated; ■ Sediment / sand from the beach expansion should be restricted to the beach area with the use of barrier systems to restrict the sand from entering the recreational dam; and ■ Monitoring of the pipeline and its service routes should be done by a surface water or aquatic specialist biannually during aforementioned survey in order to determine localities of areas subjected to erosion and increased runoff where after new mitigation actions should be implemented as per the specialist's recommendations.			
Post-Mitigation			
Duration	Project Life (5)	Increased runoff will continue throughout the life of the Project as long as impermeable / hardened surfaces remain	Negligible (negative) – 18
Extent	Limited (2)	Runoff will most likely be restricted and captured after mitigation.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease significantly, especially due to the dry nature observed throughout the study.	
Probability	Improbable (2)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme rainfall events or if mitigation structures aren't maintained.	
Nature	Negative		

Table 9-4: Potential Chemical Impacts associated with the Operational Phase

Dimension	Rating	Motivation	Significance
Activity and Interaction: Increased contaminant input in watercourses			
Impact Description: Water quality deterioration			

Dimension	Rating	Motivation	Significance
Prior to Mitigation/Management			
Duration	Project Life (5)	It is predicted that contaminant input will continue throughout the life of the Project whenever rainfall events occur.	Minor (negative) – 48
Extent	Local (3)	Due to the usual dry nature of the project area runoff is already expected to be limited which should result in limited contaminant input. However, downstream sections of the associated systems will most likely be affected when rainfall events lead to contaminant input.	
Intensity x type of impact	Serious - Negative (-4)	Due to the dry nature of the project area, the intensity of runoff is already expected to be limited. However, aquatic systems are regarded as sensitive and the entry of contaminants will result in serious aquatic related impacts	
Probability	Probable (4)	The impact is likely to occur throughout the life of the Project but limited due to periodic rainfall events.	
Nature	Negative		
Mitigation/Management Actions			
■ Bare surfaces downstream from the developments where silt traps are not an option should be vegetated in order to attempt to limit erosion and runoff that might be carrying contaminants; ■ Limited and correct chemical use (as per each chemical's environmental guidelines), such as fertilisers or toxic paint, should take place between the new developments, especially the constructed facilities (e.g. Vacation Club expansions), and associated watercourses; and ■ All chemicals in storage at the new developments should be stored correctly (i.e. in correct storage containers for each specific chemical).			
Post-Mitigation			
Duration	Long Term (5)	Contaminant runoff will continue throughout the Project life as long as chemicals are continued to be used or needed.	Negligible (negative) – 30

Dimension	Rating	Motivation	Significance
Extent	Limited (2)	Runoff containing contaminants will most likely be restricted and captured after mitigation.	
Intensity x type of impact	Moderate - Negative (-3)	If mitigation measures are all incorporated for the Project, the intensity of the impact should decrease. However, contaminants are more difficult to manage compared to solid particles and are predicted to enter associated aquatic systems resulting in	
Probability	Unlikely (3)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme rainfall events or if mitigation structures aren't maintained.	
Nature	Negative		

Table 9-5: Potential Erosion Impacts associated with the Culverts

Dimension	Rating	Motivation	Significance
Activity and Interaction: Increased flow associated with the proposed culverts			
Impact Description: Increasing the erosion and turbidity in associated watercourse			
Prior to Mitigation/Management			
Duration	Project Life (5)	It is predicted that erosion will continue throughout the life of the Project whenever rainfall events occur.	Minor (negative) – 55
Extent	Local (3)	Due to the usual dry nature of the project area flow in the upper reaches of the Central Tributary is already expected to be low where the impact will most likely be further limited due to the recreational dam situated downstream.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Moderate - Negative (-3)	Due to the dry nature of the project area, the intensity of the impact caused by increased flow is already expected to be limited. The reach is also already sedimented where it is suspected that present aquatic biota is tolerant to these conditions.	
Probability	Likely (5)	The impact is likely to occur throughout the life of the Project whenever rainfall events occur due to the general nature of culverts.	
Nature	Negative		
Mitigation/Management Actions ■ Culverts and storm water pipelines should already be designed and built with large enough diameters to limit blockages (i.e. able to manage 50-year peak flows). Monitoring and maintenance of these structures should be an ongoing process where excess debris in the structures to be removed when noticed; ■ The culverts should be designed to facilitating the movement of aquatic species up and downstream (i.e. pipe culverts should be avoided and a “stream simulation approach” should be followed); and ■ The outlets of the proposed culverts should be armoured with naturally occurring structures (i.e. rocks) in order to dissipate the predicted increase flow rates in order to limit erosion.			
Post-Mitigation			
Duration	Long Term (5)	Increased flow will continue throughout the life of the Project caused by the impermeable surfaces of the culverts.	Negligible (negative) – 30
Extent	Local (3)	The impact will still be localised to the upper reaches of the Eastern Tributary.	
Intensity x type of impact	Minor - Negative (-2)	If mitigation measures are incorporated, the intensity of the impact will be minor and limited to extreme rainfall events.	

Dimension	Rating	Motivation	Significance
Probability	Unlikely (3)	The likelihood of the impact occurring is reduced by the mitigation actions and should only result in extreme rainfall events or if mitigation structures aren't maintained.	
Nature	Negative		

9.3 Decommissioning Phase

The proposed developments are most likely not going to be decommissioned in the foreseeable future. Thus, this phase was not assessed in the study.

9.4 Unplanned and Low Risk Events

- There is a risk that watercourses associated with the Resort and especially the proposed developments might be affected by the entry of hazardous substances, such as hydrocarbons, in the event of a spillage or unseen seepage from storage facilities; and
- There is a risk that contents from the proposed effluent pipeline might enter into the associated aquatic system (namely the Eastern Tributary) in the event of leakages.

Table 9-6 below presents mitigation measures that should be implemented for the aforementioned events of the Project.

Table 9-6: Unplanned Events and Mitigation Measures

Unplanned Risk	Mitigation Measures
Chemical / contaminant spills from developments	■ Ensure correct storage of all chemicals at operations (e.g. sealed containers for hydrocarbons); ■ Ensure staff involved at the proposed developments has been trained to correctly use and clean chemicals used at the sites; and ■ Ensure spill kits (e.g. Drizit) readily available at proposed developments during construction and operation.
Spillage / leakage of effluent pipeline contents into associated aquatic systems	■ Install safety valves and emergency switches that can be used to seal off leakages from the pipe when noticed

	or triggered; ■ Ensure that spill kits and trained staff capable of using the kits are available on site in case of accidental spillages; ■ Maintenance of the pipeline should be considered an ongoing basis where leakages or issues with the pipe should be reporting to acting Environmental Coordinator of the Resort immediately after notice; and ■ Special attention needs to be paid during monitoring or inspections of the pipeline to river crossing sites.

10 Aquatics Biomonitoring Programme

An aquatics biomonitoring programme has been developed for the monitoring and preservation of the studied aquatic systems for the Project. Table 10-1 outlines the River Health Programme methods needed to be undertaken on an annual basis at the monitoring points indicated in Table 5-1 in order to determine the PES of the assessed rivers in this study and to determine if the proposed developments are impacting on the associated aquatic ecology.

Table 10-1: Biomonitoring Programme

Method / focus	Details
Water Quality	*In situ* water quality parameters as per this study
Habitat Quality	IHAS and the Index of Habitat Integrity
Macroinvertebrate assemblages	SASS5 and MIRAI
Fish assemblages	FRAI

11 Conclusion

The findings from the study classified the tributaries into the following states:

- **Western Tributary:** Category D (largely modified). This assessment was based solely on the riparian vegetation findings due to the dry nature of the tributary

observed throughout the study. The modified status can be attributed to vegetation clearing observed in the lower section of the tributary as a result of surrounding urbanisation.

- **Central Tributary:** Category C/D (moderately to largely modified). This modified state of the reach can be attributed to poor water quality findings, which were possibly attributed to discharge from the Resort's nursery area and further compounded by the poor biotic habitat available at the monitoring sites. Riparian habitat was also impacted on due to urbanisation occurring in the lower reaches and also grazing of habitat inside the Resort's boundary.
- **Eastern Tributary:** Category D (largely modified). This modified state can mainly be attributed to flow modifications and sedimentation, which is possibly linked with impacts from the upstream recreational dam and further compounded by a number of impoundments in the form of weirs along the tributary. This ultimately modifies aquatic habitat through fragmentation, resulting in the loss of selected biota from the system.

Findings from the impact assessment show that the largest threat of the proposed future developments upon on the ecology of the associated tributaries (or watercourses), is the increase in surface runoff, which will further facilitate erosion and sedimentation of the already modified systems. Furthermore, an increase in contaminant and hazardous chemicals entering the associated tributaries is expected, especially due to the predicted runoff associated with the Project. Physical alterations to riparian habitat are also suspected to occur due to proposed developments within the 32 m zones of regulation as stipulated by the NWBMA. Furthermore, findings from the impact assessment indicate that if Sun International remain outside of the 32m buffer zone from aquatic systems and implement the provided mitigation measures where necessary, the impact on aquatic ecology will be negligible.

Therefore, authorisation of the Project with regards to the aquatic environment of the area is acceptable provided that the following terms are met:

- Adhere to the North West buffer zones of 32m from all aquatic resources as indicated in Figure 9-1; and
- Ensure that the Aquatic Biomonitoring Programme (Table 10-1) is followed on an annual basis.

12 Reference List

Barbour MT, Gerristen J, Snyder DB, Stribling JB (1999) Rapid bioassessment protocols for Use in Stream and Wadeable Rivers: Periphton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. US Environmental Protection Agency, Office of Water, Washington DC.

Dallas HF (2007). River Health Programme: South African Scoring System (SASS) Data Interpretation Guidelines. Institute of Natural Resources and Department of Water Affairs and Forestry.

Department of Water Affairs (2016) A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Draft. Compiled by RQS-RDM.

Dickens CWS, Graham PM.(2002). The South African Scoring System (SASS), Version 5, Rapid bioassessment method for rivers. African Journal of Aquatic Science. 27**:** 1–10.

Digby Wells Environmental. (2018a). Specialist Wetland Report: Environmental Impact Assessment for proposed Future Developments within the Sun City Complex.

Digby Wells Environmental. (2018b). Specialist Study: Groundwater Report: Environmental Impact Assessment for proposed Future Developments within the Sun City Complex.

Directorate: Water Resource Classification. Department of Water Affairs, South Africa, (2014). Determination of Resource Quality Objectives in the Upper Vaal and Lower Vaal Water Management Areas (WMA8 and WMA10) – WP10533 and WP10536. Draft Resource Quality Objectives Gazette

Driver A, Nel JL, Snaddon K, Murray K, Roux DJ, Hill L, Swartz ER, Manuel J, Funke N (2011) Implementation Manual for Freshwater Ecosystem Priority Areas. Water Research Commission. Report Number 1801/1/11, ISBN 978-1-4312-0147-1

DWAF (Department Of Water Affairs And Forestry) (1996). South African water quality guidelines (Second Edition). Aquatic Ecosystems. Department of Water Affairs and Forestry, Pretoria.

Gerber, A. & Gabriel, M.J.M. (2002). Aquatic Invertebrates of South African Rivers: Field Guide. Institute for Water Quality Services, Department of Water Affairs and Forestry, Pretoria

Government Gazette (16 April 2013). Publication of lists of species that are threatened or protected, activities that are prohibited and exemption from restriction. *Government Gazette,* No. 36375, Notice 389 of 2013, 104-218.

Kleynhans CJ (2007). Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT330/08.

Kleynhans CJ, (1996) A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River. *Journal of Aquatic Ecosystem Health* 5: 41-54.

Kleynhans CJ, Louw MD (2007). Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Resource Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Kleynhans CJ, Louw MD, Moolman J (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kleynhans, C.J. & Louw, M.D. (2007). Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Resource Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08

Macfarlane DM, Bredin IP, Adams JB, Zungu MM, Bate GC, Dickens CWS. (2014). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. WRC Report No TT310/14, Water Research Commission, Pretoria.

McMillan PH, (1998). An integrated habitat assessment system (IHAS v2) for the rapid biological assessment of rivers and streams. Division of the Environment and Forestry Technology, Report No. ENV-P-I 98132. CSIR, Pretoria.

Nel, Jeanne & AL, Driver & Strydom, Wilma & Maherry, Ashton & Petersen, Chantel & Hill, Liesl & Roux, Dirk & S, Nienaber & Van Deventer, Heidi & Swartz, Ernst & LB, Smith-Adao. (2011). ATLAS of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources.

North West Biodiversity Management Act (Act no 4 of 2016).

Skelton PH (2001). A complete guide to freshwater fishes of southern Africa. Struik Publishers, South Africa.

Thirion CA, Mocke A, Woest R (1995). Biological monitoring of streams and rivers using SASS4. A Users Manual. Internal Report No. N 000/00REQ/1195. Institute for Water Quality Studies. Department of Water Affairs and Forestry. 46.

Thirion, C. (2007). Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 332/08.

Appendix A: Site Photographs

Site	Low Flow (November 2017)	High Flow (January 2018)
WT1		
WT2		
CT1		

Site	Low Flow (November 2017)	High Flow (January 2018)
CT2		
CT3		
ET1A		

Site	Low Flow (November 2017)	High Flow (January 2018)
ET1B		
ET2		
ET3		

Site	Low Flow (November 2017)	High Flow (January 2018)
Pal UP		

Appendix B: CV's

DIGBY WELLS
ENVIRONMENTAL

Mr. Nathan Cook

Biophysical Department

Digby Wells Environmental

1 Education

2016: Bachelors of Science Degree in Environmental Sciences (University of Pretoria)

2017: Currently studying towards a BSC Honours Degree in Aquatic ecosystem Health

2 Language Skills

- English (1st language); and
- Afrikaans (2nd language)

3 Employment

- 2016 – *Present*: Digby Wells Environmental – Aquatics Specialist

4 Experience

Nathan Cook is a certified SASS5 practitioner with a BSc in environmental sciences. He is currently working towards a BSc honors degree in Aquatic Ecosystem Health through North West University. Nathan has completed numerous aquatic ecology assessments in South Africa and has surveyed in Senegal, West Africa, as well as in the Zambezi and Chobe rivers in Botswana, Zambia and Namibia. He has a good technical understanding of the variable conditions within South African rivers as well as their biological compositions, especially in the Highveld ecoregion. The following specific skills applied in the projects are highlighted below:

- Baseline aquatic ecology assessments;
- Impact assessments on aquatic ecology;
- Biological monitoring using aquatic ecology;
- Water and sediment sample analysis/interpretation; and
- Sampling and identification of aquatic macroinvertebrates and fish species.

5 Project Experience

Since joining Digby Wells, Nathan has conducted site visits, undertaken data collection and compiled Aquatic Reports. Nathan's project experience is summarised below:

- Sasol Mining (Pty) Ltd Thubelisha section 102 Amendment application;
- Ergo Mining (Pty) Ltd dump reclamation project alongside the Blesbokspruit;
- Platreef Resources (Pty) Ltd biannual aquatic biomonitoring for the Platreef Mining Operation, Limpopo Province;**Error! Reference source not found.**
- HCI Coal PTY (Ltd) aquatic biomonitoring at the Mbali Colliery;
- HCI Coal PTY (Ltd) aquatic biomonitoring at the Palesa Colliery;
- HCI Coal PTY (Ltd) aquatic biomonitoring at the Nokuhle Colliery;
- Msobo Coal (Pty) Ltd bi-annual aquatic biomonitoring for the Tselentis and Spitzkop Collieries;
- Glencore Operations South Africa (Pty) Ltd Goedgevonden Aquatic Biomonitoring;
- Rangold Resources Masawa ESIA for a gold mine in Senegal;
- Exxaro Coal Mpumalanga (Pty) Ltd Annual Aquatic Ecology Biomonitoring Project 2016/2017; and
- KBC Joint Venture comprising Nippon Koei Co. Limited, Chodi Co. Ltd, Arcus GIBB (Pty) Limited, Bothakga Burrow Botswana (Pty), CPP Botswana (Pty) and Zulu Burrow Development Consultants Ltd 7th and 8th Quarterly Aquatic Ecology Monitoring Report for the Environmental Monitoring for the Kazungula Bridge Project;

6 Professional Affiliations

Currently registering as a candidate of the South African Council for Natural Scientific Professions.

7 Professional Registration

Accredited SASS5 macroinvertebrate practitioner.

8 Publications

None.

Mr. Byron Bester

Water Services: Aquatic Ecology

Digby Wells Environmental

Summary

Byron attained his Master's degree in Aquatic Health from the University of Johannesburg by assessing the health status and edibility of selected fish species within various impoundments within the North West Province of South Africa. In addition to various aspects of aquatic ecosystem assessment (water quality assessment, sediment composition, fish biometric indices determination, etc.), he has specific experience and knowledge in the application of histopathological fish health assessments and human health risk assessments via the consumptive pathway. His passion for further research and exposure to water-related aspects of the natural system afforded him the opportunity to spend a few months at the renowned UNESCO-IHE Institute for Water Education in Delft, The Netherlands for a Special Programme in Environmental Science at a Master of Science level, for which he attained European Credit Transfer System points for the modules completed.

He is currently registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (Reg. No. 400662/15) and is a member of the South African Society of Aquatic Scientists. Additionally, Byron has been accredited as a SASS5 River Health Programme practitioner with the Department of Water and Sanitation (previously Department of Water Affairs) since March 2012 and attended a number training sessions presented by the DWS for EcoStatus Determination and the River Ecosystem Monitoring Programme, describing the latest bioassessment tools in Present Ecological State (or Ecological Category) determination.

1 Education

- 2013: MSc Aquatic Health (University of Johannesburg).
- 2010: BSc Hons. Zoology (University of Johannesburg)
- 2009: BSc Biochemistry & Zoology (University of Johannesburg)

Other Qualifications/Skills

- South African Scoring System: Version 5 (SASS5) Field Assessment Accreditation in terms of the River Health Programme, Department of Water Affairs and Sanitation (March 2012 – Present)
- Special Programme (Module 3 & 4): MSc Environmental Science at UNESCO-IHE Institute for Water Education in The Netherlands (December 2012 – February 2013)

Other Training / Courses / Workshops:

- **Fish Invertebrate Flow Habitat Assessment (FIFHA) - Short Course** *presented by* Dr Neels Kleynhans (Fish Scientist) at Department of Water and Sanitation: Resource Quality Information Services, 2015.
- **National Training and Development Buffer Zone Tool – Gauteng Workshop** *presented by* Ian Bredin (Senior Scientist) at Institute of Natural Resources and Doug Macfarlane (Director and Principal Scientist) at Eco-Pulse Consulting, 2015.
- **Rapid Habitat Assessment Model (RHAM) training** *presented by* Dr Neels Kleynhans (Fish Scientist) & Christa Thirion (Macroinvertebrate Scientist) at Department of Water and Sanitation: Resource Quality Information Services, 2015.
- **Quantum GIS (QGIS) training** *presented by* Michael Breetzke (UAV & LiDAR Technician) at Southern Mapping Geospatial, 2015.
- **New River Health Programme training** *presented by* Dr Neels Kleynhans (Fish Scientist) & Christa Thirion (Macroinvertebrate Scientist) at Department of Water Affairs: Resource Quality Services, 2014.
- **National Water Act, 1998 (Act No. 36 of 1998) Section 21 (c) & (i) Water Uses** *presented by* Ms Valerie du Plessis – Deputy Director: Environment and Recreation, 2013.
- **Atlas of Freshwater Ecosystem Priority Areas (FEPAs) in South Africa – Maps to support sustainable development of water resources** *presented by* Dr Jeanne Nel – Project Leader of the NFEPA Project and CSIR Principal Scientist, 2012.
- **SASS5 Aquatic Biomonitoring Training Course** *presented by* Dr Mark Graham – Director of Groundtruth and Regional KwaZulu-Natal SASS5 Auditor, 2012.
- **Health Risk Assessment of Contaminants in Fish Training** *presented by* Ms Bettina Genthe – Group Leader of Water and Human Health Research Group at CSIR Natural Resources and the Environment, 2011.

2 Language Skills

- English (1st language)
- isiZulu (2nd language)
- Afrikaans (Conversational)

3 Employment

- 09/2017 – Present: Aquatic Ecology Unit Manager at *Digby Wells Environmental (Pty) Ltd.*
- 05/2015 – 08/2017: Project Manager & Aquatic Ecologist at *GIBB (Pty) Ltd.*
- 10/2011 – 04/2015: Junior Natural Scientist (Aquatic Ecology) at *Strategic Environmental Focus (Pty) Ltd.*

- 08/2011 – 09/2011: Sampling Assistant (Histopathology) at *University of Johannesburg*

4 Services Experience

Throughout his postgraduate studies and subsequent career, Byron's involvement in numerous biodiversity-related studies and health-risk assessments has culminated in the delivery of the following services and/or deliverables:

- **Desktop analysis** of aquatic ecology functionality and associated catchment level importance and sensitivity;
- **Aquatic biological monitoring** (or biomonitoring) through the application of various biological response assessment indices (incl. aquatic macroinvertebrate, fish and diatoms assemblages), as well as development of subsequent biomonitoring programmes;
- **Baseline aquatic biodiversity assessments** (including defining a list of expected freshwater species of conservation concern and alien invasive species);
- **Impact assessments** on aquatic ecology, as well as determination of recommended buffer zone surrounding affected watercourses;
- **Fish health assessments** through the application of a number of fish biomarkers (e.g. conditions factors, organosomatic indices, haematological assessment, necropsy-based evaluation, histopathology, and ageing of fish;
- Experience in the application of **human health risk assessment models** through oral consumption of bioaccumulated pollutants sequestered within the muscle tissue of selected fish (or freshwater) species;
- **Basic riparian habitat assessment** of ephemeral streams; and
- **Basic 'passability' (or movement capability) assessments** of instream freshwater species within fragmented watercourses (e.g. culverts, weirs, dams, etc.).

5 Project Experience

During various tenures at large multidisciplinary environmental and engineering consulting companies, Byron has established himself as an aquatic ecologist (or scientist) with experience in both South Africa (7 of the 9 provinces) and abroad (e.g. Botswana, Democratic Republic of Congo, Ghana, Namibia, Zambia). He has been involved at various levels of the compilation of the Specialist Input required for the nationally legislated environmental process of South Africa, especially in the form of Environmental Impact Assessments (EIA's), Mining Right Applications and Water Use License Applications (WULA's).

He completed numerous specialist aquatic biodiversity assessments in a wide range of sectors, including mining (e.g. coal, gold, platinum, titanium, etc.), industrial (e.g. smelters, brick-making projects, special economic zones, etc.), transport infrastructure upgrades (e.g. roads, airports, rapid transport systems, etc.), services infrastructure (e.g. powerline installations, bulk water pipelines, etc.), as well as mixed-use, residential and commercial

developments. Consequently, he is in a good position to assess the potential impact upon aquatic ecosystems likely to be associated with a wide range of different type of projects and/or development plans.

6 Professional Affiliations

- South African Council for Natural Scientific Professions: Professional Natural Scientist. Registration number 400089/15;
- Member of the South African Society of Aquatic Scientists

7 Professional Registration

- South African Council for Natural Scientific Professions (SACNASP): Professional Natural Scientist (Registration. No. 400662/15)
    - Aquatic Science
    - Zoological Science

8 Publications/Presentations

- Bester, B. M., Wagenaar, G. M. & Van Dyk, J. C. (2013) An assessment of the histology and edibility of *Clarias gariepinus* and *Cyprinus carpio* from two impoundments in the North West Province, South Africa, Poster presentation, SASAqS Conference – Catchments, Coastal interfaces and Communities, Arniston.
- Bester, B. M., Wagenaar, G. M. & Van Dyk, J. C. (2012) Is there a human health risk from consumption of freshwater fish in the North West Province? Oral PPT presentation, SASAqS Conference – Aquatic ecosystems; conservation & connectivity, Cape St Francis.
- Bester, B. M., Wagenaar, G. M. & Van Dyk, J. C. (2011) Histology-based fish health assessment and edibility of fish from two impoundments in the North West Province, South Africa. Poster/PPT presentation, Suid-Afrikaanse Akademie Vir Wetenskap en Kuns (SAWEK).
- Bester, B. M. & De Lange-Jacobs, P. C. (2010) Histological assessment of the main visceral organs of *Sternophysinx filaris* and *S. calceola* (Crustacea: Amphipoda). Oral PPT presentation, SAWEK.