Project Name	Status	Project
Environmental Management Plan(EMP)		
Heidelberg X 12	ROD	EMP
Monavoni Shopping Centre	Completed	EMP
Forest Hill Development	Completed	EMP
Weltevreden Farm 105KQ	Completed	EMP+EIA
Raslouw Holding 93	Completed	EMP+BA
Durley Development	Completed	EMP+BA
Rooihuiskraal North X 28	Completed	EMP

Rehabilitation Plan		
Norwood Mall/Sandspruit	In Progress	Rehabilitation
Project Shelter Heidelberg	In Progress	Rehabilitation
Sagewood Attenuation Pond	ROD	Rehabilitation
Velmore Hotel	Completed	Rehabilitation
Grace Point Church	Completed	Rehabilitation
Mmamelodi Pipeline	Completed	Rehabilitation

Visual Impact Assessment		
Swatzkop Industrial Developme	Completed	Assessment +DFA
Erasmia	Completed	Assessment

Signage Application		
Menlyn Advertising	Completed	Signage
The Villa Mall	Completed	Signage+EMP+BA

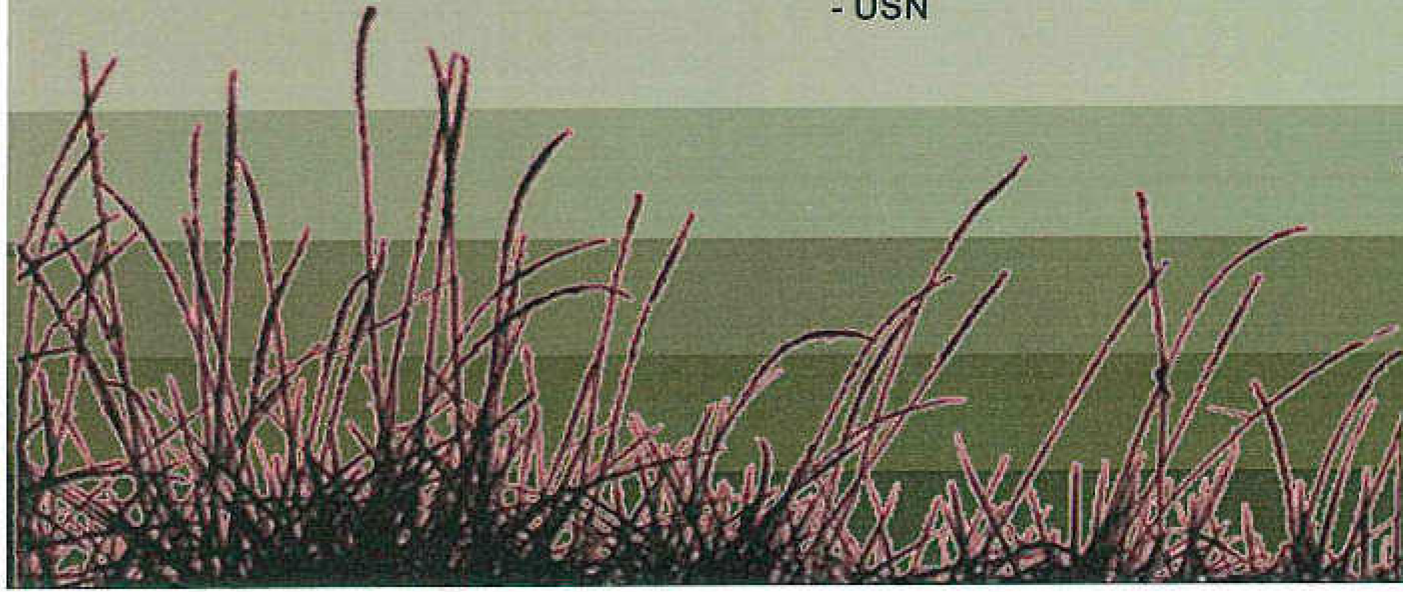
Bokamoso

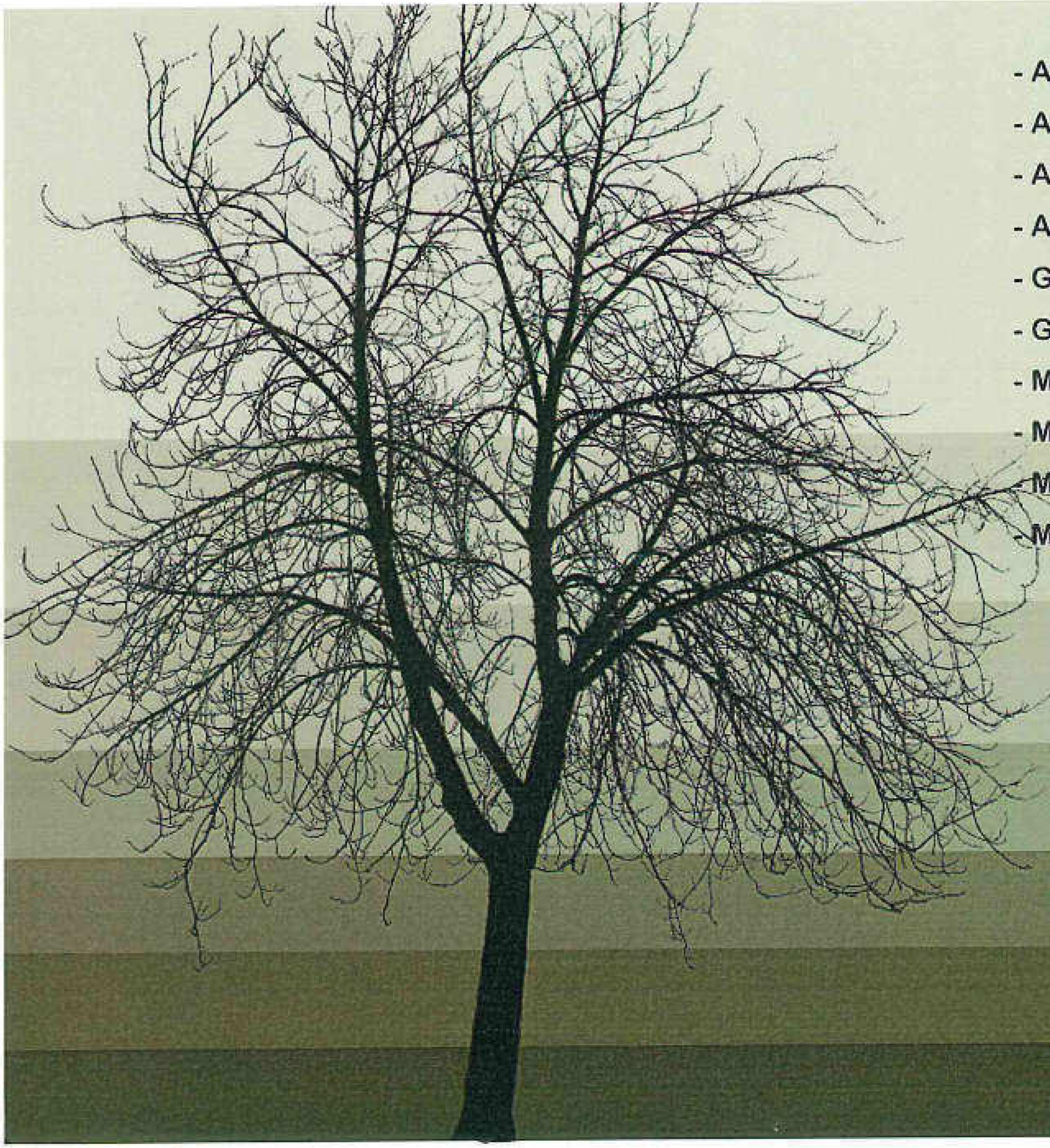
07 Current Environmental Projects

074 EMP, Rehabilitation , Waste Management & Signage Application

08 Indicative Clients

- Billion Property Group
- Cavaleros Developments
- Centro Developers
- Chaimberlains
- Chieftain
- Century Property Group
- Coca Cola
- Elmado Property Development
- Flanagan & Gerard
- Gautrans
- Hartland Property Group
- Moolman Group
- MTN
- M&T Development
- Old Mutual
- Property Investment Company
- Petroland Developments
- RSD Construction
- SAND
- Stephan Parsons
- Twin City Developments
- Urban Construction
- USN





- Adobe Illustrator CS3
- Adobe Photoshop CS3
- Adobe InDesign CS3
- AutoCAD
- Google SketchUP
- GIS
- Microsoft Office Word
- Microsoft Office Excel
- Microsoft Office Publisher
- Microsoft Office Power Point

Bokamoso

09 Tools

Qualifications And Experience In The Field Of Environmental Planning And Management (Lizelle Gregory (Member Bokamoso)):

Qualifications:

-Qualified as ***Landscape Architect*** *at UP 1991;*
-Qualified as ***Professional Landscape Architect in 1997;***
-A Registered Member at The ***South African Council for the Landscape Architect Profession (SACLAP)*** *with Practise Number:* ***PrLArch97078;***
- A Registered Member at the ***International Association for Impact Assessment Practitioners (IAIA);***
- Qualified as an ***Environmental Auditor in July 2008*** *and also became a Member of the International Environmental Management Association (IEMAS) in 2008.*

Working Experience:

-Worked part time at Eco-Consult – 1988-1990;
-Worked part time at ***Plan Associates as Landscape Architect in training*** *– 1990-1991;*
-Worked as Landscape Architect at ***Environmental Design Partnership (EDP)*** *from 1992 - 1994*
-Practised under ***Lizelle Gregory Landscape Architects*** *from 1994 until 1999;*
-Lectured *at Part-Time at* ***UP*** *(1999) – Landscape Architecture and* ***TUT*** *(1998- 1999)- Environmental Planning and Plant Material Studies;*
-Worked as ***part time Landscape Architect and Environmental Consultant at Plan Associates*** *and* ***managed their environmental division for more that 10 years*** *– 1993 – 2008 (assisted the* ***PWV Consortium*** *with various road planning matters which amongst others included environmental Scans, EIA's, Scoping reports etc.)*
-Renamed business as ***Bokamoso in 2000*** *and is the only member of Bokamoso Landscape Architects and Environmental Consultants CC;*
-More than 20 years experience in the compilation of Environmental Reports, *which amongst others included the compilation of various* ***DFA Regulation 31 Scoping Reports,*** *EIA's for EIA applications in terms of the applicable environmental legislation, Environmental Management Plans, Inputs for Spatial Development Frameworks, DP's, EMF's etc. Also included EIA Application on and adjacent to mining land and slimes dams (i.e. Brahm Fisherville, Doornkop)*

Qualifications And Experience In The Field Of Landscape Architecture (Lizelle Gregory (Member Bokamoso)):

Landscape Architecture:

-Compiled landscape and rehabilitation plans for more than 22 years.

The most significant landscaping projects are as follows:
-Designed the Gardens of the Witbank Technicon (a branch of TUT). Also supervised the implementation of the campus gardens (2004);
-Lizelle Gregory was the Landscape Architect responsible for the paving and landscape design at the UNISA Sunnyside Campus and received a Corobrick Golden Award for the paving design at the campus (1998-2004);
-Bokamoso assisted with the design and implementation of a park for the City of Johannesburg in Tembisa (2010);
-The design and implementation of the landscape gardens (indigenous garden) at the new Coca-Cola Valpre Plant (2012-2013);
-Responsible for the rehabilitation and landscaping of Juksei River area at the Norwood Shopping Mall (Johannesburg) (2012-2013);
-Designed and implemented a garden of more than 3,5ha in Randburg (Mc Arthurpark). Bokamoso also seeded the lawn for the project (more than 2,5 ha of lawn successfully seeded) (1999);
-Bokamoso designed and implemented more than 800 townhouse complex gardens and submitted more than 500 Landscape Development Plans to CTMM for approval (1995 – 2013);
-Assisted with Landscape Designs and the Masterplan at Eco-Park (M&T Developments) (2005-2011);
-Bokamoso designed and implemented an indigenous garden at an office park adjacent to the Bronberg. In this garden it was also necessary to establish a special garden for the Juliana Golden Mole. During a recent site visit it was established that the moles are thriving in this garden. Special sandy soils had to be imported and special indigenous plants had to be established in the natural section of the garden.

-Lizelle Gregory also owns her own landscape contracting business. **For the past 20 years she trained more than 40 PDI jobless people (sourced from a church in Mamelodi)** to become landscape contracting workers. All the workers are (on a continuous basis) placed out to work at nurserys and other associated industries;
-Over the past 20 years the Bokamoso team compiled more than 800 landscape development plans and also implemented most of the gardens. Bokamoso also designed and implemented the irrigation for the gardens (in cases where irrigation was required). Lizelle regarded it as important to also obtain practical experience in the field of landscape implementation.

Annexure E

Rejection of Amendment Application

Annexure HCB 9

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GAUTENG PROVINCE

AGRICULTURE AND RURAL DEVELOPMENT

REPUBLIC OF SOUTH AFRICA

Reference: Gaut 006/12-13/E0070
Enquiries: Simon Mafu
Email: Simon.Mafu@gauteng.gov.za

Mr. Werner van Rhyn and Mr. Ibrahim Mia
Waterval Islamic Institute
P.O. Box 5
Johannesburg
2000

GDARD
Office of the HOD
13 -03- 04
000092

Facsimile: (011) 802 1563 / (011) 253 9229

PER FACSIMILE & REGISTERED MAIL

Dear Sir (s)

APPLICATION FOR AMENDMENT OF THE ENVIRONMENTAL AUTHORISATION GAUT 002/05-06/1476: THE PROPOSED NORTHERN RESIDENTIAL ESTATE ON PORTIONS OF THE REMAINDER OF PORTION 1 OF THE FARM WATERVAL 5 IR: GAUT 006/12-13/E0070

The above matter and more specifically your application for an amendment received on 20 May 2012, have reference.

Please be advised that the Department has, under the powers vested in it by Regulations 41 and 42 of the Environmental Impact Assessment Regulations, 2010 ("the Regulations") decided not to amend the Environmental Authorisation (EA) (GAUT 002/05-06/1476) issued on 12 October 2007 in respect of the above-mentioned project.

The Annexure reflecting the reasons for the decision are attached hereto.

In terms of Regulation 10(2), you are instructed to notify all Registered Interested and Affected Parties in writing and within 12 (twelve) calendar days of the date of this letter, of the Department's decision not to amend the Environmental Authorisation as well as the provisions regarding the making of appeals that are provided in the Regulations.

Your attention is drawn to Chapter 7 of the Regulations which regulates appeal procedures. Should you wish to appeal any aspect of the decision, you must, *inter alia,* lodge a Notice of Intention to Appeal with the Member of the Executive Council (MEC), within 20 (twenty) days of the date of this letter, by means of one of the following methods:

By facsimile:	(011) 333 - 0620
By post:	P. O. Box 8769 Johannesburg 2000; and
By hand:	16th Floor Diamond Corner Building 68 Eloff Street Johannesburg

Should you decide to appeal, you must serve a copy of your Notice of Intention to. Appeal on all Registered Interested and Affected Parties and any organ of state within 10 (ten) days of having submitted such a Notice of Intent to Appeal as well as a Notice indicating that the appeal submission will be made available to all parties on the day of lodging it with the MEC and where and for what period the appeal submission will be available for inspection. The prescribed appeal form is available on the Department's website; www.gdard.gpg.gov.za .

Yours faithfully

GDARD
Office of the HOD
13 -03- 04
000092

Ms S.J. Sekgobela
Head: Agriculture and Rural Development
Date: 01/02/2013

CC:	GDARD Compliance & Enforcement Branch	Attn: Tel: Fax	Environmental Compliance Monitoring (011) 355 - 1900 (011) 355 - 1850
	City of Johannesburg Environment Management	Attn: Fax:	Lebo Molefe 086 627 - 7516
	Landscape Architect and Environmental Planner	Attn: Tel: Fax	Dr. Gwen Theron (012) 344 3582 086 606 6130

Annexure 1

REASONS FOR DECISION

1. Background

The Department issued Environmental Authorisation Gaut: 002/05-06/1476 on 12 October 2007 to Waterval Islamic Institute to undertake the following activities–

- **'the construction, erection or upgrading of roads, railways, airfields and associated structures': item 1(d) of Government Notice R1182;**
- **'the construction, erection or upgrading of canals and channels, including structures causing disturbances to the flow of water in a river bed, and water transfer schemes between water catchments and impoundments': item 1(i) of Government Notice R1182;**
- **'the construction, erection or upgrading of dams, levees or weirs affecting the flow of a river' :item 1(j) of Government Notice R1182;**
- **'the construction, erection or upgrading of public and private resorts and associated infrastructure': item 1(m) of Government Notice R1182;**
- **'the change of landuse from agriculture or undetermined use to any other land use': item 2(c) of Government Notice R1182,**

all of which fall within the ambit of Government Notice R1182 (as amended) promulgated under Sections 21; 26 and 28 of the Act (Environment Conservation Act, (Act 73 of 1989)).

2. Information Considered

The Department took, *inter alia*, the following into consideration -

2.1 The information contained in the amendment application form received by the Department on 20 May and August 2012;
2.2 The initial Environmental Authorisation issued on 12 October 2007;
2.3 Relevant information contained in the Departmental information data base including the Geographical Information System specifically the C-Plan Version 3; and
2.4 The objectives, principles and requirements of relevant legislation, policies and guidelines, including the principles contained in Section 2 of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

3. Key Factors Considered

All information presented to the Department was taken into account in the Department's consideration of the application. A summary of the issues which, in the Department's view, were of the most significance is set out below.

a) The contents of the Environmental Authorisation issued by the Department on the 12 October 2007;
b) A request was made to relax the buffers of the northern section of the wetland (north of the Maxwell Drive bridge) that affect the land parcels through the use of the 1:100 year floodline delineated in 2006 (reduction) instead of the wetland buffers as set out in the ROD;
c) A request was made to relax the buffers of the southern section of the wetland (south of the Maxwell Drive bridge) that affect a 400m stretch of the Jukskei Drive Road, on the eastern side of the watercourse. It also affects the land parcels located along this road and proposes buffer

leniency (reduction) which allows for encroachment of the fill/toe of the road within the watercourse buffers instead of the buffers (32m and 30m) as set out in the ROD;

d) The conditions of the Water Use License (License No: 27/2/2/A321/118/2; File No: 27/2/2/A21C/118) from the National Department of Water Affairs and issued in order to undertake the necessary construction activities;
e) The prevailing environmental status quo in the wetland area (northern part of the site, south of Allandale Drive interchange, along N1) to be affected by the proposed buffer zone reduction. There is erosion of that section of stream due to the canalization and increased stormwater volumes of water from a culvert from the Allandale Road, as a result of the upgrade of the Allandale interchange by the South African National Road Agency Limited (SANRAL); and
f) Encroachment of the buffers as requested would affect the buffers that have been set in Conditions 2(a) and 3(d)(i); 4 and 5.

Matters of clarity regarding your letters dated 20 May 2012 and 20 August 2012 (revised) submitted by to the Department by the Environmental Assessment Practitioner (LEAP):

g) The buffers on the wetlands are set at 30m as stated in Condition 2(a) which is correctly set.
h) Condition 3(d) (i) simply relates to all the buffers which include both the 30m buffer for the wetlands and 32m buffer for the rivers and streams which must be fenced-off as per the requirements of Condition 3(d) (i).
i) Therefore, if according to Figure 1 in your letter dated 29/02/2012, the presence of the wetland area and 30m buffer are going to be bigger than the river and its 32m buffer, it would mean that the fence would be located on the bigger buffer (i.e. the wetland). What this means is that the different systems (wetland and riverine) must be delineated according to the respective buffers as stated in the condition 3(d) (i).

Office of the HOD 13 -08- 06 000002

4. Findings

Having considered the information and factors listed above, the Department made the following findings:

a) The Department does not agree with encroachment of the road edge/verge into the wetland or river buffers, be it for accommodating the land parcels (3/2 and 2/2) on the northern section of the watercourse or construction of a wall for 400m or the fill from the edge of the road (Jukskei View Drive) on the southern section of the amendment proposal site. The Department is of the view that reducing the buffer along the 400m length of road and would exacerbate the existing erosion that is currently affecting the watercourse. Rather rehabilitation measures should be implemented and include the buffers that your proposal seeks to reduce. Development that seeks to build within the buffer is viewed as leading to increased problems such as increased storm water, potential flooding and assured destruction of the watercourse.
b) The activites required for complying with the Water Use License (License No: 27/2/2/A321/118/2; File No: 27/2/2/A21C/118) have been approved in the ROD dated 12 October 2007.
c) Encroachment and/or relaxation of the buffers as requested would serve to contradict the Department's guidelines that seek to conserve and promote sustainable ecological services in the Gauteng Province.
d) It is rather advised that SANRAL be engaged in order to solve the erosion through rehabilitation measures.

In view of the above, the Department is of the opinion that the requested amendment would result in unacceptable negative environmental impact that would conflict with the general principles and objectives of intergrated environmental management laid down in Chapter 5 of the National Environmental Management Act, 1998 and that any potentially detrimental environmental impact resulting from the proposed activity cannot be mitigated to acceptable levels.

The amendment to the EA is accordingly refused.

GDARD
Office of the HOD
13 -03- 06
000002

Annexure HCB 10

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REPUBLIC OF SOUTH AFRICA

Reference: 002/08-09/N0993
Enquiries: Ms Thandaza Dlulane
E-mail Address: Thandaza.dlulane@gauteng.gov.za

JA Venter
Adriaan Venter Attorneys
14th – 12th Street
PRETORIA
0001

Email Address: info@avatt.co.za

PER ELECTRONIC MAIL

Dear Sir/Madam

RE: APPEAL AGAINST THE REFUSAL TO AMEND THE ENVIRONMENTAL AUTHORISTION IN RESPECT OF THE PROPOSED NORTHERN RESIDENTIAL ESTATE ON PORTIONS OF THE REMAINDER OF PORTION 1 OF FARM WATERVAL 5 IR

Your appeal lodged dated 28 May 2013 refers.

I have considered your appeal and in issuing my decision I have taken into account the following:

1. The contents of the project file;
2. The appeal documentation; and

Having considered the above information, I am of the view that:

1. The Department's decision not to amend the environmental authorisation was issued correctly and in compliance with applicable legislation and policies.

2. The condition imposing 30 meter buffer zone to wetlands present on site is aimed at protecting these wetlands. Further, the imposition of the 30 meter buffer clearly indicates the Department's commitment to discharging its duty towards the environment.

3. The request by the applicant that the 30 meter buffer be reduced will lead to unacceptable negative impacts to the environment.

4. The information submitted in respect of the application was adequate to enable the Department to issue a decision.

5. The Department's officials are qualified and experienced to formulate and provide credible opinions or views on issues relating to the environment.

Yours faithfully

Ms Nandi Mayathula-Khoza
MEC: Agriculture, Rural and Social Development
Date: 13 SEPT 2013

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Annexure HCB 11

ADRIAAN VENTER
PROKUREURS & ASSOSIATE
ATTORNEYS & ASSOCIATES

Lady Brooks Gebou / Lady Brooks Building
14 - 12de Straat, Menlopark, Pretoria
14 - 12th Street, Menlo Park, Pretoria
✉ 1335, Pretoria, 0001
☎ 012 346 1075
012 346 1845
012 346 6665
info@avatt.co.za

OUR REF / ONS VERW: JA VENTER/LJ/AA0041
YOUR REF / U VERW:

DATE / DATUM: 2013-05-28

MEC: GAUTENG DEPARTMENT OF
AGRICULTURE & RURAL DEVELOPMENT
16th Floor
Diamond Corner Building
68 Eloff Street
Johannesburg

PER HAND

ERKEN ONTVANGS HIERVAN
ACKNOWLEDGE RECEIPT
GOVERNMENT
Department Of Agriculture
And Rural Development
29-05-2013
OP/ON:
RECEIVED
OFFICE OF THE MEC
P O BOX 8769 JOHANNESBURG 2000

Dear Sir,

APPEAL AGAINST THE REFUSAL TO AMEND ENVIRONMENTAL AUTHORISATION
REFERENCE: GAUT 002/05-06/1476 (GAUT 002/08-09-N0993)
IN RESPECT OF THE PROPOSED NORTHERN RESIDENTIAL ESTATE ON PORTIONS OF THE REMAINDER OF PORTION 1 OF THE FARM WATERVAL 5 IR
YOUR REF: GAUT 006/12-13/E0070

We refer to the lodgement of the abovementioned Appeal on 20 May 2013 as well as the re-lodgement thereof, on 23 May 2013, both of which you received but indicated that the complete document apparently was not transmitted or received in its entirety. Copies of proof of such lodgements are attached hereto for your convenience.

We further refer to subsequent telephonic conversations between your Paulina and our Ms Suné Meyer with regards to the aforementioned situation. As mentioned above Paulina indicated once again that the Appeal was not received in its entirety and advised us that this might be caused by network problems at the MEC's office.

Therefore kindly find attached hereto, as agreed between Pauline and Ms Meyer, a hard copy of the aforementioned Appeal.

We trust you find the above in order.

Yours faithfully

obo
ADRIAAN VENTER
ATTORNEYS & ASSOCIATES

Annexure F

Correspondence from Attorney confirming withdrawal of High Court Application and the Proposed Way Forward

IN THE HIGH COURT OF SOUTH AFRICA

(GAUTENG DIVISION, PRETORIA)

CASE NR: 23130/14

In the Application between

WITWATERSRAND ESTATES LIMITED First Applicant

ATTERBURY WATERFALL INVESTMENT COMPANY Second Applicant

AND

THE HEAD OF THE DEPARTMENT:
AGRICULTURE & RURAL DEVELOPMENT
GAUTENG PROVINCIAL GOVERNMENT First Respondent

THE MEC:
DEPARTMENT AGRICULTURE & RURAL DEVELOPMENT
GAUTENG PROVINCIAL GOVERNMENT Second Respondent

NOTICE OF WITHDRAWAL

KINDLY NOTE that the Applicants herewith withdraws the Review Application lodged on the 19th of March 2014 in the above Honourable Court.

KINDLY FURTHER NOTE that the Applicants herewith tender the taxed party party costs of the Respondents relating to the drafting and filing of their answering papers in this matter.

SIGNED AT PRETORIA ON THIS 9th DAY OF MARCH 2016.

ADRIAAN VENTER ATTORNEYS
AND ASSOCIATES
ATTORNEYS FOR THE APPLICANTS
LADY BROOKS BUILDING
14 – 12TH STREET
MENLO PARK
PRETORIA
TEL: 012 346 1075
FAX: 012 346 6665
EMAIL: info@avatt.co.za
REF: JA VENTER/DS/AA0049

TO: THE REGISTRAR
HIGH COURT OF SOUTH AFRICA
GAUTENG DIVISION, PRETORIA

AND TO: THE FIRST RESPONDENT
THE HEAD OF THE DEPARTMENT:

AGRICULTURE & RURAL DEVELOPMENT

GAUTENG PROVINCIAL GOVERNMENT

C/O

THE STATE ATTORNEY, PRETORIA

SALU BUILDING

316 THABO SEHUME STREET

PRETORIA

ATT: MRS RN NTLOKO

STATE ATTORNEY
PRIVATE BAG/PRIVAATSAK X91
2016 -03- 09
PRETORIA 0001
STAATSPROKUREUR

AND TO: THE SECOND RESPONDENT

THE MEC:

DEPARTMENT OF AGRICULTURE & RURAL DEVELOPMENT

GAUTENG PROVINCIAL GOVERNMENT

C/O

THE STATE ATTORNEY, PRETORIA

SALU BUILDING

316 THABO SEHUME STREET

PRETORIA

ATT: MRS RN NTLOKO

STATE ATTORNEY
PRIVATE BAG/PRIVAATSAK X91
2016 -03- 09
PRETORIA 0001
STAATSPROKUREUR

Annexure G

Copy of Rehabilitation Plan
Already Implemented

LEAP
Gwen Theron
PrLArch No 97062

Landscape Architect
Environmental Planner

Imbrilinx cc 2010/089610/23

P.O. Box 13185
Hatfield 0028

012 343 2751
083 302 2116
086 606 6130 fax
gwen.theron@telkomsa.net

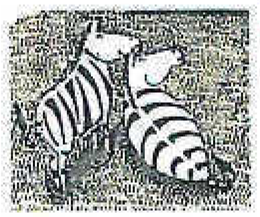
WATERFALL

OPEN SPACE, AND WETLAND MANAGEMENT PLAN

August 2012

Prepared in response to the ROD for Northern Residential Estate

GAUT 002/05-06/1476



To:	Gauteng Department of Agriculture and Rural Development
From:	Dr. Gwen Theron
Date:	14 June 2012 - Updated August 2102
Project	Northern Residential Estate
Distribution	GDARD Century Properties Development Atterbury Property Development

Contents

1. INTRODUCTION

The purpose of an Open Space Management plan is to guide the management, maintenance and enhancement of the Open space over time. Interventions and proposal are flexible and are linked to the annual seasons.

The purpose of a Wetland Management Plan is to guide the rehabilitation work within and adjacent to the sensitive areas on site.

The plans are flexible to be adapted where necessary and to address issues that may arise during the construction phase.

Objectives;

The purpose of this document is to

- guide the management of the ecological attributes of wetland and open space areas, as well as
- provide remedial measures that had deteriorated during the various phases of construction.
- suitable rehabilitation measures are provided in order to facilitate the ongoing ecological functioning of the wetland and associated open space features.

2. DOCUMENTATION CONSULTED

The following reference material was considered during the development of the addendum to the rehabilitation and open space management plan:

- ROD for Northern Residential Estate – GAUT 002/05-06/1476
- Wetland report and ecological assessments prepared as part of the EIA application – completed by SEF.
- The ecological assessment undertaken by Scientific Aquatic Services CC as part of the initial EIA application;
- The Wetland Rehabilitation and Management Plan of Waterfall Estate as drafted by Scientific Aquatic Services CC
- National Environmental Management Act (1998) (NEMA and related EIA regulations;
- National Water Act (Act 36 of 1998)
- National Environmental Management: Biodiversity Act (2004)
- Conservation of Agricultural Resources Act (CARA), 1983 (Act No. 43 of 1983)
- National Heritage Resources Act (1999); and
- The Convention on Biological Diversity (1995)
- Other general stream rehabilitation mitigation and management guidelines.

3. ENVIRONMENTAL CONDITIONS

The ecological, wetland, geotechnical and other applicable assessments, prepared by any of the specialists must be studies as part of the implementation of any rehabilitation work on the land. Specific attenti0on must be paid to the underlying soil, which is highly dispersive and will give way to any water coming in contact with it.

The areas where the soil is exposed for periods during the rainy season must be covered with hessian and pegged. The slopes must also be planted with fast growing grass. The only way to keep the slopes from eroding is to keep water away from it.

4. OPEN SPACE MANAGEMENT

4.1 INTRODUCTION

An open space management plan allows open space in the greater Waterfall Estate to be viewed as a whole rather than as several individual unrelated parcels. This view supports continuity in planning and management of open space as a collective resource. Each parcel is evaluated and examined to establish its unique position as open space and to determine what is appropriate in each area, what the neighbors want, and what the issues and opportunities are associated with each of the open spaces.

The benefits of developing an open space management plan are numerous. A broad-based public involvement approach is encouraged to allow for a participatory environment where residents, land owners, occupants, and interested parties are able to offer their input into the shape of their natural surroundings. It is hoped that continuing dialogue will lead to a constituency that is informed about challenges with open space and a planning team that is aware of the concerns of citizens. Dialogue is managed at a high level between the various land owns and developers.

From these management recommendations a schedule for implementation is operated by each land owner and developer.

4.2 GOALS

The goals of management and stewardship in the open spaces of Waterfall are to:

- Promote ecosystem sustainability
- Enhance and protect natural, cultural, educational and scenic resources
- Provide safe and enjoyable passive outdoor recreation activities.

Each of these goals will be achieved through specific management actions that may include:

- Control of noxious invasive weeds through an integrated Pest Management plan
- Monitoring of vegetation, wildlife and water
- Planting of favorable plant species
- Maintaining trails

- Maintaining amenities such as fences, signs and benches, and introducing them as appropriate for enhanced management
- Working to provide educational opportunities through on-site informational materials and guided nature hikes where appropriate.
- Targeted enhancement based on public input

4.3 ACTIONS

- Maintain fences between open spaces and development pockets until all development parcels has been completely built up, rehabilitated and signed-off by the building inspectors and occupancy certificates issued.
- Evaluate trees to identify and remove hazards in the open areas.
- Retain falls trees and plant materials that area not a hazard to increase biomass and microbial activity in the open spaces.
- Trim trees and shrubs to maintain clearance along trails.
- Continue mowing and trimming regularly.
- Maintain wooden boardwalks.
- Maintain bird hides and lookout spots.
- Dredge ponds periodically.
- Clear weeds form lawns and storm water areas.
- Trim the grass around the pond and along the pathway.
- Periodically test water quality in the ponds.
- Stock fish in large ponds.
- Monitor fish population for a healthy fish stock.
- Install bird houses, bat and owl boxes in larger trees.
- Install more benches/shelters around native area.
- Formalize the dirt trails to ensure people stay on the trail and not rat-run across the grass.
- Implement and maintain signage for the trail system.
- Plant with indigenous vegetation where at all possible. (Pennisitum may be used as a stabilising material)
- Enhance native plant communities by encouraging planting of indigenous vegetation is all gardens.
- Remove invasive species from around native plant communities to increase sunlight and reduce competition. Additional native plantings and natural regeneration will encourage these plant populations to spread beyond their current extent.

5. REHABILITATION

This Rehabilitation Plan has been compiled in accordance with the requirements contained in Government Notice No. R. 541 (General Authorisation in terms of Section 39 of the National Water Act 1998, Act 36 of 1998). The rehabilitation plan contains the following:

- Rehabilitation objectives;
- Rehabilitation problems;

- Areas requiring rehabilitation interventions;
- Rehabilitation measures;
- Ongoing problems within the wetlands and open spaces and specific mitigation measures. ;
- Final rehabilitation plans;
- Rehabilitation intervention;
- Maintenance details;
- Monitoring and evaluation data; and
- Construction notes.

The rehabilitation plan, in addition to the Environmental Management Programme (EMP), is a comprehensive document describing all rehabilitation measures aimed at rehabilitating the identified riparian zones along the tributaries and steams, thereby allowing for the efficient coordination and implementation of the proposed rehabilitation measures.

5.1 OBJECTIVES

Objectives pertaining to the rehabilitation of the riparian zones along the tributaries and stream are indicated below:

- Stabilisation and rehabilitation of adjacent area to the tributaries and stream;
- Stabilisation and rehabilitation of the wetland habitat units
- Rehabilitation of construction areas adjacent to the wetlands, tributaries and stream ; and
- Biodiversity conservation to maintain habitat for species associated with riparian areas.
- Ensure as far as is practicable that the measures contained in the report are implemented;
- Manage activities on the study area in order to maintain and improve ecological integrity of the study area;
- Minimise adverse impacts on the environment;
- Minimise impacts on the receiving environment;
- Maximise the service provision of open space areas and especially the wetland areas;
- Maximise the ecological functioning of the open space areas, wetland system and green belts and;
- Monitor the impact of the project on the receiving environment.

A rehabilitation strategy will provide guidance as to the strategic decision making by the Department of Water Affairs (DWA) and GDARD. The rehabilitation strategy in the form of this rehabilitation plan will provide a perspective and strategic approach for the rehabilitation of the affected areas along the tributaries and stream.

5.2 REHABILITATION PROBLEMS

The success of the rehabilitation measures will only be evident after a certain time period has elapsed. Having assessed the existing status of the previously affected wetlands along the tributaries.
Vegetation used for the rehabilitation and stabilisation of wetland habitat units must be done according to the EMP and Rehabilitation Plan in order for adequate cover. Should such measures not be implemented correctly the risk of storm water erosion and siltation of wetlands will be encountered.

5.3 AREAS REQUIRING REHABILITATION INTERVENTION

5.3.1 Wetland, tributaries and streams.

The tributaries and streams are encountered within a steep and incised embankment. It is located within private Open space erven running along its entirety. The erven allows for the movement of wildlife and pedestrian traffic along the length of the tributaries and stream without disturbing any wetland features. Wetlands are impacted to varying degrees, mainly by the construction of the road crossings, infrastructure crossings, and adjacent development sites. Construction across the wetlands, the tributaries and stream necessitates the excavation, entrenching and fitment of new pipes. All of these proposed construction activities will take place within various wetland habitat units.

Other small scale excavations will be necessary to accommodate the casting of concrete infrastructure. There will therefore not be large stockpile areas of soil that could pose a threat to smothering nearby wetlands. It is, however, be prudent to protect any stored topsoil from erosion.

5.3.2 Construction camp and storage areas

The construction camp and material storage area, including vehicle and machinery maintenance area will be situated outside of the 30m Wetland buffer zone. However it lies immediately adjacent to the Jukskei River and special precautions must be taken to prevent erosion, run-off or impact on the wetland areas. Another large construction camp is located on parcel 10, but is located far from the N1 tributary. Other smaller construction camp must best be located more than 100m from any wetland, tributary or stream.

5.3.3 Infrastructure zones, residential erven, commercial erven etc.

Residential areas form the majority of the approved development area for the Islamic Northern Residential Estate. The construction commenced in 2008 with infrastructure and small residential areas being built, with the development expanding to include large expansions covering many hectares. The commercial development has been developed in appropriate pockets and has escalated to the current development of Parcel 10, comprising of the development of a major commercial node at the N1, Allendale road intersection.

5.4 REHABILITATION MEASURES

5.4.1 General

These measures apply to all wetland, stream, open spaces, river and tributary areas or any area affected by construction impacts.

In general, affected and scarred area must be tilled, shaped and levelled whether mechanically or manually in order to provide suitable conditions for grass germination. Soil is to be tilled to a minimum depth of 60mm and with a tilling spacing of not more than 200mm apart. Soil, due to the dispersive characteristics, MUST be covered and staked with bio-degradable material and stakes. All erosion gullies shall be filled with uncontaminated soil and compacted so that the final level of the gully is level with the surrounding soil surface. Entrances, exit areas and every 8 m in gullies shall be staked with straw bales – at least three bales perpendicular to the flow must be installed.

The shaping of the land must take storm water movement into account and must aim to disperse the energy of water rather than channel water where it can cause later soil erosion. All stones in excess of 50mm must be collected and packed in overflow channels/berm offshoots, this would include those dislodged in any soil preparation works. When Offshoots channels/berms are considered they are not to be directed into areas that are not stabilised well enough to cope with the waters energies which may cause erosion.

5.4.2 Rehabilitation measures:

a. Clearance:

- All construction/building related rubble left on site is to be collected and removed from site and disposed of at a permitted waste disposal site. Proof of disposal must be made available to the Environmental Control Officer (ECO) on site.
- Rubble to a depth of 100mm in the soil must all be removed.
- Cement mixing areas remaining on site must be removed to a depth necessary to clear all signes of cement.

b. **Levelling:**

- The affected and scarred area is to be levelled off as close as possible to the surrounding topography and with storm water management in mind so as not to hinder water drainage and cause channelling which may in time lead to erosion.
- If the area requires a cut and fill of greater than 300mm then the topsoil in the area is to first be removed, the cut and fill process completed and then the topsoil returned.
- Should additional topsoil be required to be brought onto site it must be of a suitable standard. (The Contractor shall provide the EMS Manager with a sample thereof prior to having the product delivered to site).
- It must be free of stones and organic matter in excess of 50mm.
- It must be loose and friable (to avoid crusting when compacted or watered.)
- It must be of a similar texture and moisture retaining ability to that on site.
- It must be a comparable or improved nutrient base to that on site.

c. **Alien invasive vegetation eradication:**

- The Contractor's methods and programs shall provide rapid and effective control of alien invasive vegetation for the overall site. Techniques, programming and chemicals employed shall therefore be directed at this aim. The Contractor shall carry out immediate treatment of growth in all instances where rapid and effective control is not achieved during any period of the contract.
- Where a chemical approach to vegetation control is adopted, hoeing (skoffel) will not be allowed as method of achieving control. Herbicides which act as a scorching agent (e.g. with Paraquate or similar active ingredient) are incapable of meeting the definition of control and shall not be used.
- Scorching of above-surface part of the canopy growth only shall not constitute control of vegetation as defined.
- Slashing of dead material to below 150mm will be permitted provided that no erosion is caused and that it is effective in stopping re-sprouting of alien trees.
- Application methods shall, however, be entirely in accordance with the manufacturer's specifications and recommendations for safe and effective use of the herbicides or herbicide mixtures concerned.

- The essence of this contract regarding vegetation control is that Rand Water requires the control of living invasive alien vegetation and the management of dead remains of previously living vegetation, to the extent that areas controlled in terms of this contract are free from any form of invasive alien vegetation in all areas included in this contract.

d. Soil preparation:

- Rip site with tractor mounted single tine sub soiler to a depth of 300mm to relive compaction.
- The area is then to be rotovated to obtain an even (fine) tilth (not dug over) to a depth of 100mm.
- Where topsoil is not present, spread topsoil to a depth of at least 75mm and compact lightly.
- Prepare and shape the final levels of the area ensuring once the veld grass seed is planted the finished level will tie in with the existing hard landscape levels and take the movement of storm water in to account.

e. Other grassing:

- Should an area become apparent where the embankment will have to withstand fast moving water from the flooding or scouring of water, the use of non-indigenous sterile Vetifer grass will be used.
- Vetifer grass has deep rooting mechanisms which will allow for appropriate vegetative control in such circumstances.
- According to the available international literature, the time of planting should be scheduled during the rainy season or irrigation provided. (a Vetiver Grass planting guide can be provided in event it becomes necessary)

f. Planting of Wet areas:

- Areas that remain permanently wet (flat or slightly sloping) will be rehabilitated with riverine vegetation such as:
  - Sedges (cyperus sp. And Schoenoplectus),
  - Rushes (Juncus sp).
  - Bull rushes (Typhasp) indigenous Miscanthus,
  - Phragmites and appropriate water loving Eragrotis such as plana or planiculmis.
  - Bulbs such as Crinum kniphfia and Zantedeschia could also be used.
- Installation of the plants must reflect their natural position in a riparian zone.

g. Instant grassing:

- The areas that currently have instant grass will be re-grassed with the equivalent grass to ensure a quick turnaround time in the rehabilitation of such areas.

h. Veldt grass seeding:

- The entire scarred area must be tilled either mechanically or manually in order to provide suitable conditions for grass germination and minimise water/wind disturbances. Soil is to be tilled to a minimum depth of not less than 60mm and with a scarification spacing of not more than 200mm apart.
- All seeding mixtures must contain a suitable fast propagating, non-invasive grass sees to establish quickly. This is specifically necessary to stabilise the dispersive soils.
- Use a Potch mixture (Smutsfinger / Rhodesgrass / Borseltjie)
- Alternatively, a seeding mixture of Eragrostis teff, Digitaria smutsii, Chloris gayana and Cynodon dactylon.
- These mixtures ensure adequate variety and blends in well with surrounding grass species.

- These mixtures remain open to further species being added. Should the Contractor wish to recommend additional/replacement indigenous grass species, these must be specified in the quotation together with the Contractors' recommended application rate. Preference will be given to improved seeding mixtures recommended by the Contractor.
- Seeding rate:
  - Eragrostis teff 5 kg/ha
  - Digitaria smutsii 5 kg/ha
  - Chloris gayana 5 kg/ha
  - Cynodon dactylon 10 kg/ha
  - Themeda triandra5 kg/ha
  - Melinis repens 5 kg/ha
  - Further species that can be combined with the above include Themeda trianda and Panicum maximum.
- It is envisaged that with the above-mentioned seeding mixtures and at the given application rate a 95% cover can obtained by the end of the second growing season. The Contractor shall ensure then that no single area of 2 m2 or larger is left uncovered with a total uncovered area not in excess of 5% over the entire scarred area. Should these conditions not be acceptable to a Contractor' guaranteed percentage cover.
- A total die back not in excess of 5% will be accepted. Should a larger die back be experienced, plants must be replaced at the cost of the Contractor. This die back percentage will be determined 2 months after planting. Over this 2 month period it will be left to the Contractor's discretion as to whether or not the water. (The 2 month period, applies to the months of September to March. If plants are planted from March to September, the 2 month assessment period will commence from end of September.)

i. **Construction of berms/water offshoots/soil erosion prevention structures at outlets(see Figure 1 below)**

- The minimum height of berms is to be not less than 200mm, measured from the surrounding soil level to the peak of the berm.
- The water gully/offshoot on the upward (top) side of each berm/water offshoot is to be not less than 200mm deep, measured from the surrounding soil level to the trough of the gully
- Each berm/water offshoot must be constructed in such a way that the water runs down the offshoot and off the area (road, scarred area). Wear possible berms on roadways should direct water into alternate sides of the roadway so that water is dissipated as far as possible. The berm should end in a dissipation settling area.
- No berm/water offshoot is to have an angle of more than 1:4, measured from the horizontal down towards the vertical. This is to ensure that water run-off is slow enough not to start unwanted erosion problems.
- The length of the berms on roadways shall where feasible commence at least 1m into vegetated soil on the top side of the berm and will continue across the scarred area/road requiring protection from erosion and end at least 2m into vegetated soil on the down side of the berm.
- This is to ensure that water removed from the protected area spreads out sufficiently over a vegetated area without causing any further erosion and simultaneously does not return to the area being protected.
- The minimum width of a berm is to be not less than 2m. The gradual height differences in the berm is to ensure that a standard 2 wheel drive vehicle can transgress the berm without the potential of getting stuck and cause skid of tyres. The berm must allow vehicles to cross easily without undue jerking.

- The placing of soil onto a berm must be sufficiently compacted in to the required shape so that it does not wash away.
- Rocks and stones in the soil mass should not protrude up and become a hazard to car traversing the berms on roadways.
- Rock packing on the leeward side of berms that are not traversed by vehicles is encouraged when possible.
- The position of the berms will be indicated on site by the ECO. The following guidelines shall apply in all instances where the position and length of the berms is not indicated by the ECOt.
- The position of the berms will be indicated on site by the ECO
- The factors influencing distances between berms:
    - Rainfall of the area
    - Soil types
    - Length of slope
    - Catchment area plus surface runoff water
    - Potential to establish vegetation
- Siltation prevention measures such as hay bales, must be installed at the outflows from all storm water outlets to catch any further sediment still in suspension. Measures such as use of sand bags or hay bales are also to be used to prevent any erosion at the outflow areas.

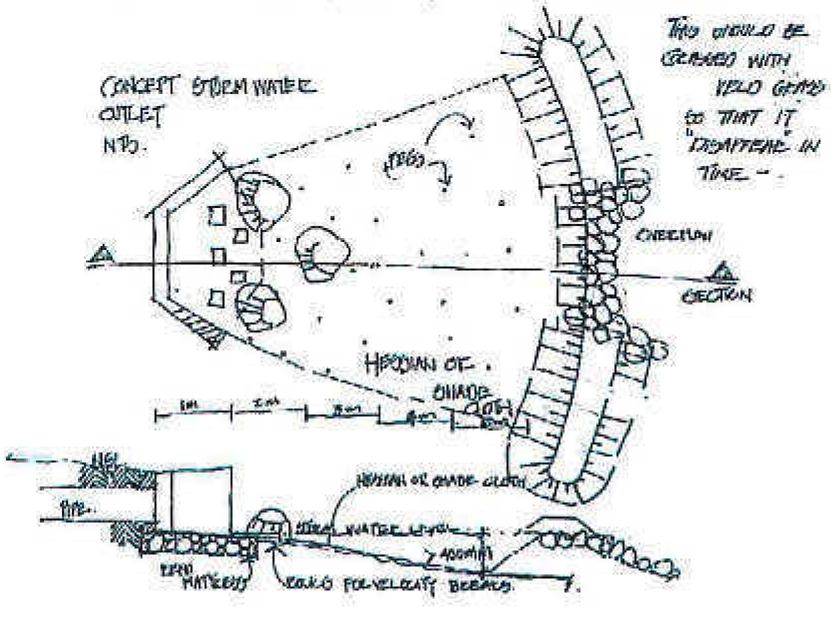


Figure 1: Soil erosion prevention structures

- After construction all the material such as silt traps, berms, etc. are to be removed from the site rehabilitation measures as prescribed in this report to be implemented.
- Water accumulated in open excavation due to surface/ sub-surface flow must be pumped out of the excavation to the downstream side thereof. A secondary containment pit/sump must be used into which such water is pumped. Siltation prevention measures such as hay bales, silt traps or another method approved by the ECO must be installed at the outflows from the sump to catch any further sediment still

in suspension. Measures such as use of sand bags or hay bales are also to be used to prevent any erosion at the outflow areas of the pumped water.

j. Branch packing

- Branch packing can be used to repair small, localised slumps and holes in the stream's banks. It consists of alternate layers of live branches and compacted backfill. The live branches used should be from 1.5cm to 10,5cm in diameter and long enough to touch the undisturbed soil of the back of the slump and extend slightly from the stream bank. The wooden stakes should be 1.5m to 2.5m long, depending on the depth of the slump being repaired and made from poles that are 7cm to 10cm in diameter. To install, the bottom at or below the stream bed must be dug out, and a layer of rock or root wad must be placed in combination on the bottom.
- The aforementioned must be covered with 5cm to 10cm of soil. Start driving the poles vertically 7cm to 10cm into the ground at the lowest point of the slump and set them about 45cm apart. Place an initial layer of living branches 10cm to 15cm thick in the bottom of the hole between the vertical stakes and perpendicular to the slope face.
- Place them in a crisscross configuration with te growing tips oriented toward the slope face. The basal ends of the branches should touch the undisturbed soil at te back of the hole. Follow each layer of branches with a layer of compacted soil to ensure soil contact with the branches and wet the soil. Install subsequent layers of branches with the basal ends lower than the growing tips of the branches. When the installation is final, branches should protrude only slightly. Key in this technique to the bank or end at an existing tree or rock outcrop. **See figure 2 below.**

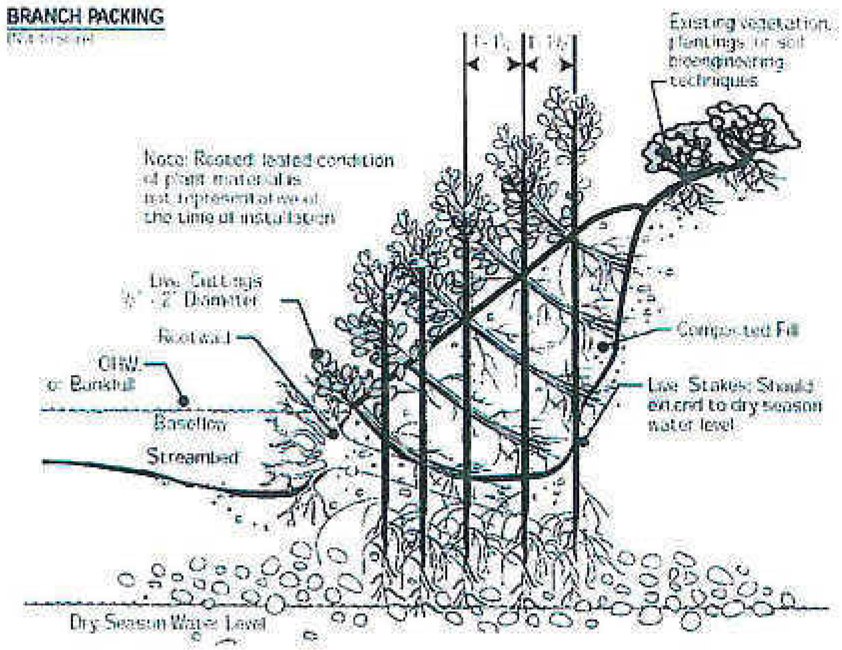


Figure 2: Branch Packing.

6. ONGOING PROBLEMS WITHIN THE WETLANDS AND OPEN SPACES AND SPECIFIC MITIGATION MEASURES.

6.1 EXCESSIVE EROSION AT THE STORM WATER DISCHARGE POINTs

Figure 3: Severe erosion due storm water runoff, storm water management is insufficient

- Energy dissipation devices such as gabions, straw bales or other dissipation devices must be installed at storm water inlets and outlets to decrease the speed and energy of the water and to minimize the potential for downstream erosion by reduction the velocity of concentrated storm water flows.
- Figure 1 shows an option of a dissipation device to decrease the speed and energy of the flow of water.
- Straw bales or other screening devices must be installed at storm water inlets to prevent silt on the roads to silt up the storm water pipes and thus the outlet trenches downstream.
- This, or an approved equal, MUST be used and implemented at the outlet of the storm water pipes.
- Ensure that service systems implemented within the development are maintained to prevent leakages within the wetland wand water system.
- Sheet runoff from cleared areas, paved surfaces and access roads needs to be curtailed.
- Runoff from paved surfaces should be slowed down by the strategic placement of berms.
- During the construction and operational phases of the development erosion berms or straw bales should be installed to prevent gully formation and siltation of the wetland resources. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms or straw bales every 50m should be installed.
  - Where the track slopes between 2% and 10%, berms or straw bales every 25m should be installed.
  - Where the track slopes between 10%-15%, berms or straw bales every 20m should be installed.
  - Where the track has slope greater than 15%, berms or straw bales every 10m should be installed

- Refuge pools and stilling basins are to be constructed within the stream bed at 30m intervals to minimise siltation/ sedimentaion, aid in attentuation and provide habitat.
- Cobble beds may be constructed within the streambed to minimise siltation.
- Regular desilting is to take place.

6.2 ERODED GULLIES ACROSS THE SITE

- The runoff of silt and rubbish into the stream must be prevented.
- Littering in the area must be prevented by placing a fence along the stream preventing access to the stream.
- No dumping will be allowed within any drainage areas. No bins shall be located within 50m of these areas.
- Surface runoff must be directed away from the streams and must be filtered or put into a municipal system prior to being released into the stream.
- All surface runoff shall be managed in such a way as to ensure that erosion of soil does not occur.
- Soil must be ripped as indicated under the Rehabilitation section in this report.
- Erosion of the stream banks can be prevented by placing gabions, straw bales or stone pitching on the banks of the river.
- For shallow slopes plants are a good solution to riverbank erosion, the planting of herbaceous plants with a dense surface root mat and ground cover are effective for stabilising the soil that can erode rapidly. Plants must be planted in rows along the contour lines of the stream banks.

Figure 4: Filling and mulching of gullies

6.3 THE JUKSKEI RIVER, TRIBUTARIES AND STREAMS AND WETLANDS.

The Jukskei River and several smaller tributaries flow through the site. The Jukskei is under jurisdiction of the City of Johannesburg, but cleaning of trash is being done by the land owners adjacent to the river. Other tributaries and stream must be managed and rehabilitated in the manner discussed below.

Figure 5: Tributaries and stream are polluted and eroded.

- Gabion structures to be reinstated and securely fixed to stream banks. See **Annexure A** for Engineering drawings of the proposals for the stream along the N1.
- Gabion structures must be constructed to above the height of a 1:50 year flood event to ensure that incision at the toe in point to the stream bank is minimised.
- Use must also be made of geo-fabrics to conserve sediment with geo-fabrics being installed in conjunction with gabion structures.
- Gabions should be designed in such a way as to form small attenuation ponds in order to slow water flow through the system.
- Settling ponds should be developed at all existing gabion structures and additional structures should be developed to have stilling features at approximately 40m intervals. **Figures 4 and 5** provide concept sketches for the softening and landscape installation at the gabion structures.
- Natural smooth pebbles, reno-mattress and large rocks should be placed within the stream bed at selected areas, especially below gabion structures in order to improve in stream habitat and overall ecological functioning of the system and to minimise incision and sedimentation of the system.
- Re-profiling of stream banks needs to take place after alien and invasive species have been cleared in all areas where incision and bank failure have occurred. Stream banks to be re-profiled to a minimum **1:4 slope.**
- Stabilisation of stream banks to take place by means of placement of gabion structures where re-sloping is impractical.
- Slopes devoid of vegetation and all re profiled banks are to be hydro seeded with indigenous veld grass mixture.

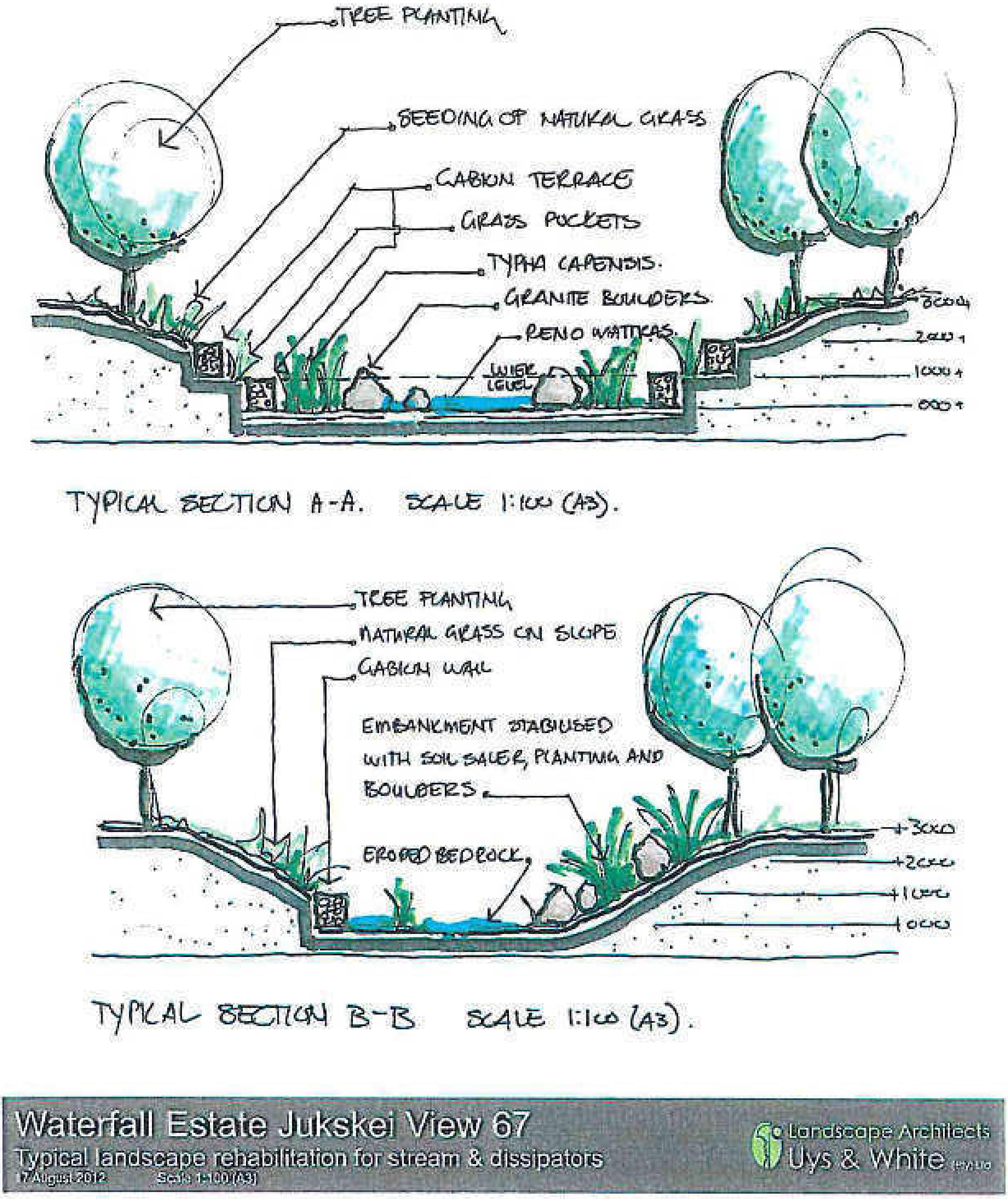


Figure 6: Sections at Gabion structures to provide softening and a "Natural Condition"

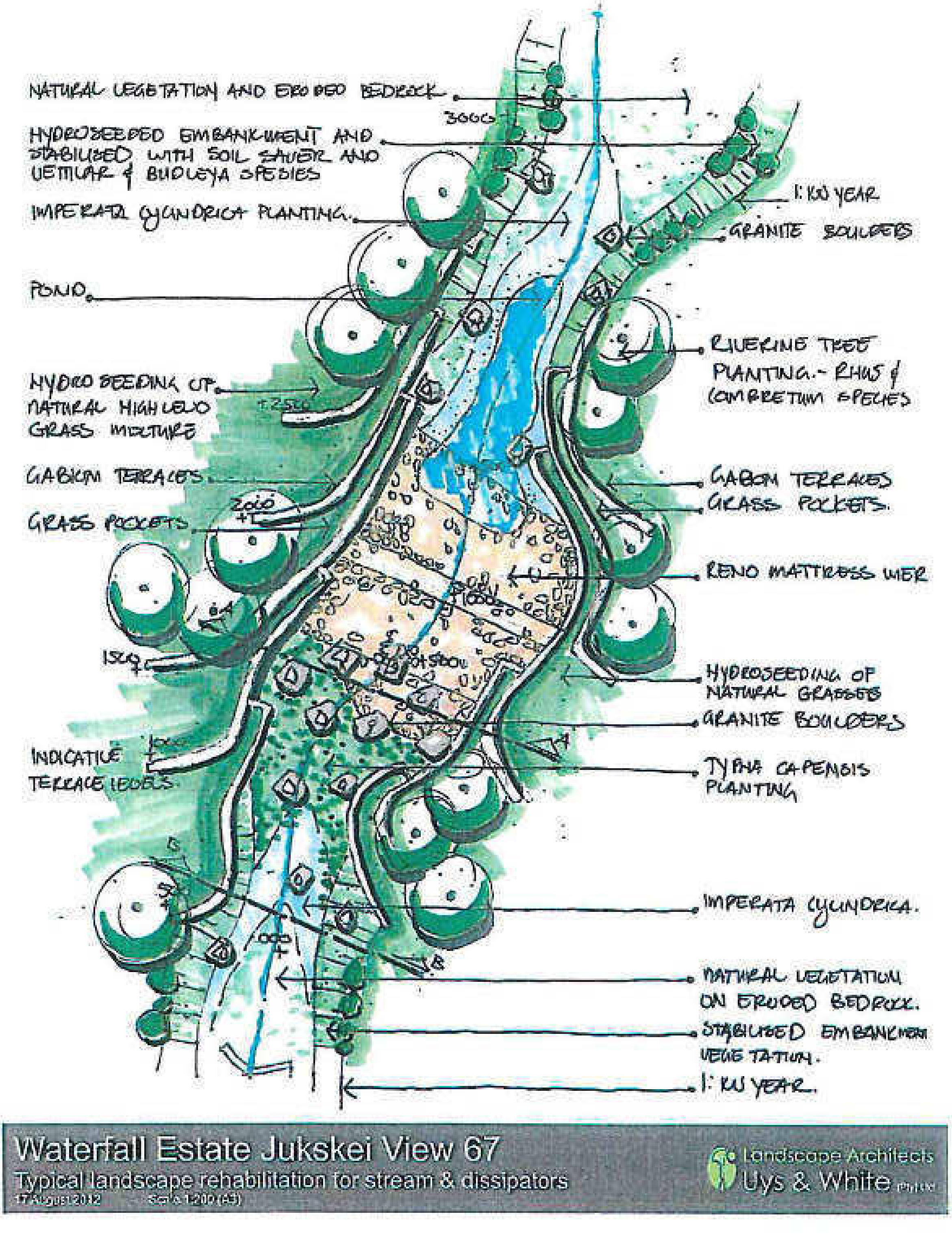


Figure 7: Plan at Gabion structures to provide softening and a "Natural Condition

6.4 GENERAL DETERIORAITON AND DUMPING WITHIN SENSITIVE WETLAND AREAS.

Figure 8: A play area was constructed within a sensitive wetland area

Several impacts were identified:

- Disturbance of the soil by infilling in the wetland, as a result of the installation of bulk services;
- High levels of vegetation transformation in sections of the wetland, with historic and current impacts occurring;
- Alien floral invasion was observed to be a problem, leading to further transformation of the vegetation community structure;
- Historic/current disturbances with special mention of the disposal of building rubble and
- In some areas incision and erosion of the wetland have occurred, and this has led to a loss of wetland vegetation and flood attenuation and filtration functions.

When effective wetland zone rehabilitation takes place, its ecological service provision capability and sensitivity will increase. The most pertinent threats which are currently posed to the system, over which the proponent for this development has control, are alien invasion, soil infilling and erosion / incision of the wetland. Should these factors be mitigated and effective rehabilitation measures be implemented, the wetland zone will regain most of its ecological service provision capability. The management plan can also mitigate future impacts on water quality in the area.

Actions required to mitigate physical wetland character:

- All sensitive areas and their prescribed buffer zones must be fenced off and no access is allowed within these areas.

- The fences around the wetland areas must be maintained and any broken fences must be repaired.
- Re-grade land slopes to natural levels and remove severe incised slopes.
- Re-condition soil to represent a suitable growth medium.
- Restore or rehabilitate transformed areas to historically natural vegetation conditions;
- Remove alien floral invasion;
- Remove all waste and all building rubble and
- Treat incision and erosion of the wetland as per mitigation measures above.

Actions required to mitigate **siltation and water quality**:

- All sensitive areas and their prescribed buffer zones must be fenced off and no access is allowed within these areas.
- The fences around the wetland areas must be maintained and any broken fences must be repaired.
- Prevent any vehicular traffic in wetland or buffer zones which breaks, flatten the grass, break the soil structures and loosen the soils.
- Do not remove any fallen trees, brush or grass cutting in the buffer areas to allow increase in bio-mass and thus microbes in the buffer areas.
- Install gabions perpendicular to flow to slow the velocity and create shallow ponds.
- Plant endemic wetland vegetation in the manner in which it occured in the on-site – predevelopment riparian zones.

6.5 WASTE MANAGEMENT AND BUILDING RUBBLE

Figure 9: Waste management on site does not adhere to EMP requirements

- Cement mixing shall be done only at specifically selected sites.
- Use plastic trays or liners when mixing cement and concrete: Do not mix cement and concrete directly on the ground.
- Building rubble and rubbish dumped within the wetland buffer and soil stockpiles within the buffer zone and maintenance of fences around wetland areas
- No dumping of rubble or rubbish or stockpiling is permitted within the sensitive wetland areas. All the sensitive areas must be checked for rubble, rubbish or stockpiling and same must be removed from the sensitive area. N

- No storage of any waste product should occur next to the fence of the sensitive areas.
- The waste storage area must be fenced off to prevent the waste from being transferred to the stream or sensitive wetland areas by wind or storm water.
- Build a bund around waste storage area to stop overflow of waste into storm water channels.
- Cover any wastes that are likely to wash away or contaminate storm water running of into the stream and sensitive wetland areas.
- Wastes must be removed on a regular basis (once a week).
- Stockpiling must only be done in designated places where it will not interfere with the natural drainage paths of the environment.
- No stockpiling shall be allowed below the 1:100 year flood line / within the transitional zones.
- Cover stockpiles and surround downhill sides with a sediment fence to stop materials washing away.
- Care must be taken to prevent the runoff of silt from open soil and stockpiles into the sensitive areas.
- Strip topsoil at start of works and store in stockpiles no more than 2m high and $4m^2$ footprints in a designated materials storage area.
- Stockpiles must be seeded.
- No vehicles are allowed to traverse the stockpiled topsoil areas.
- After construction activities ended all cement mixing areas, waste storage areas and stock-pile areas shall be rehabilitated by removing all remaining material, by ripping the ground and planting or seeding with suitable material.

7. CONCLUSION

The measures as set out in this document are deemed sufficient for the conservation of ecological processes and provide a tool for managing and improving the current state of the wetland and open space areas. If these measures are adhered to, ecological processes within the wetland areas will not only re-establish, but also allow the improvement of the functionality of the system. If these measures are implemented along with measures to minimise footprint areas, especially within the wetland areas, impacts on the system can be adequately minimised.

Compiled by Dr Gwen Theron

August 2012

Annexure H
Updated Wetland Report

TERRASOIL
SCIENCE

REPORT

HYDROPEDOLOGY BASED WETLAND BUFFER ASSESSMENT AND MANAGEMENT REPORT:

LAND PARCEL 10, WATERFALL DEVELOPMENT SITE, GAUTENG PROVINCE

3 September, 2015

Compiled by:
J.H. van der Waals
(PhD Soil Science, Pr.Sci.Nat.)
Member of:
Soil Science Society of South Africa (SSSSA)

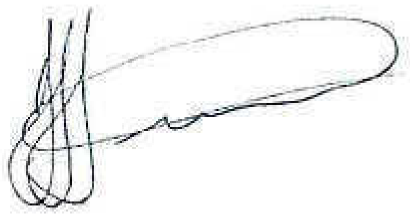
Accredited member of:
South African Soil Surveyors Organisation (SASSO)

Registered with:
The South African Council for Natural Scientific Professions
Registration number: 400106/08

Declaration

I, Johan Hilgard van der Waals, declare that:

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing
  - any decision to be taken with respect to the application by the competent authority; and
  - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.



J.H. VAN DER WAALS
TERRA SOIL SCIENCE

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HYDROPEDOLOGY BASED WETLAND BUFFER ASSESSMENT AND MANAGEMENT REPORT: LAND PARCEL 10, WATERFALL DEVELOPMENT SITE, GAUTENG PROVINCE

1. INTRODUCTION

1.1 TERMS OF REFERENCE

Terra Soil Science was appointed by **Bokamoso** and **Atterbury** to conduct a hydropedology based wetland buffer assessment and management investigation for Land Parcel 10 of the Waterfall development site in the Gauteng Province. The focus of the investigation is to address specifically the functioning of the wetland, historical impacts and drivers of change in the wetland system, hydropedology parameters for the wetland and site as well as the usefulness and requirement for a buffer on the wetland / watercourse system.

1.2 AIM OF THIS REPORT

The aim of this report is to provide a hydropedology perspective on the functioning of the wetland / watercourse, historical impacts and drivers of change in the wetland / watercourse system and hydropedology parameters for the wetland / watercourse and site. Ultimately the aim is to provide guidance on the requirement and extent of a buffer on the wetland / watercourse system for the purpose of effective water, wetland and watercourse management on the site and maintenance and protection of downstream wetlands and watercourses.

1.3 DISCLAIMER

This report was generated under the regulations of NEMA (National Environmental Management Act) that guides the appointment of specialists. The essence of the regulations are 1) independence, 2) specialisation and 3) duty to the regulator. The independent specialist has, in accordance with the regulations, a duty to the competent authority to disclose all matters related to the specific investigation should he be requested to do such (refer to declaration above).

It is accepted that this report can be submitted for peer review (as the regulations also allow for such). However, the intention of this report is not to function as one of several attempts by applicants or competent authorities to obtain favourable delineation outcomes. Rather, the report is aimed at addressing specific site conditions in the context of current legislation, guidelines and best practice with the ultimate aim of ensuring the conservation and adequate management of the water resource on the specific site.

Due to the specific legal liabilities wetland specialists face when conducting wetland delineations and assessments this author reserves the right to, in the event that this report becomes part of a delineation comparison exercise between specialists, submit the report to the competent authorities, without entering into protracted correspondence with the client, as an independent report.

1.4 METHODOLOGY

The report was generated through:

1. The collection and presentation of baseline land type and topographic data for the site;
2. The thorough consideration of the statutory context of wetlands assessment and the process of wetland delineation;
3. The identification of water related landscape parameters (conceptual and real) for the site;
4. Aerial photograph interpretation of the site;
5. Assessment of historical impacts and changes on the site through the accessing of various historical aerial photographs and topographic maps;
6. Focused soil and site survey in terms of soil properties as well as drainage feature properties;
7. Assessment of the functioning, status and hydropedology of the wetlands on the site; and
8. Presentation of the findings of the various components of the investigation.

2. SITE LOCALITY AND DESCRIPTION

2.1 SURVEY AREA BOUNDARY

The site lies between 26° 00' 45" and 26° 01' 35" south and 28° 06' 33" and 28° 06' 53" east near Halfway House in the Gauteng Province (**Figure 1**).

2.2 LAND TYPE DATA

Land type data for the site was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC). The land type data is presented at a scale of 1:250 000 and entails the division of land into land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units (in the cross section). The soil data is classified according to the Binomial System (MacVicar et al., 1977). The soil data was interpreted and re-classified according to the Taxonomic System (Soil Classification Working Group, 1991).

The site falls into the **Bb1** land type (Land Type Survey Staff, 1972 - 2006) with **Figure 2** providing the land type distribution for the site. The **Bb1** and **Bb2** land types are restricted to the Halfway House Granite Dome with typical bleached sandy soils dominating the bulk of the landscape (details provided later in the report).

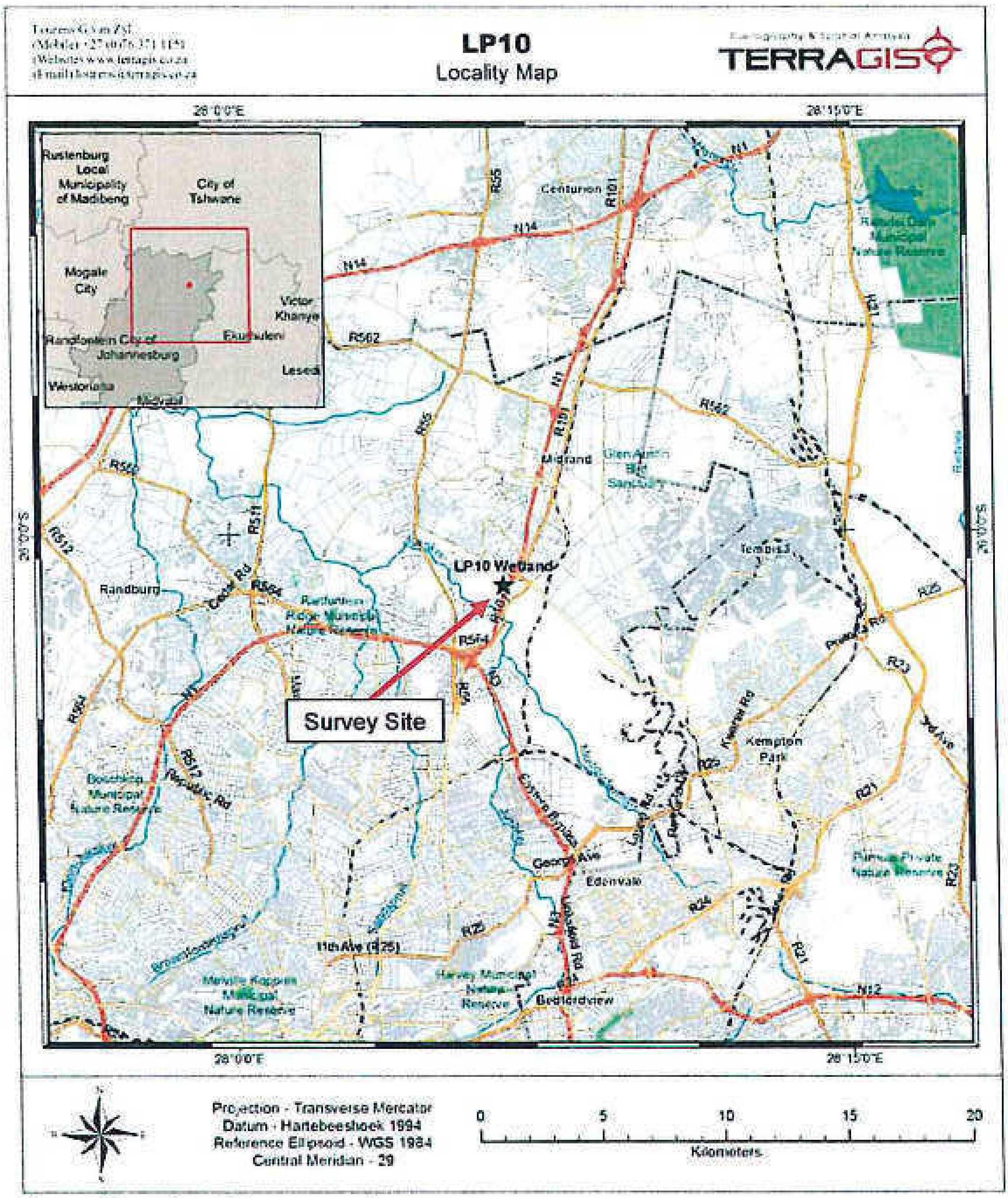

Figure 1 Locality of the survey site

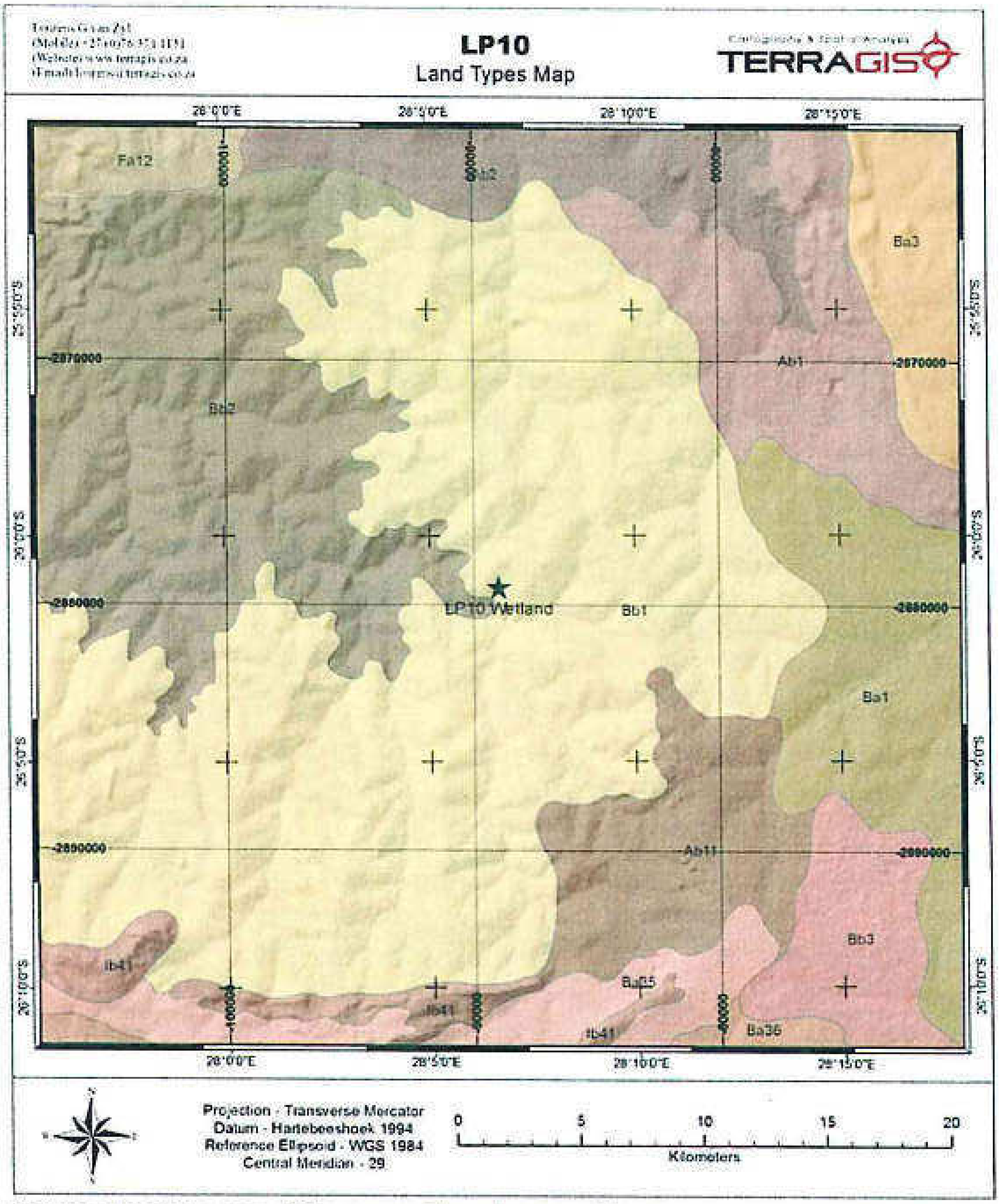

Figure 2 Land type map of the survey site and surrounding area

2.3 TOPOGRAPHY

The topography of the site is undulating. The contour map for the site is provided in **Figure 3**. From the contour data a digital elevation model (DEM) was generated. The topographic data was further interpreted and the approaches and results are discussed later in the report.

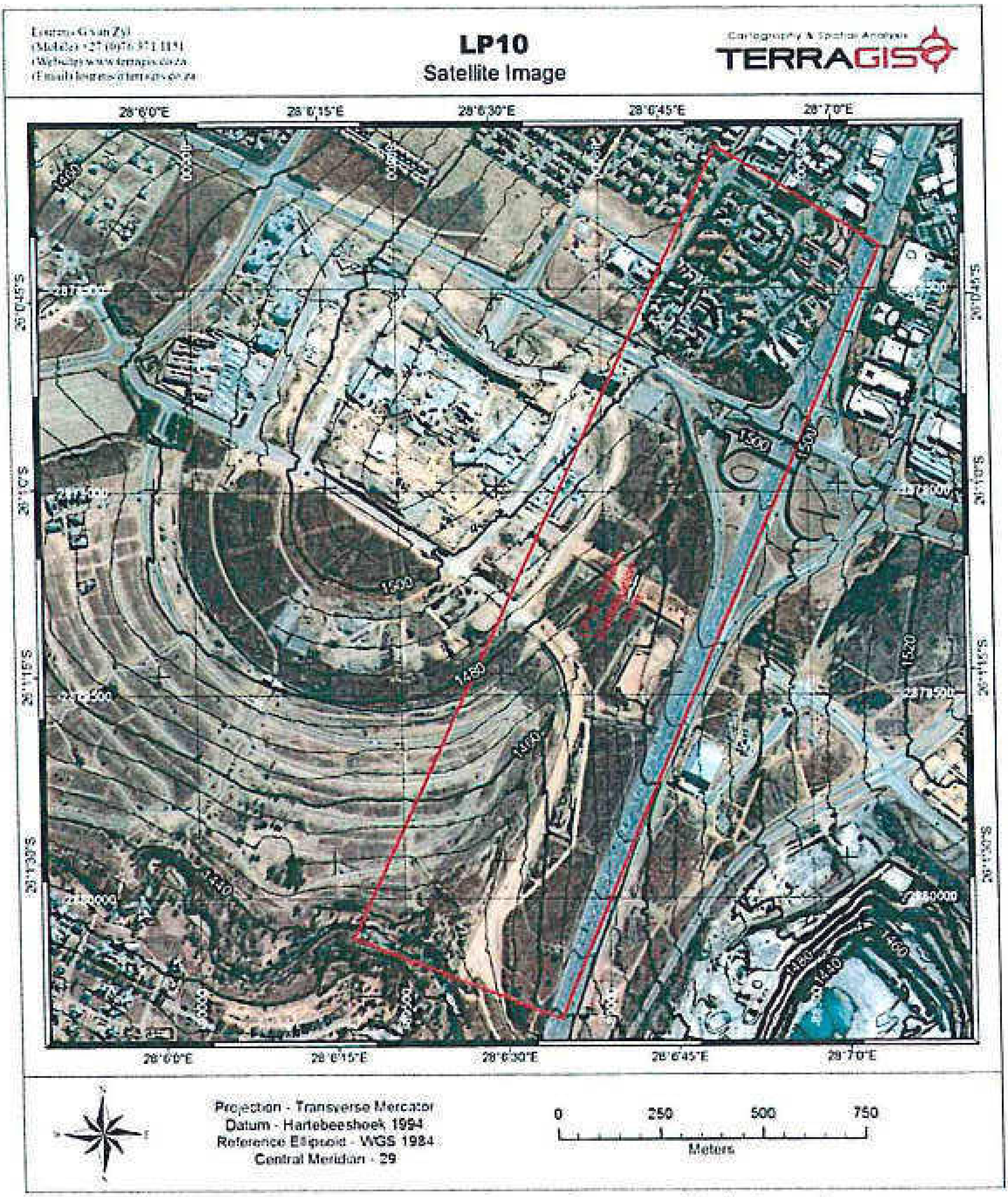

Figure 3 Contours of the survey area superimposed on an aerial photograph

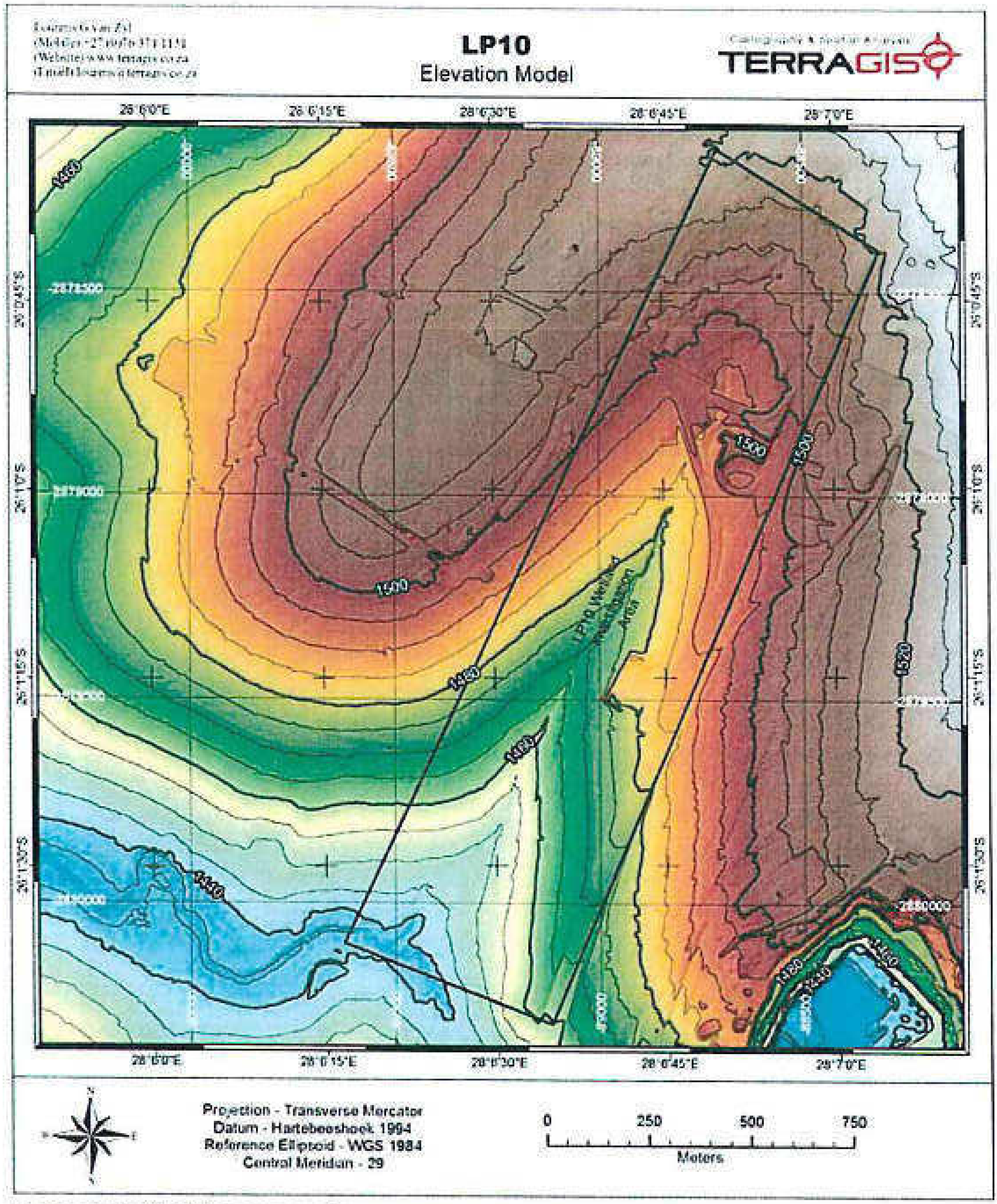

Figure 4 DEM of the survey site

3. PROBLEM STATEMENT

The delineation of wetland in the HHGD area is challenging due to a range of factors that lead to difficulty in distinguishing between wetland and terrestrial zones. One of the main factors contributing to the difficulty is the specific geological context of the HHGD. From a soil form and wetness perspective the specific land type exhibits some form of "wetland" characteristic, according to the present wetland delineation guidelines (DWAF, 2005), in at least 75 % of the landscape. This aspect has led to significant challenges and friction regarding the interpretation of the guidelines as well as the specific soils in the area. The following section provides a perspective of the statutory as well as biophysical context of wetland delineation in the HHGD area. This investigation will therefore focus on the identification of the wetland features based on soil hydromorphy, landscape hydrology as well as various historical modifiers through a dedicated assessment and elucidation of hydropedological processes experienced in the catchment and on the site.

4. STATUTORY CONTEXT

The following is a brief summary of the statutory context of wetland delineation and assessment. Where necessary, additional comment is provided on problematic aspects or aspects that, according to this author, require specific emphasis.

4.1 Wetland Definition

Wetlands are defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

4.2 Watercourse Definition

"Catchment" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"..., in relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points;"

"Watercourse" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"*(a)* a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the *Gazette*, declare to be a water course,
and a reference to a watercourse includes, where relevant, its bed and banks;"

4.3 THE WETLAND DELINEATION GUIDELINES

In 2005 the Department of Water Affairs and Forestry published a manual entitled "A practical field procedure for identification and delineation of wetland and riparian areas" (DWAF, 2005). The "...manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries." The definition of a wetland in the guidelines is that of the NWA and it states that wetlands must have one or more of the following attributes:

- "**Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation"
- "The presence, at least occasionally, of **water loving plants (hydrophytes)**"
- "A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil."

The guidelines further list four indicators to be used for the finding of the outer edge of a wetland. These are:

- Terrain Unit Indicator. The terrain unit indicator does not only identify valley bottom wetlands but also wetlands on steep and mild slopes in crest, midslope and footslope positions.
- Soil Form Indicator. A number of soil forms (as defined by MacVicar et al., 1991) are listed as indicative of permanent, seasonal and temporary wetland zones.
- Soil Wetness Indicator. Certain soil colours and mottles are indicated as colours of wet soils. The guidelines stipulate that this is the primary indicator for wetland soils. (Refer to the guidelines for a detailed description of the colour indicators.) In essence, the reduction and removal of Fe in the form of "bleaching" and the accumulation of Fe in the form of mottles are the two main criteria for the identification of soils that are periodically or permanently wet.
- Vegetation Indicator. This is a key component of the definition of a wetland in the NWA. It often happens though that vegetation is disturbed and the guidelines therefore place greater emphasis on the soil form and soil wetness indicators as these are more permanent whereas vegetation communities are dynamic and react rapidly to external factors such as climate and human activities.

The main emphasis of the guidelines is therefore the use soils (soil form and wetness) as the criteria for the delineation of wetlands. The applicability of these guidelines in the context of the survey site will be discussed in further detail later in the report.

Due to numerous problems with the delineation of wetlands there are a plethora of courses being presented to teach wetland practitioners and laymen the required techniques. Most of the courses and practitioners focus on ecological or vegetation characteristics of landscapes and soil characteristics are often interpreted incorrectly due to a lacking soil science background of these practitioners. As such this author regularly presents, in conjunction with a colleague (Prof. Cornie van Huysteen) from the University of the Free Sate, a course on the aspects related to soil classification and wetland delineation.

4.4 THE RESOURCE DIRECTED MEASURES FOR PROTECTION OF WATER RESOURCES

The following are specific quotes from the different sections of the "Resource Directed Measures for Protection of Water Resources." as published by DWAF (1999).

4.4.1 The Resource Directed Measures for Protection of Water Resources: Volume 4: Wetland Ecosystems.

From the Introduction:

"This set of documents on Resource Directed Measures (RDM) for protection of water resources, issued in September 1999 in Version 1.0, presents the procedures to be followed in undertaking **preliminary determinations of the class, Reserve and resource quality objectives for water resources**, as specified in sections 14 and 17 of the South African National Water Act (Act 36 of 1998).

The development of procedures to determine RDM was initiated by the Department of Water Affairs and Forestry in July 1997. Phase 3 of this project will end in March 2000. Additional refinement and development of the procedures, and development of the full water resource classification system, will continue in Phase 4, until such time as the detailed procedures and full classification system are ready for publication in the Government Gazette.

It should be noted that until the final RDM procedures are published in the Gazette, and prescribed according to section 12 of the National Water Act, all determinations of RDM, whether at the rapid, the intermediate or the comprehensive level, will be considered to be preliminary determinations."

4.4.2 The Resource Directed Measures for Protection of Water Resources: Generic Section "A" for Specialist Manuals – Water Resource Protection Policy Implementation Process

"Step 3: Determine the reference conditions of each resource unit"

"What are reference conditions?"

"The determination of reference conditions is a very important aspect of the overall Reserve determination methodology. Reference conditions describe the natural unimpacted characteristics of a water resource. Reference conditions quantitatively describe the ecoregional type, specific to a particular water resource."

4.4.3 The Resource Directed Measures for Protection of Water Resources: Appendix W1 (Ecoregional Typing for Wetland Ecosystems)

Artificial modifiers are explained namely:

"Many wetlands are man-made, while others have been modified from a natural state to some degree by the activities of humans. Since the nature of these alterations often greatly influences the character of such habitats, the inclusion of modifying terms to accommodate human influence is important. In addition, many human modifications, such as dam walls and drainage ditches, are visible in aerial photographs and can be easily mapped. The following Artificial Modifiers are defined and can be used singly or in combination wherever they apply to wetlands:

Farmed: the soil surface has been physically altered for crop production, but hydrophytes will become re-established if farming is discontinued

Artificial: substrates placed by humans, using either natural materials such as dredge spoils or synthetic materials such as concrete. Jetties and breakwaters are examples of Non-vegetated Artificial habitats

Excavated: habitat lies within an excavated basin or channel

Diked/Impounded: created or modified by an artificial barrier which obstructs the inflow or outflow of water

Partially Drained: the water level has been artificially lowered, usually by means of ditches, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes."

4.4.4 The Resource Directed Measures for Protection of Water Resources: Appendix W4 IER (Floodplain Wetlands) Present Ecological Status (PES) Method

In Appendix W4 the methodology is provided for the determination of the present ecological status (PES) of a palustrine wetland.

The present ecological state (PES) of the wetland was determined according to the method described in "APPENDIX W4: IER (FLOODPLAIN WETLANDS) PRESENT ECOLOGICAL STATUS (PES) METHOD" of the "Resource Directed Measures for Protection of Water Resources. Volume 4: Wetland Ecosystems" as published by DWAF (1999). However, the PES methodology already forms an adaptation from the methodology to assess palustrine wetlands. Hillslope seepage wetlands have a range of different drivers and as such some modification of the criteria has been made by this author to accommodate the specific hydropedology drivers of hillslope seepage wetlands.

The criteria as described in Appendix 4 is provided below with the relevant modification or comment provided as well.

The summarised tasks in the PES methodology are (for detailed descriptions refer to the relevant documentation):

1. Conduct a literature review (review of available literature and maps) on the following:
    a. Determine types of development and land use (in the catchment in question).

b. Gather hydrological data to determine the degree to which the flow regime has been modified (with the "virgin flow regime" as baseline). The emphasis is predominantly on surface hydrology and hydrology of surface water features as well as the land uses, such as agriculture and forestry, that lead to flow modifications. Important Note: The hydropedology of landscapes is not explicitly mentioned in the RDM documentation and this author will make a case for its consideration as probably the most important component of investigating headwater systems and seepage wetlands and areas.

c. Assessment of the water quality as is documented in catchment study reports and water quality databases.

d. Investigate erosion and sedimentation parameters that address aspects such as bank erosion and bed modification. Important Note: The emphasis in the RDM documentation is again on river and stream systems with little mention of erosion of headwater and seepage zone systems. Again a case will be made for the emphasis of such information generation.

e. Description of exotic species (flora and fauna) in the specific catchment in question.

2. Conduct and aerial photographic assessment in terms of the parameters listed above.
3. Conduct a site visit and make use of local knowledge.
4. Assess the criteria and generate preliminary PES scores.
5. Generation of report.

Table 1 presents the scoresheet with criteria for the assessment of habitat integrity of palustrine wetlands (as provided in the RDM documentation).

Table 1 "Table W4-1: Scoresheet with criteria for assessing Habitat Integrity of Palustrine Wetlands (adapted from Kleynhans 1996)"

Criteria and attributes	Relevance	Score	Confidence
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.		
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.		
Water Quality			
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland		
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.		

Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.		
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns.		
Biota			
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant speciesdue to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.		
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.		
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).		
Alien fauna	Presence of alien fauna affecting faunal community structure.		
Overutilisation of biota	Overgrazing, Over-fishing, etc		
TOTAL MEAN			

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Important Note: The present ecological state (PES) determination is, as discussed earlier in the report, based on criteria originally generated for palustrine and floodplain wetlands. Seepage wetlands very rarely have the same degree of saturation or free water and consequently often do not have permanent wetland zones. These wetlands are therefore often characterised by seasonal or temporary properties and as such a standard PES approach is flawed. The existing criteria is provided below as is a comment on the applicability as well as proposed improvements.

Criteria

Hydrological Criteria

- "Flow modification: Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland." Comment: Although the description is wide it is very evident that seepage or hillslope wetlands do not become inundated but rather are fed by hillslope return flow processes. The main criterion should therefore be the surface and subsurface hydrological linkages expressed as a degree of alteration in terms of the surface, hydropedology and groundwater hydrology.

- "Permanent inundation: Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota." Comment: Mostly not applicable to hillslope seepage wetlands.

Water Quality Criteria

- "Water quality modification: From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland." Comment: Water quality in this context applies generally but cognisance should be taken of seepage water quality that can be natural but significantly different to exposed water bodies. The main reason for this being the highly complex nature of many redox processes within the hillslope.
- "Sediment load modification: Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats." Comment: This is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences.

Hydraulic / Geomorphic Criteria

- "Canalisation: Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.
- "Topographic Alteration: Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.

Biological Criteria

- "Terrestrial encroachment: Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.

- "Indigenous vegetation removal: Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion."
- "Invasive plant encroachment: Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading)."
- "Alien fauna: Presence of alien fauna affecting faunal community structure."
- "Overutilisation of biota: Overgrazing, Over-fishing, etc."

Scoring Guidelines
Scoring guidelines per attribute:
Natural, unmodified = 5
Largely natural = 4
Moderately modified = 3
Largely modified = 2
Seriously modified = 1
Critically modified = 0

Relative confidence of score:
Very high confidence = 4
High confidence = 3
Moderate confidence = 2
Marginal/low confidence = 1

4.4.5 The Resource Directed Measures for Protection of Water Resources: Appendix W5 IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and the Ecological Management Class (EMC)

In Appendix W5 the methodology is provided for the determination of the ecological importance and sensitivity (EIS) and ecological management class (EMC) of floodplain wetlands.

"Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC)." Please refer to the specific document for more detailed information.

The following primary determinants are listed as determining the EIS:

1. Rare and endangered species
2. Populations of unique species
3. Species / taxon richness
4. Diversity of habitat types or features
5. Migration route / breeding and feeding site for wetland species

6. Sensitivity to changes in the natural hydrological regime
7. Sensitivity to water quality changes
8. Flood storage, energy dissipation and particulate / element removal

The following modifying determinants are listed as determining the EIS:

1. Protected status
2. Ecological integrity

4.5 Summary and Proposed Approach

When working in environments where the landscape and land use changes are significant (such as urban and mining environments) it is important to answer the following critical questions regarding the assessment and management planning for wetlands:

1. What is the reference condition?
2. What is the difference between the reference condition and the current condition and how big is this difference from a hydrological driver perspective?
3. What are the hydrological drivers (as a function of geology, topography, rainfall and soils) and what are the relative contributions of these drivers to the functioning of the wetland system?
4. What is the intended or planned land use in the wetland as well as terrestrial area and how will these developments impact on the hydrology of the landscape and wetlands?
5. How can the intended land use be plied to secure the best possible hydrological functioning of the landscape in terms of storm water attenuation, erosion mitigation and water quality?

The key to the generation of adequate information lies in the approach that is to be followed. In the next section an explanation about and motivation in favour of will be provided for a hydropedology assessment approach. Due to the detailed nature of the information that can be generated through such an approach it is motivated that all wetland assessments be conducted with the requirements of criminal law in mind. The main reason for this is the fact that many well-meaning administrative exercises often yield not tangible results due to the gap in terms of information that is required should there be a compliance process followed.

To Summarise:

During wetland assessments and delineations it is important to provide a perspective on assessment tools, the original or reference state of the wetland, the assessment process and outcome as well as the intended or possible state of the wetland and site post development. Urban and mining developments are good examples of cases where surrounding developments and land use changes have significant effects on wetland integrity and water quality emanating from the site.

5. CHALLENGES REGARDING WETLAND DELINEATION ON THE HALFWAY HOUSE GRANITE DOME

Disclaimer: The following section represents a discussion that I use as standard in describing the challenges regarding wetland delineation and management in the Halfway House Granite Dome (HHGD) area. This implies that the section is verbatim the same as in other reports provided to clients and the authorities. Copyright is strictly reserved.

In order to discuss the procedures followed and the results of the wetland identification exercise it is necessary at the outset to provide some theoretical background on soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena).

5.1 PEDOGENESIS

Pedogenesis is the process of soil formation. Soil formation is a function of five (5) factors namely (Jenny, 1941):

- Parent material;
- Climate;
- Topography;
- Living Organisms; and
- Time.

These factors interact to lead to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through and out of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as Fe and Mn. Under reducing conditions Fe and Mn are reduced and become more mobile in the soil environment. Oxidizing conditions, in turn, lead to the precipitation of Fe and Mn and therefore lead to their immobilization. The dynamics of Fe and Mn in soil, their zones of depletion through mobilization and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

5.2 WATER MOVEMENT IN THE SOIL PROFILE

In a specific soil profile, water can move upwards (through capillary movement), horizontally (owing to matric suction) and downwards under the influence of gravity.

The following needs to be highlighted in order to discuss water movement in soil:

- Capillary rise refers to the process where water rises from a deeper lying section of the soil profile to the soil surface or to a section closer to the soil surface. Soil pores can be regarded as miniature tubes. Water rises into these tubes owing to the adhesion (adsorption) of water molecules onto solid mineral surfaces and the surface tension of water.

  The height of the rise is inversely proportional to the radius of the soil pore and the density of the liquid (water). It is also directly proportional to the liquid's surface tension and the degree of its adhesive attraction. In a soil-water system the following simplified equation can be used to calculate this rise:

  $$\text{Height} = 0.15/\text{radius}$$

  Usually the eventual height of rise is greater in fine textured soil, but the rate of flow may be slower (Brady and Weil, 1999; Hillel, 1983).

- Matric potential or suction refers to the attraction of water to solid surfaces. Matric potential is operational in unsaturated soil above the water table while pressure potential refers to water in saturated soil or below the water table. Matric potential is always expressed as a negative value and pressure potential as a positive value.

  Matric potential influences soil moisture retention and soil water movement. Differences in the matric potential of adjoining zones of a soil results in the movement of water from the moist zone (high state of energy) to the dry zone (low state of energy) or from large pores to small pores.

  The maximum amount of water that a soil profile can hold before leaching occurs is called the field capacity of the soil. At a point of water saturation, a soil exhibits an energy state of 0 $J.kg^{-1}$. Field capacity usually falls within a range of -15 to -30 $J.kg^{-1}$ with fine textured soils storing larger amounts of water (Brady and Weil, 1999; Hillel, 1983).

- Gravity acts on water in the soil profile in the same way as it acts on any other body; it attracts towards earth's centre. The gravitational potential of soil water can be expressed as:

  $$\text{Gravitational potential} = \text{Gravity} \times \text{Height}$$

  Following heavy rainfall, gravity plays an important part in the removal of excess water from the upper horizons of the soil profile and recharging groundwater sources below.

  Excess water, or water subject to leaching, is the amount of water that falls between soil saturation (0 $J.kg^{-1}$) or oversaturation (> 0 $J.kg^{-1}$), in the case of heavy rainfall resulting in a pressure potential, and field capacity (-15 to -30 $J.kg^{-1}$). This amount of water differs according to soil type, structure and texture (Brady and Weil, 1999; Hillel, 1983).

- Under some conditions, at least part of the soil profile may be saturated with water, resulting in so-called saturated flow of water. The lower portions of poorly drained soils are often saturated, as are well-drained soils above stratified (layers differing in soil texture) or impermeable layers after rainfall.

The quantity of water that flows through a saturated column of soil can be calculated using Darcy's law:

$$Q = Ksat.A.\Delta P/L$$

Where Q represents the quantity of water per unit time, Ksat is the saturated hydraulic conductivity, A is the cross sectional area of the column through which the water flows, ΔP is the hydrostatic pressure difference from the top to the bottom of the column, and L is the length of the column.

Saturated flow of water does not only occur downwards, but also horizontally and upwards. Horizontal and upward flows are not quite as rapid as downward flow. The latter is aided by gravity (Brady and Weil, 1999; Hillel, 1983).

- Mostly, water movement in soil is ascribed to the unsaturated flow of water. This is a much more complex scenario than water flow under saturated conditions. Under unsaturated conditions only the fine micropores are filled with water whereas the macropores are filled with air. The water content, and the force with which water molecules are held by soil surfaces, can also vary considerably. The latter makes it difficult to assess the rate and direction of water flow. The driving force behind unsaturated water flow is matric potential. Water movement will be from a moist to a drier zone (Brady and Weil, 1999; Hillel, 1983).

The following processes influence the amount of water to be leached from a soil profile:

- Infiltration is the process by which water enters the soil pores and becomes soil water. The rate at which water can enter the soil is termed infiltration tempo and is calculated as follows:

  $$I = Q/A.t$$

  Where I represents infiltration tempo ($m.s^{-1}$), Q is the volume quantity of infiltrating water (m^3), A is the area of the soil surface exposed to infiltration (m^2), and t is time (s).

  If the soil is quite dry when exposed to water, the macropores will be open to conduct water into the soil profile. Soils that exhibit a high 2:1 clay content (swelling-shrinking clays) will exhibit a high rate of infiltration initially. However, as infiltration proceeds, the macropores will become saturated and cracks, caused by dried out 2:1 clay, will swell and close, thus leading to a decline in infiltration (Brady and Weil, 1999; Hillel, 1983).

- Percolation is the process by which water moves downward in the soil profile. Saturated and unsaturated water flow is involved in the process of percolation, while the rate of percolation is determined by the hydraulic conductivity of the soil.

  During a rain storm, especially the down pouring of heavy rain, water movement near the soil surface mainly occurs in the form of saturated flow in response to gravity. A sharp boundary, referred to as the wetting front, usually appears between the wet soil and the underlying dry soil. At the wetting front, water is moving into the underlying soil in response to both matric and gravitational potential. During light rain, water movement at the soil surface may be ascribed to unsaturated flow (Brady and Weil, 1999; Hillel, 1983).

The fact that water percolates through the soil profile by unsaturated flow has certain ramifications when an abrupt change in soil texture occurs (Brady and Weil, 1999; Hillel, 1983). A layer of course sand, underlying a fine textured soil, will impede downward movement of water. The macropores of the coarse textured sand offer less attraction to the water molecules than the macropores of the fine textured soil. When the unsaturated wetting front reaches the coarse sand, the matric potential is lower in the sand than in the overlying material. Water always moves from a higher to a lower state of energy. The water can, therefore, not move into the coarse textured sand. Eventually, the downward moving water will accumulate above the sand layer and nearly saturate the fine textured soil. Once this occurs, the water will be held so loosely that gravitational forces will be able to drag the water into the sand layer (Brady and Weil, 1999; Hillel, 1983).

A coarse layer of sand in an otherwise fine textured soil profile will also inhibit the rise of water by capillary movement (Brady and Weil, 1999; Hillel, 1983).

Field observations and laboratory-based analysis can aid in assessing the soil-water relations of an area. The South African soil classification system (Soil Classification Working Group, 1991.) comments on certain field observable characteristics that shed light on water movement in soil. The more important of these are:

- Soil horizons that show clear signs of leaching such as the E-horizon – an horizon where predominantly lateral water movement has led to the mobilisation and transport of sesquioxide minerals and the removal of clay material;
- Soil horizons that show clear signs of a fluctuating water table where Fe and Mn mottles, amongst other characteristics, indicate alternating conditions of reduction and oxidation (soft plinthic B-horizon);
- Soil horizons where grey colouration (Fe reduction and redox depletion), in an otherwise yellowish or reddish matrix, indicate saturated (or close to saturated) water flow for at least three months of the year (Unconsolidated/Unspecified material with signs of wetness);
- Soil horizons that are uniform in colouration and indicative of well-drained and aerated (oxidising) conditions (e.g. yellow brown apedal B-horizon).

5.3 Water Movement in the Landscape

Water movement in a landscape is a combination of the different flow paths in the soils and geological materials. The movement of water in these materials is dominantly subject to gravity and as such it will follow the path of least resistance towards the lowest point. In the landscape there are a number of factors determining the paths along which this water moves. **Figure 6** provides a simplified schematic representation of an idealised landscape (in "profile curvature". The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape.

The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil and/or geological strata from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil and geological strata. In a landscape there is an accumulation of water down the slope as water from higher lying areas flow to lower lying areas.

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 m^3 (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 m^3 of water as well as the added 4 500 m^3 from the upslope section to contend with, therefore 9 000 m^3. The next section has 13 500 m^3 to contend with and the following one 18 000 m^3. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

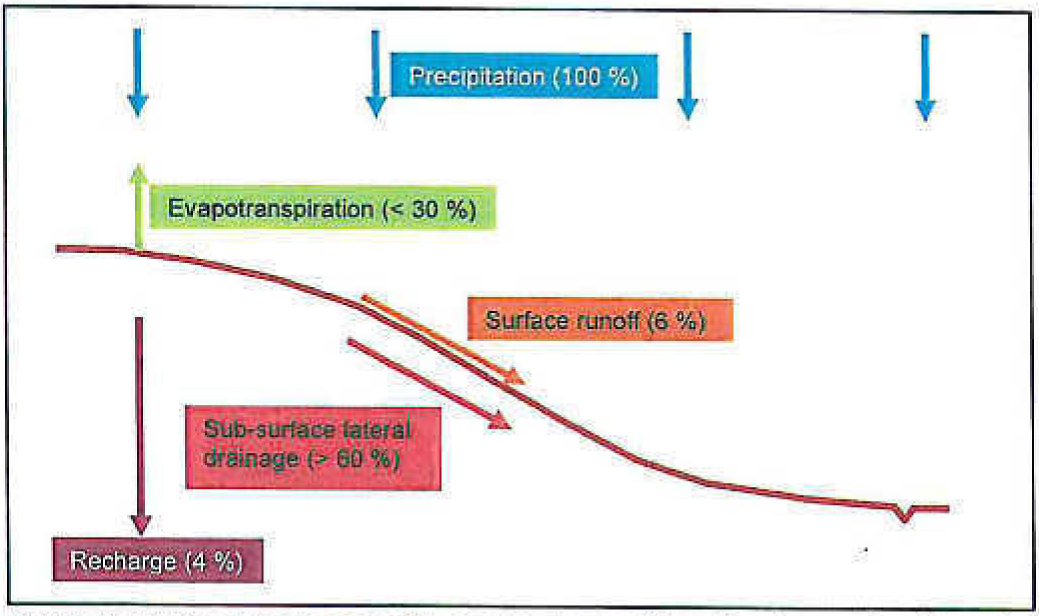

Figure 6 Idealised landscape with assumed quantities of water moving through the landscape expressed as a percentage of total precipitation (100 %).

Flow paths through soil and geological strata, referred to as "interflow" or "hillslope water", are very varied and often complex due to difficulty in measurement and identification. The difficulty in identification stems more from the challenges related to the physical determination of these in soil profile pits, soil auger samples and core drilling samples for geological strata. The identification of the morphological signs of water movement in permeable materials or along planes of weakness (cracks and seams) is a well-established science and the expression is mostly referred to as "redox morphology". In terms of the flow paths of water large variation exists but these can be grouped into a few simple categories. **Figure 7** provides a schematic representation of the different flow regimes that are usually encountered. The main types of water flow can be grouped as 1) recharge (vertically downwards) of groundwater; 2) lateral flow of water through the landscape along the hillslope (interflow or hillslope water); 3) return flow water that intercepts the soil/landscape surface; and 4) surface runoff. Significant variation exists with these flow paths and numerous combinations are often found. The main wetland types associated with the flow paths are: a) valley bottom wetlands (fed by groundwater, hillslope processes, surface runoff, and/or in-stream water); b) hillslope seepage wetlands (fed by interflow water and/or return flow water); and wetlands associated with surface runoff, ponding and surface ingress of water anywhere in the landscape.

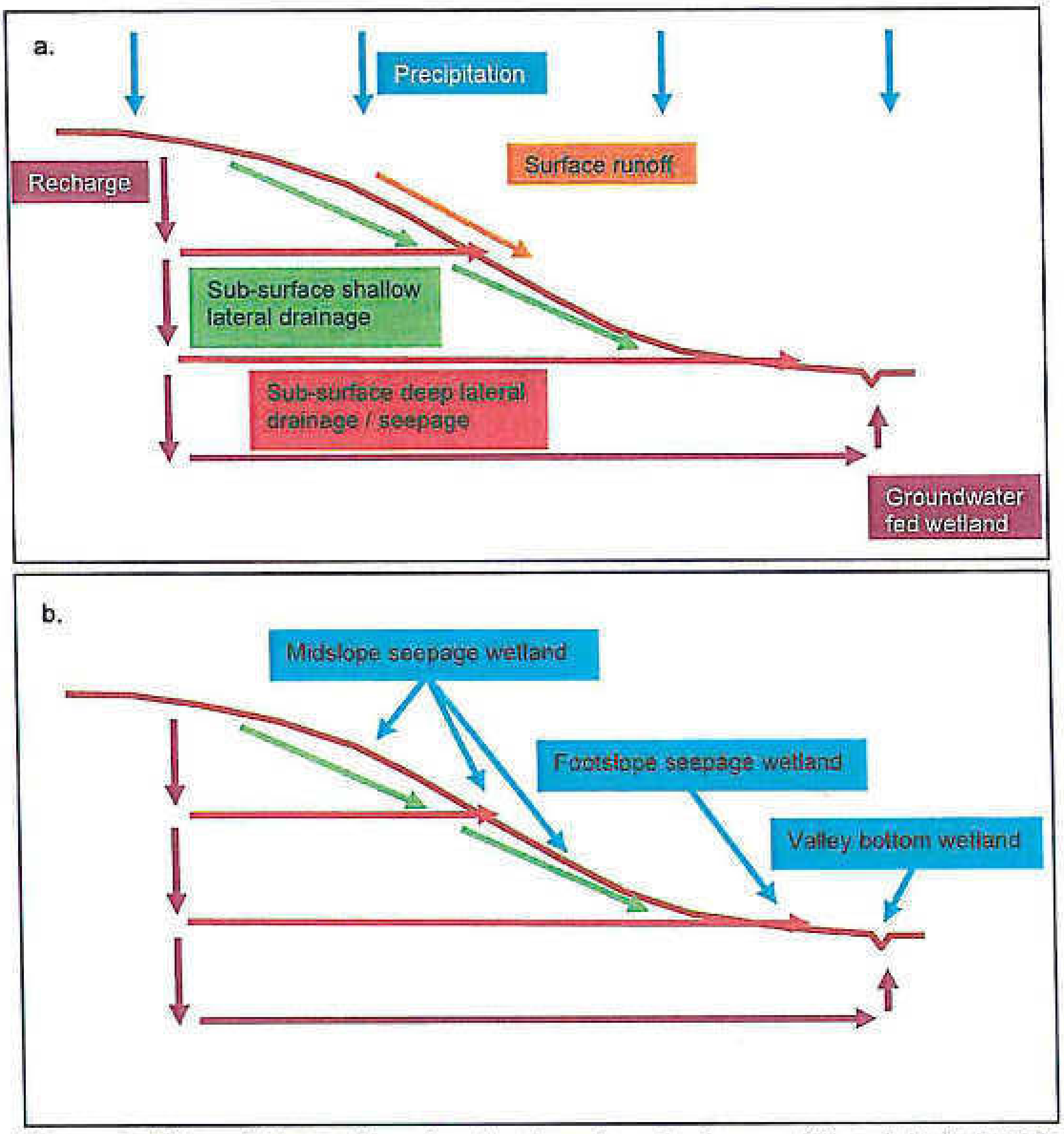

Figure 7 Different flow paths of water through a landscape (a) and typical wetland types associated with the water regime (b)

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. **Figure 8** illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently: The volume of water moving through the soil per surface area of an imaginary plane perpendicular to the direction of water flow is much higher for the thin soil profile than for the thick soil profile. This aspect has a significant influence on the expression of redox morphology in different landscapes of varying soil/geology/climate composition.

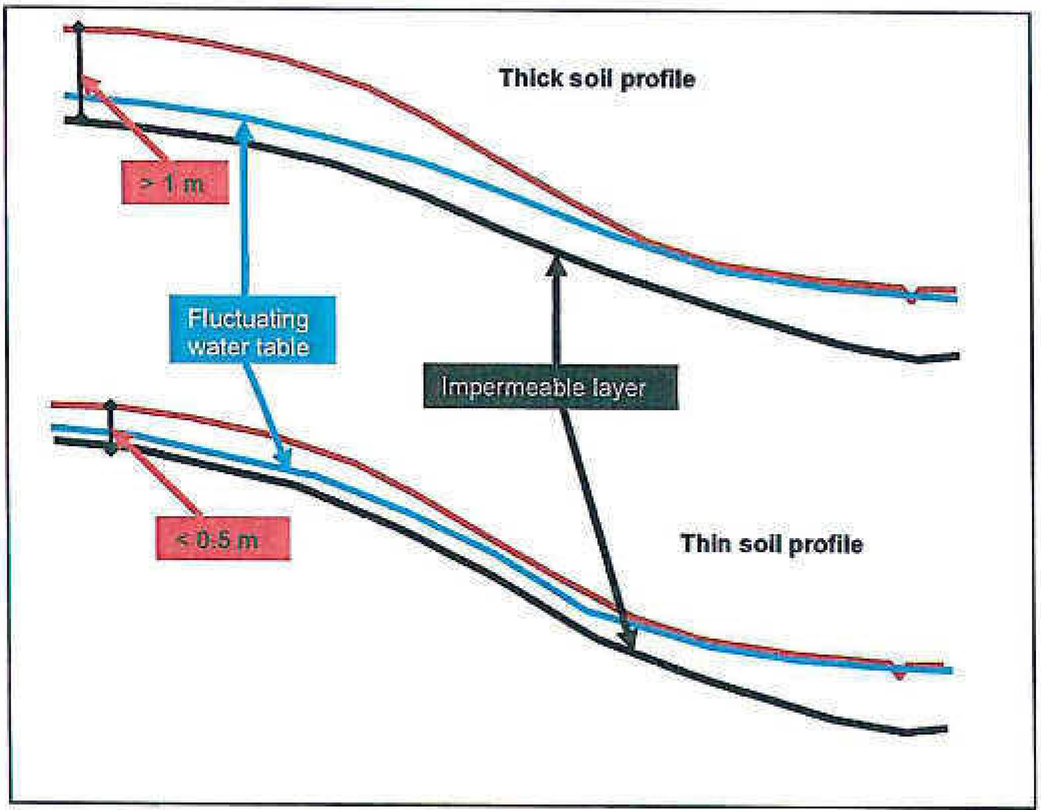

Figure 8 The difference in water flow between a dominantly thick and dominantly thin soil profile.

5.4 THE CATENA CONCEPT

Here it is important to take note of the "catena" concept. This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. **Figure 9** illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively sandy the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation soils of the Champagne form may develop (typical peat land). Variations on this sequence (as is often found on the Mpumalanga Highveld) may include the presence of hard plinthic materials instead of soft plinthite with a consequent increase in the occurrence of bleached soil profiles. Extreme examples of such landscapes are discussed below.

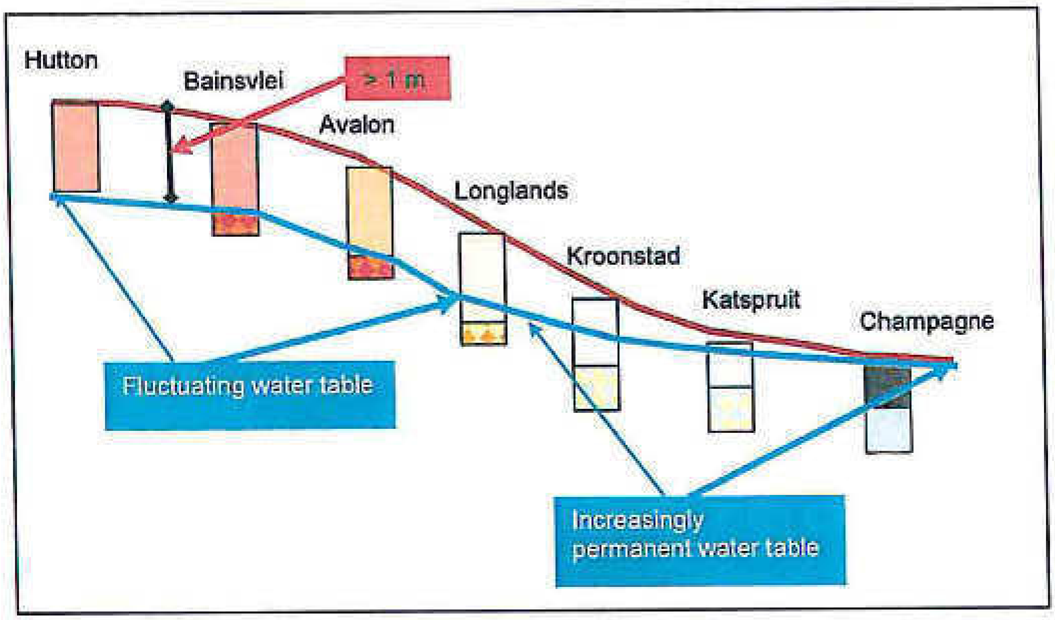

Figure 9 Idealised catena on a quartz rich parent material.

5.5 THE HALFWAY HOUSE GRANITE DOME CATENA

The Halfway House Granite Catena is a well-studied example of a quartz dominated Bb catena. As a result of the elucidation of the wetland delineation parameters and challenges in the specialist testimony in the matter between The State versus 1. Stefan Frylinck and 2. Mpofu Environmental Solutions CC (Case Number 14/1740/2010) it will be discussed in further detail here.

The typical catena that forms on the Halfway House granite differs from the idealised one discussed above in that the landscape is an old stable one, often with extensive subsoil ferricrete (or hard plinthic) layers where perched water tables occur. The parent material is relatively hard and the ferricrete layer is especially resistant to weathering. The quartz rich parent materials have a very low Fe content/"reserve", and together with the age of the material leads to the dominance of bleached sandy soils. The implication is that the whole catena is dominated by bleached sandy soils with a distinct and shallow zone of water fluctuation. This zone is often comprised of a high frequency of Fe/Mn concretions and sometimes exhibits feint mottles. In lower lying areas the soils tend to be deeper due to colluvial accumulation of sandy soil material but then exhibit more distinct signs of wetness (and pedogenesis). **Figure 10** provides a schematic representation of the catena.

The essence of this catena is that the soils are predominantly less than 50 cm thick and as such have a fluctuating water table (mimicking rainfall events) within 50 cm of the soil surface. One of the main criteria used during wetland delineation exercises as stipulated by the guidelines (DWAF, 2005) is the presence of mottles within 50 cm of the soil surface (temporary and seasonal wetland zones). Even from a theoretical point of view the guidelines cannot be applied to the above-described catena as soils at the crest of the landscape would already qualify as temporary wetland zone soils (upon request many such examples can be supplied). The practical implication of this statement as well as practical examples will be discussed in the next section.

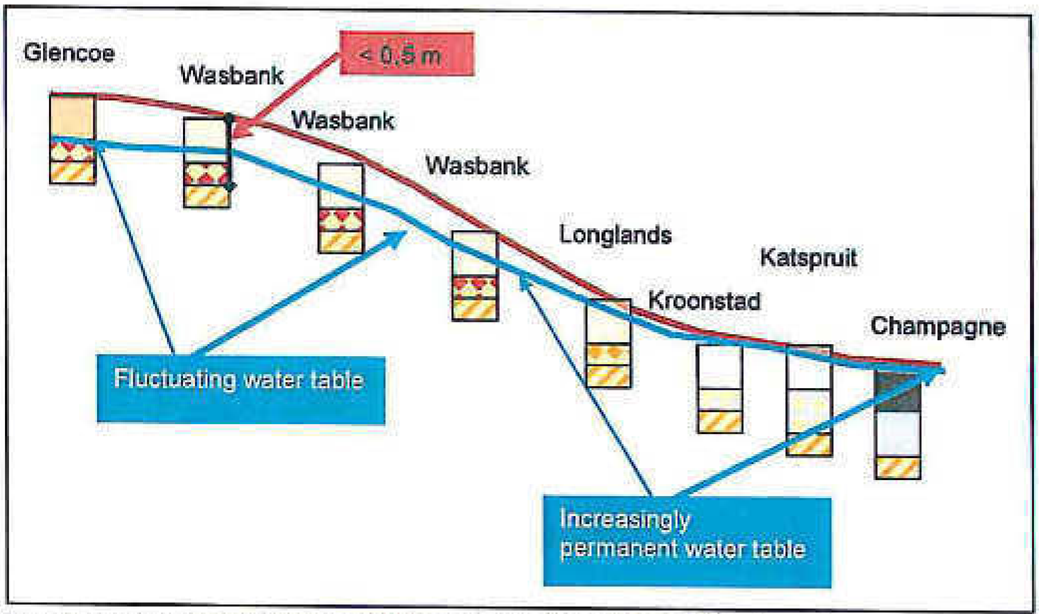

Figure 10 Schematic representation of a Halfway House Granite catena.

5.6 Convex Versus Concave Landscapes in the Halfway House Granite Catena

An additional factor of variation in all landscapes is the shape of the landscape along contours (referred to a "plan curvature"). Landscapes can be either concave or convex, or flat. The main difference between these landscapes lies in the fact that a convex landscape is essentially a watershed with water flowing in diverging directions with a subsequent occurrence of "dryer" soil conditions. In a concave landscape water flows in converging directions and soils often exhibit the wetter conditions of "signs of wetness" such as grey colours, organic matter and subsurface clay accumulation. **Figure 11** presents the difference between these landscapes in terms of typical soil forms encountered on the Halfway House granites. In the convex landscape the subsurface flow of water removes clays and other weathering products (including Fe) in such a way that the midslope position soils exhibit an increasing degree of bleaching and relative accumulation of quartz (E-horizons). In the concave landscapes clays and weathering products are transported through the soils into a zone of accumulation where soils start exhibiting properties of clay and Fe accumulation. In addition, coarse sandy soils in convex environments tend to be thinner due to the removal of sand particles through erosion and soils in concave environments tend to be thicker due to colluvial accumulation of material transported from upslope positions. Similar patterns are observed for other geological areas with the variation being consistent with the soil variation in the catena.

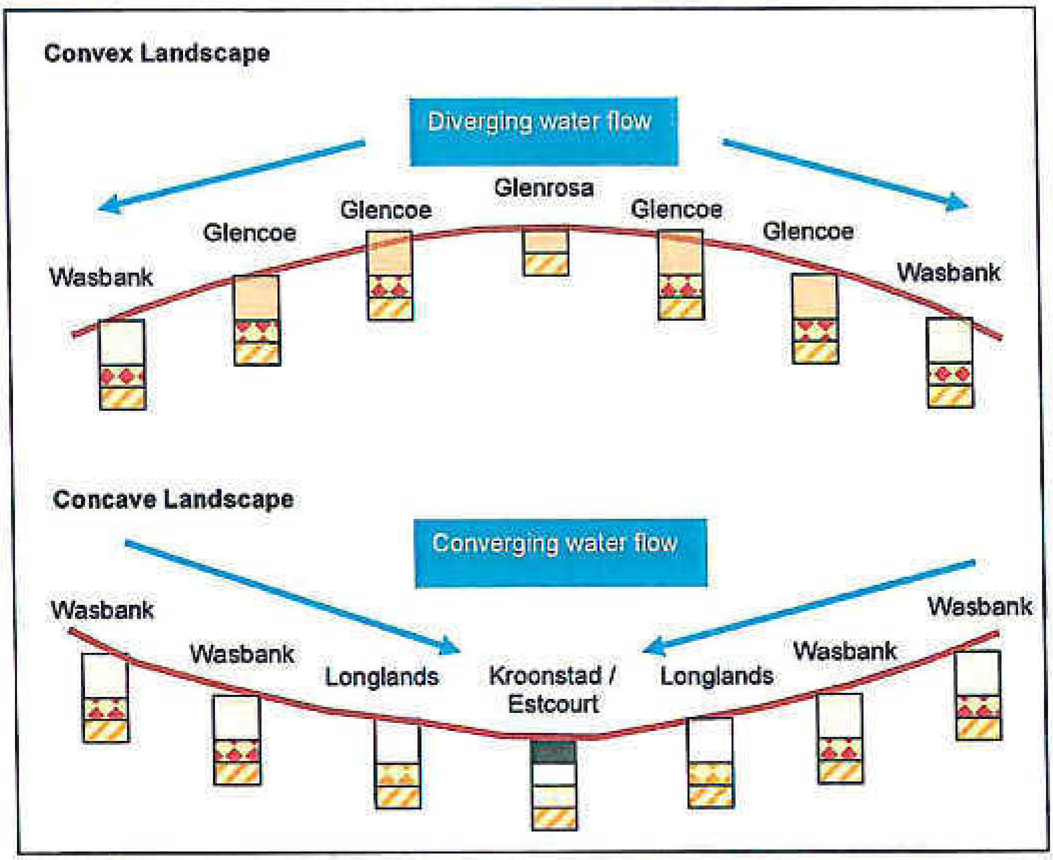

Figure 11 Schematic representation of the soils in convex and concave landscapes in the Halfway House Granite catena.

Often these concave and convex topographical environments occur in close proximity or in one topographical sequence of soils. This is often found where a convex upslope area changes into a concave environment as a drainage depression is reached (**Figure 12**). The processes in this landscape are the same as those described for the convex and concave landscapes above.

5.7 IMPLICATIONS FOR WETLAND DELINEATION AND APPLICATION OF THE GUIDELINES

When the 50 cm criterion is used to delineate wetlands in the HHGD environment, the soils in convex positions often "qualify" as temporary wetland soils due to their relatively thin profile and the presence of concretions (often weathering to yield "mottles") within this zone. In conjunction with a low Fe content in the soils and subsequent bleached colours (as defined for E-horizons) in the matrix a very large proportion of the landscape "qualifies" as temporary wetland zones. On the other hand, the soils in the concave environments, especially in the centre of the drainage depression, tend to be thicker and the 50 cm criterion sometimes does not flag these soils as being wetland soils due to the depth of the signs of wetness (mottles) often occurring only at depths greater than 80 cm. Invariably these areas are always included in wetland delineations due to the terrain unit indicator flagging it as a wetland area and drainage feature.

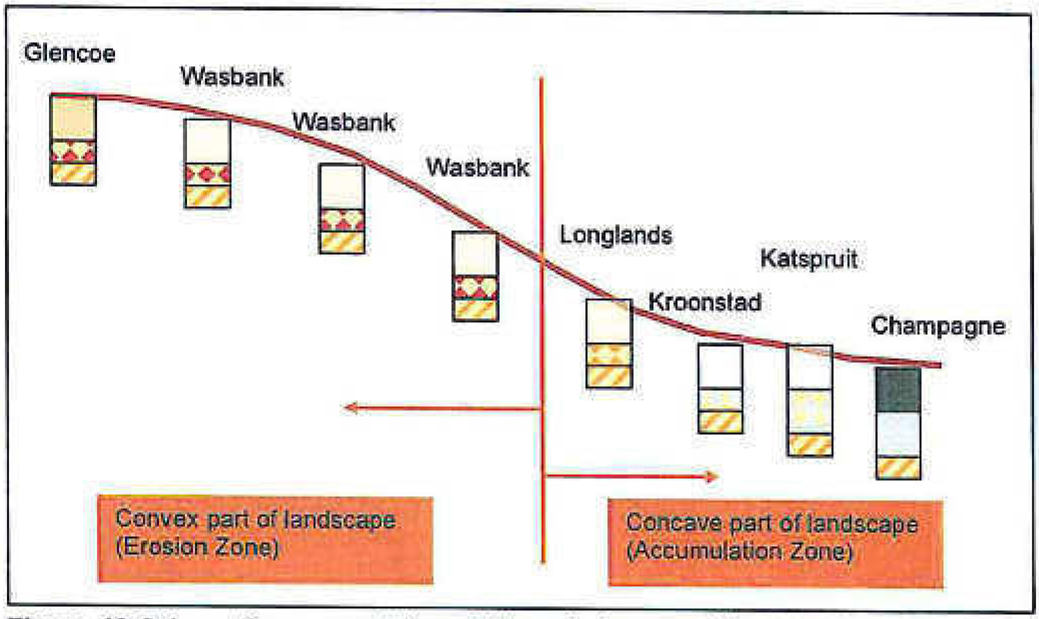

Figure 12 Schematic representation of the soils in a combined convex and concave landscape in the Halfway House Granite catena.

The strict application of the wetland delineation guidelines in the Halfway House Granite area often leads to the identification of 70 % or more of a landscape as being part of a wetland. For this reason a more pragmatic approach is often followed in that the 50 cm criterion is not applied religiously. Rather, distinctly wet horizons and zones of clay accumulation within drainage depressions are identified as distinct wetland soils. The areas surrounding these are assigned to extensive seepage areas that are difficult to delineate and on which it is difficult to assign a realistic buffer area. The probable best practice is to assign a large buffer zone in which subsurface water flow is encouraged and conserved to lead to a steady but slow recharge of the wetland area, especially following rainfall events. In the case where development is to take place within this large buffer area it is preferred that a "functional buffer" approach be followed. This implies that development can take place within the buffer area but then only within strict guidelines regarding storm water management and mitigation as well as erosion prevention in order to minimise sediment transport into stream and drainage channels and depressions.

5.8 Implications for Wetland Conservation in Urban Environments

Whether an area is designated a wetland or not loses some of its relevance once drastic influences on landscape hydrology are considered. If wetlands are merely the expression of water in a landscape due to proximity to the land surface (viz. the 50 cm mottle criterion in the delineation guidelines) it follows that potentially large proportions of the water moving in the landscape could fall outside of this sphere – as discussed in detail above. **Figures 13** and **14** provide schematic representations (as contrasted with **Figure 7**) of water dynamics in urban environments with distinct excavations and surface sealing activities respectively.

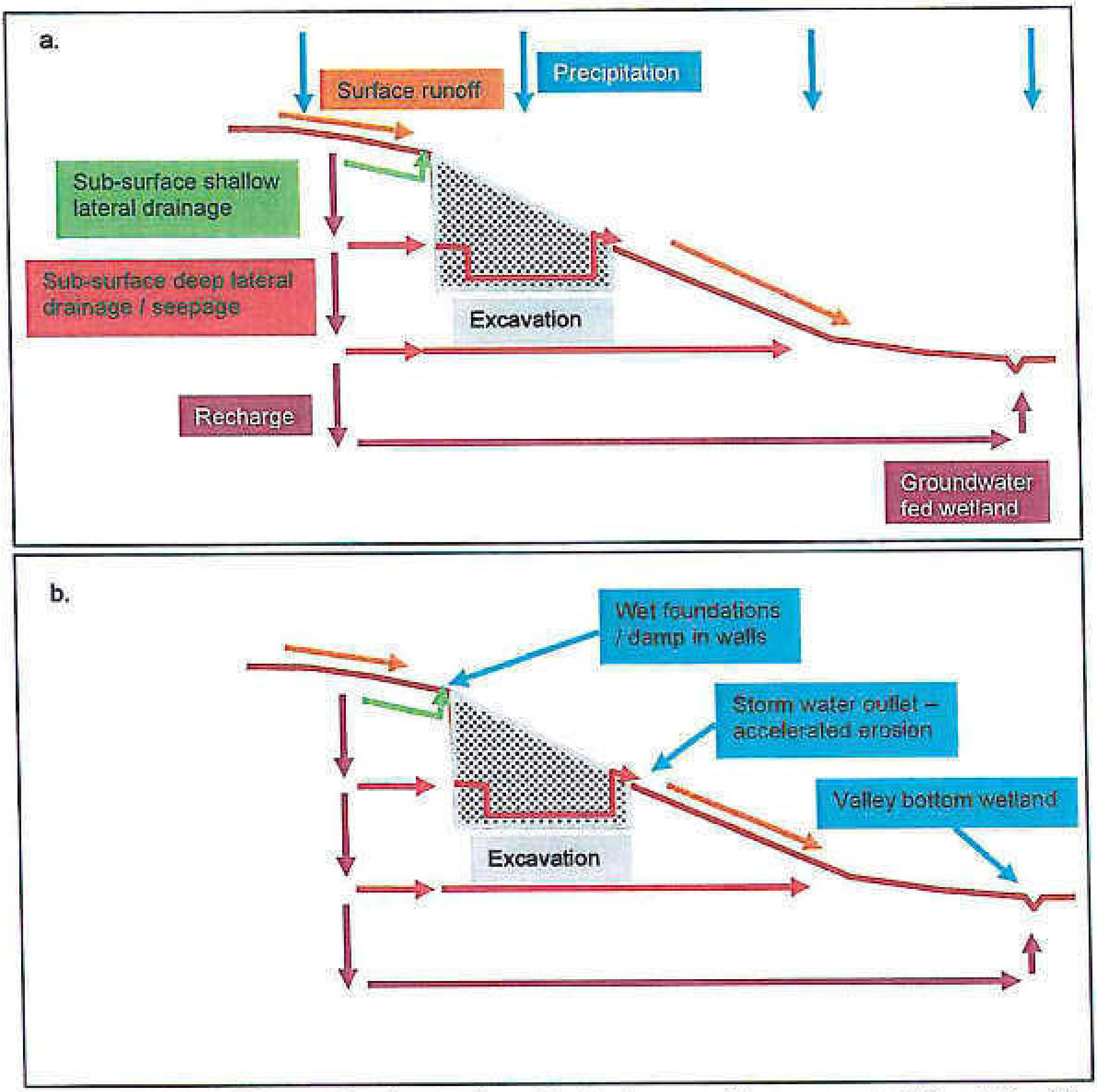

Figure 13 Different flow paths of water through a landscape with an excavated foundation (a) and typical wetland types associated with the altered water regime (b)

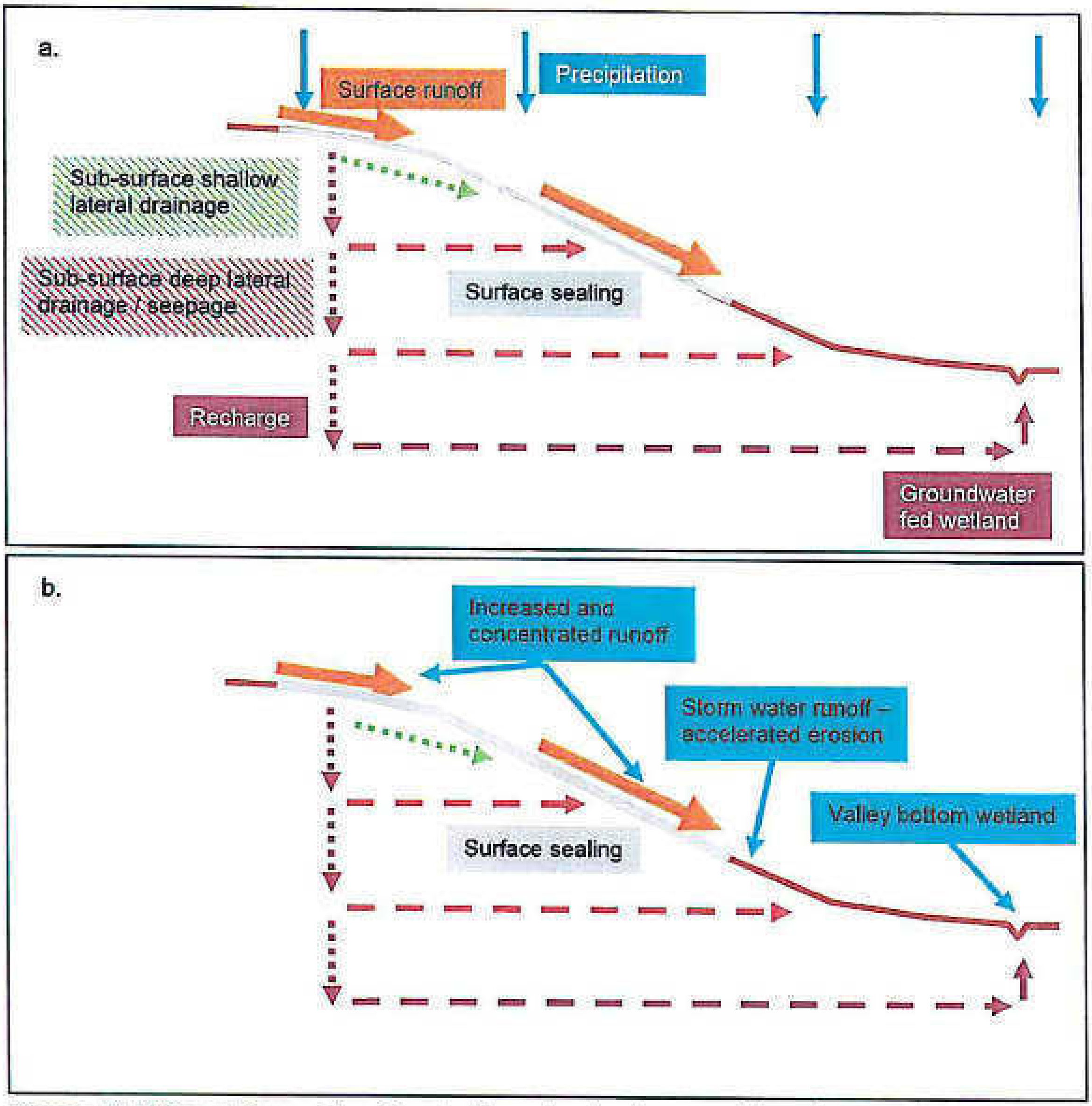

Figure 14 Different flow paths of water through a landscape with surface sealing (buildings and paving) (a) and typical wetland types associated with the altered water regime (b)

Through the excavation of pits (**Figure 13**) for the construction of foundations for infrastructure or basements for buildings the shallow lateral flow paths in the landscape are severed. As discussed above these flow paths can account for up to 60 % of the volume of water entering the landscape in the form of precipitation. These severed flow paths often lead to the ponding of water upslope from the structure with a subsequent damp problem developing in buildings. Euphemistically we have coined the term "wet basement syndrome" (WBS) to describe the type of problem experienced extensively on the HHGD. A different impact is experienced once the surface of the land is sealed through paving (roads and parking areas) and the construction of buildings (in this case the roof provides the seal) (**Figure 14**). In this case the recharge of water into the soil and weathered rock experienced naturally is altered to an accumulation and concentration of water on the surface with a subsequent rapid flowing downslope. The current approach is to channel this water into storm water structures and to release it in the nearest low-lying position in the landscape. These positions invariable correlate with drainage features and the result is accelerated erosion of such features due to a drastically altered peak flow regime.

The result of the above changes in landscape hydrology is the drastic alteration of flow dynamics and water volume spikes through wetlands. This leads to wetlands that become wetter and that experience vastly increased erosion pressures. The next section provides a perspective on the erodibility of the soils of the HHGD. It is important to note the correlation between increasing wetness, perching of water and erodibility.

5.9 Soil Erosion on the Halfway House Granite Dome

Infiltration of water into a soil profile and the percolation rate of water in the soil are dependent on a number of factors with the dominant one being the soil's texture (**Table 2**). Permeability and the percolation of water through the soil profile are governed by the least permeable layer in the soil profile. The implication of this is that soil horizons that overlie horizons of low permeability (i.e. hard rock, hard plinthite, G-horizon) are likely to become saturated with water relatively quickly - particularly if the soil profile is shallow and a large amount of water is added. Another impermeable layer is one that is saturated with water and such a layer acts the same way as the ones mentioned earlier. In cases where internal drainage is hampered by an impermeable layer such as hard rock (the Dresden or Wasbank soil forms) evaporation and lateral water movement are the only processes that will drain the soil profile of water.

Table 2 Infiltration/permeability rates for soil textural classes (Wischmeier, Johnson & Cross 1971)

Texture class	Texture	Permeability Rate (mm/hour)	Permeability Class
Coarse	Gravel, coarse sand	>508	Very rapid
	Sand, loamy sand	152 – 508	Rapid
Moderately coarse	Coarse sandy loam Sandy loam Fine sandy loam	51 - 152	Moderately rapid
Medium	Very fine sandy loam Loam Silt loam Silt	15 – 51	Moderate
Moderately fine	Clay loam Sandy clay loam Silty clay loam	5.1 – 15.2	Moderately slow
Fine	Sandy clay Silty clay Clay (>60%)	1.5 – 5.1	Slow
Very fine	Clay (>60%) Clay pan	< 1.5	Very slow

Infiltration of water into a soil profile is dependent on the factors leading to the downward movement of water. In cases where impermeable layers exist water will infiltrate into the profile until it is saturated. Once this point is reached water infiltration will cease and surface runoff will become the dominant water flow mechanism. A similar situation will develop if a soil has a slow infiltration rate of water due to fine texture, hardened or compacted layers and low hydraulic conductivity. When these soils are subjected to large volumes and rates of rainfall the rate of infiltration will be exceeded and excess water will flow downslope on the soil surface.

The texture, permeability and presence of impeding layers are some of the main determinants of soil erosion. Wischmeier, Johnson and Cross (1971) compiled a soil erodibility nomograph from soil analytical data (**Figure 15**). The nomograph uses the following parameters that are regarded as having a major effect on soil erodibility:

- The mass percentage of the fraction between 0.1 and 0.002 mm (very fine sand plus silt) of the topsoil.
- The mass percentage of the fraction between 0.1 and 2.0 mm diameter of the topsoil.
- Organic matter content of the topsoil. This "content" is obtained by multiplying the organic carbon content (in g/100 g soil – Walkley Black method) by a factor of 1.724.
- A numerical index of soil structure.
- A numerical index of the soil permeability of the soil profile. The least permeable horizon is regarded as horizon that governs permeability.

Box 1 describes the procedure to use the nomograph.

As part of a different study 45 soil samples were collected from 19 points on the HHGD. The samples were described in terms of soil form and analysed with respect to texture (6 fractions) and organic carbon content of the A-horizons (data not presented here but available upon request). The erodibility index and maximum stable slope were calculated for each horizon (according to the method discussed above) in both an unsaturated and saturated soil matrix (data not presented here but available upon request).

The erosion risk is based on the product of the slope (in percentage) and the K-value of erodibility (determined from the Wischmeier, Johnson and Cross (1971) nomograph). This product should not exceed a value of 2.0 in which case soil erosion becomes a major concern. The K-value allows for a "hard" rainfall event but is actually based on scheduled irrigation that allows for infiltration and percolation rates and so-called "normal" rainfall intensity. Soil erosion potential increases with an increase in the very fine sand plus silt fraction, a decrease in the organic matter content, an increase in the structure index and a decrease in permeability. Water quality is assumed not to be a problem for the purposes of the erosion hazard calculations.

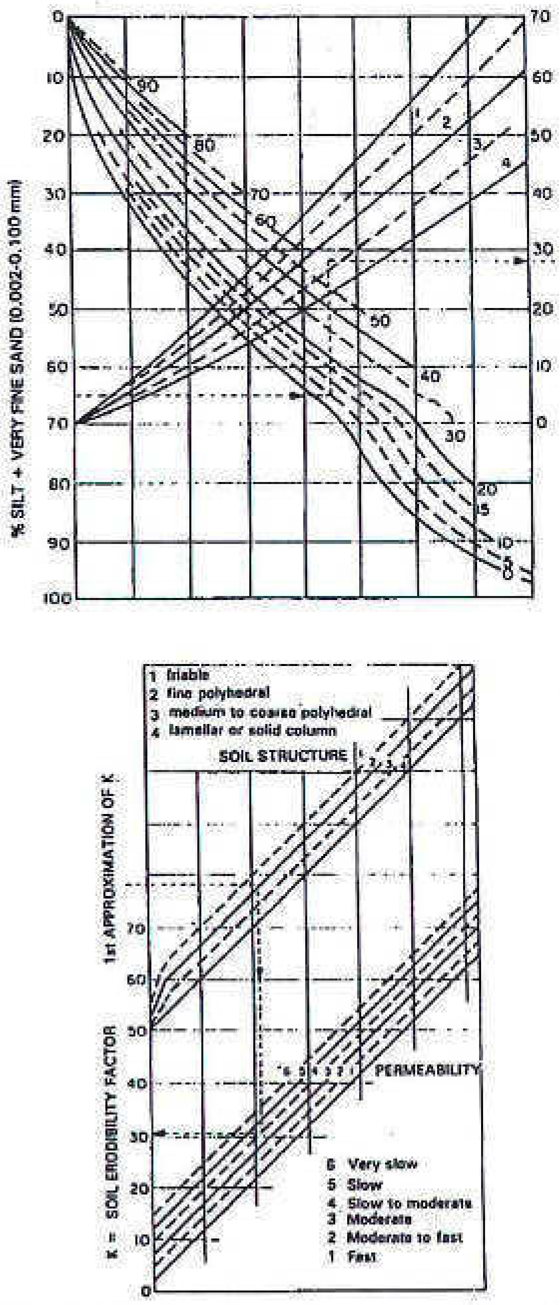

Figure 15 The nomograph by Wischmeier, Johnson and Cross (1971) that allows a quick assessment of the K factor of soil erodibility

> **Box 1: Using the nomograph by Wischmeier, Johnson and Cross (1971)**
> In examining the analysis of appropriate surface samples, enter on the left of the graph and plot the percentage of silt (0.002 to 0.1 mm), then of sand (0.10 to 2 mm), then of organic matter, structure and permeability in the direction indicated by the arrows. Interpolate between the drawn curves if necessary. The broken arrowed line indicates the procedure for a sample having 65% silt + very fine sand, 5% sand, 2.8% organic matter, 2 of structure and 4 of permeability. Erodibility factor K = 0,31.

Note: The erodibility factor increase due to saturation was also calculated. These results indicated an increase in erodibility of a factor predominantly between 3 and 4 for saturated soil conditions.

5.10 DETAILED SOIL CHARACTERISTICS – SUMMARISING CONCLUSIONS

The following general conclusions can be made regarding the soil characteristics of the HHGD (and the catchment):

1. The site (and catchment) is dominated by shallow to moderately deep sandy soils with deep soils occurring in the drainage features only;
2. The soils are dominantly coarse sandy in texture;
3. On the bulk of the site the soils are underlain by a hard plinthic layer (ferricrete) that acts as an aquaclude under natural conditions;
4. The bulk of the water movement on the site occurs within 50 cm of the soil surface on top of the ferricrete layer in the absence of human impacts;
5. Wetland delineation is a challenging exercise on the HHGD; and
6. The soils of the HHGD, as those of the site, are highly erodible, especially when saturated with water.

5.11 RECOMMENDED ASSESSMENT APPROACH – HYDROPEDOLOGY INVESTIGATION

5.11.1 Hydropedology Background

The identification and delineation of wetlands rest on several parameters that include topographic, vegetation and soil indicators. Apart from the inherent flaws in the wetland delineation process, as discussed earlier in this report, the concept of wetland delineation implies an emphasis on the wetlands themselves and very little consideration of the processes driving the functioning and presence of the wetlands. One discipline that encompasses a number of tools to elucidate landscape hydrological processes is "hydropedology" (Lin, 2012). The crux of the understanding of hydropedology lies in the fact that pedology is the description and classification of soil on the basis of morphology that is the result of soil and landscape hydrological, physical and chemical processes. But, the soils of which the morphology are described, also take part in and intimately influence the hydrology of the landscape. Soil is therefore both an indicator as well as a participator in the processes that require elucidation.

Wetlands are merely those areas in a landscape where the morphological indicators point to prolonged or intensive saturation near the surface to influence the distribution of wetland vegetation. Wetlands therefore form part of a larger hydrological entity that they cannot be separated from.

5.11.2 Hydropedology – Proposed Approach

In order to provide detailed pedohydrological information both detailed soil surveys and hydrological investigations are needed. In practice these intensive surveys are expensive and very seldom conducted. However, with the understanding of soil morphology, pedology and basic soil physics parameters as well as the collection and interpretation of existing soil survey information, assessments at different levels of detail and confidence can be conducted. In this sense four levels of investigation are proposed namely:

1. Level 1 Assessment: This level includes the collection and generation of all applicable remote sensing, topographic and land type parameters to provide a "desktop" product. This level of investigation rests on adequate experience in conducting such information collection and interpretation exercises and will provide a broad overview of dominant hydropedological parameters of a site. Within this context the presence, distribution and functioning of wetlands will be better understood than without such information.
2. Level 2 Assessment: This level of assessment will make use of the data generated during the Level 1 assessment and will include a reconnaissance soil and site survey to verify the information as well as elucidate many of the unknowns identified during the Level 1 assessment.
3. Level 3 Assessment: This level of assessment will build on the Level 1 and 2 assessments and will consist of a detailed soil survey with sampling and analysis of representative soils. The parameters to be analysed include soil physical, chemical and mineralogical parameters that elucidate and confirm the morphological parameters identified during the field survey.
4. Level 4 Assessment: This level of assessment will make use of the data generated during the previous three levels and will include the installation of adequate monitoring equipment and measurement of soil and landscape hydrological parameters for an adequate time period. The data generated can be used for the building of detailed hydrological models (in conjunction with groundwater and surface hydrologists) for the detailed water management on specific sites.

For most wetland delineation exercises a Level 2 or Level 3 assessment should be adequate. For this investigation a Level 2 assessment was conducted with a reconnaissance soils survey and field work. Analysis of soils was not conducted but data from other sites with highly similar soils was also used to illustrate the challenges faced on the site and in the broader area.

The process of the hydropedology assessment entails the aspects listed in the methodology description below. These items also correspond with the proposed PES assessment methodology discussed in section 4.4.4. The results of the assessment will therefore be structured under the headings as provided below.

6. METHOD OF SITE INVESTIGATION

6.1 WETLAND CONTEXT DETERMINATION

For the purposes of the wetland buffer assessment the context of the specific wetland was determined. This was done through the thorough consideration of the geological, topographical, climatic, hydropedological and catchment context of the site. In this sense the relative contribution of water flow from the catchment upstream was compared to the contribution from the slopes on the specific site. The motivation being that the larger the contribution of the catchment upstream the smaller the impacts of the proposed developments on the site would be in terms of modification of the wetland. The elements of context are described in more detail below.

6.2. Aerial Photograph Interpretation

An aerial photograph interpretation exercise was conducted through the use of Google Earth images and historical aerial photographs of the site. This data was used to obtain an indication of the extent of the wetlands on the site as well as to provide an indication of the artificial modifiers evident on the site and in the catchment.

6.3 Terrain Unit Indicator

Detailed contours of the site (filtered to 5 m intervals for the purpose of map production) were used to provide an indication of drainage depressions and drainage lines. From this data the terrain unit indicator was deduced.

6.4 Soil Form and Soil Wetness Indicators

The soil form and wetness indicators were assessed on the site through a dedicated soil survey within the context of the description of the HHGD as provided in sections 5.5 to 5.7. During the soil survey areas of significance were identified and soil auger profile description activities conducted for the specific areas.

Historical impacts were identified as the impacts on the soils are very distinct. Soil characteristics could therefore be used to provide a good indication of the historical impacts on the grounds of a forensic approach. In areas where soil impacts are limited the standard approach in terms of identification of soil form and soil wetness indicators was used.

6.5 Vegetation Indicator

Due to the extent of the historical impacts as well as the timing of the investigation a dedicated vegetation survey for the purpose of wetland delineation was not conducted. Relevant vegetation parameters were noted and these are addressed in the report where applicable.

6.6 Artificial Modifiers

Artificial modifiers of the landscape and wetland area were identified during the different components of the investigation and are addressed in the context of the wetland management plan.

7. SITE SURVEY RESULTS AND DISCUSSION

7.1 WETLAND CONTEXT

The land type, topography and geological setting of the site have been elucidated in section 2 of this document. The main wetland feature on the site is limited to a drainage channel and associated wetland area that runs from north to south parallel to the Ben Schoeman (N1) highway. The original wetland area is also crossed by Allandale road and its associated on- and off-ramps from the N1. The headwater area of the wetland has been developed extensively and is for all intents and purposes entirely sealed with hard surfaces. The original catchment is indicated on the DEM in **Figure 15** and on the recent satellite image with contours in **Figure 16**.

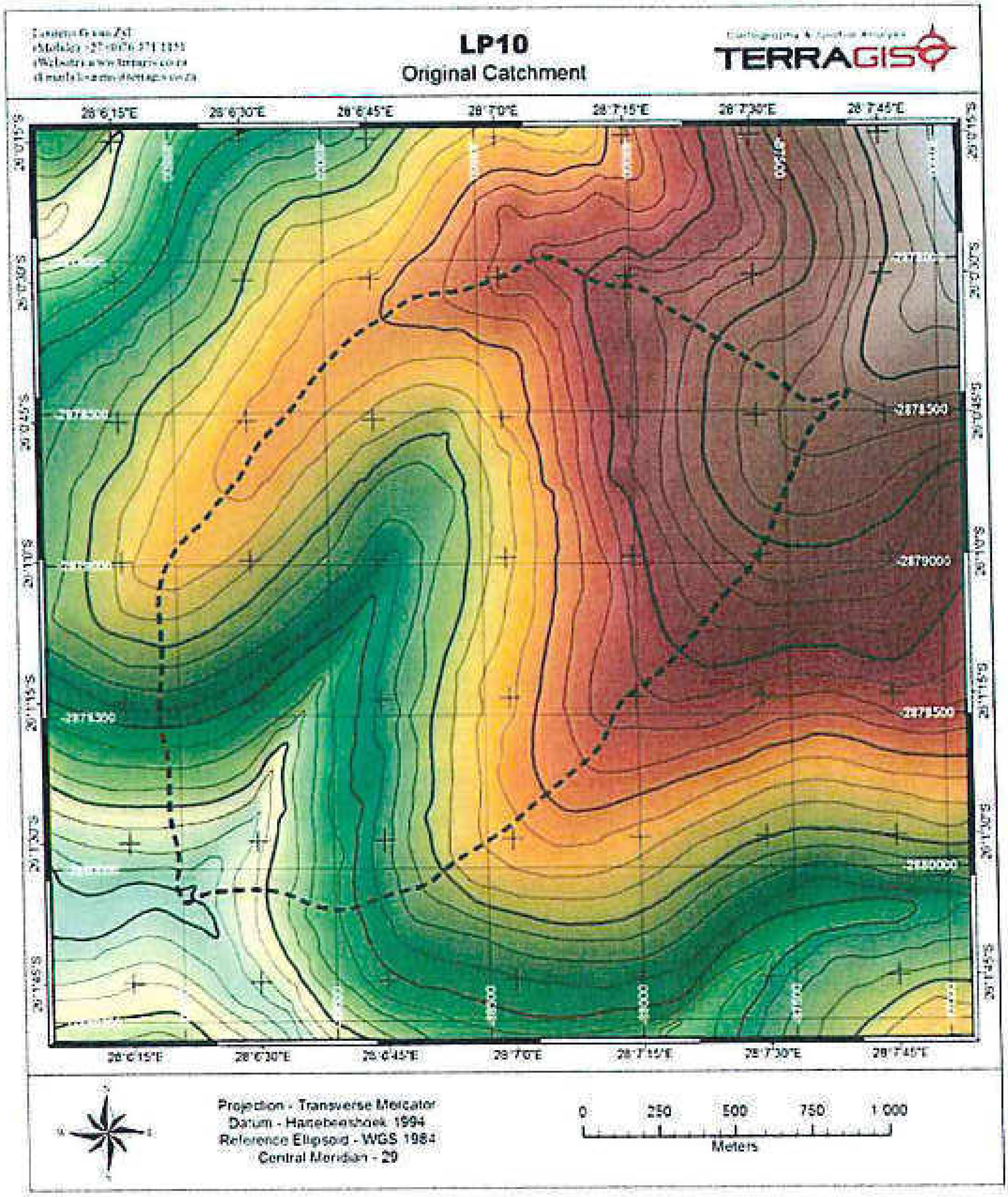

Figure 15 DEM of the wetland/watercourse catchment

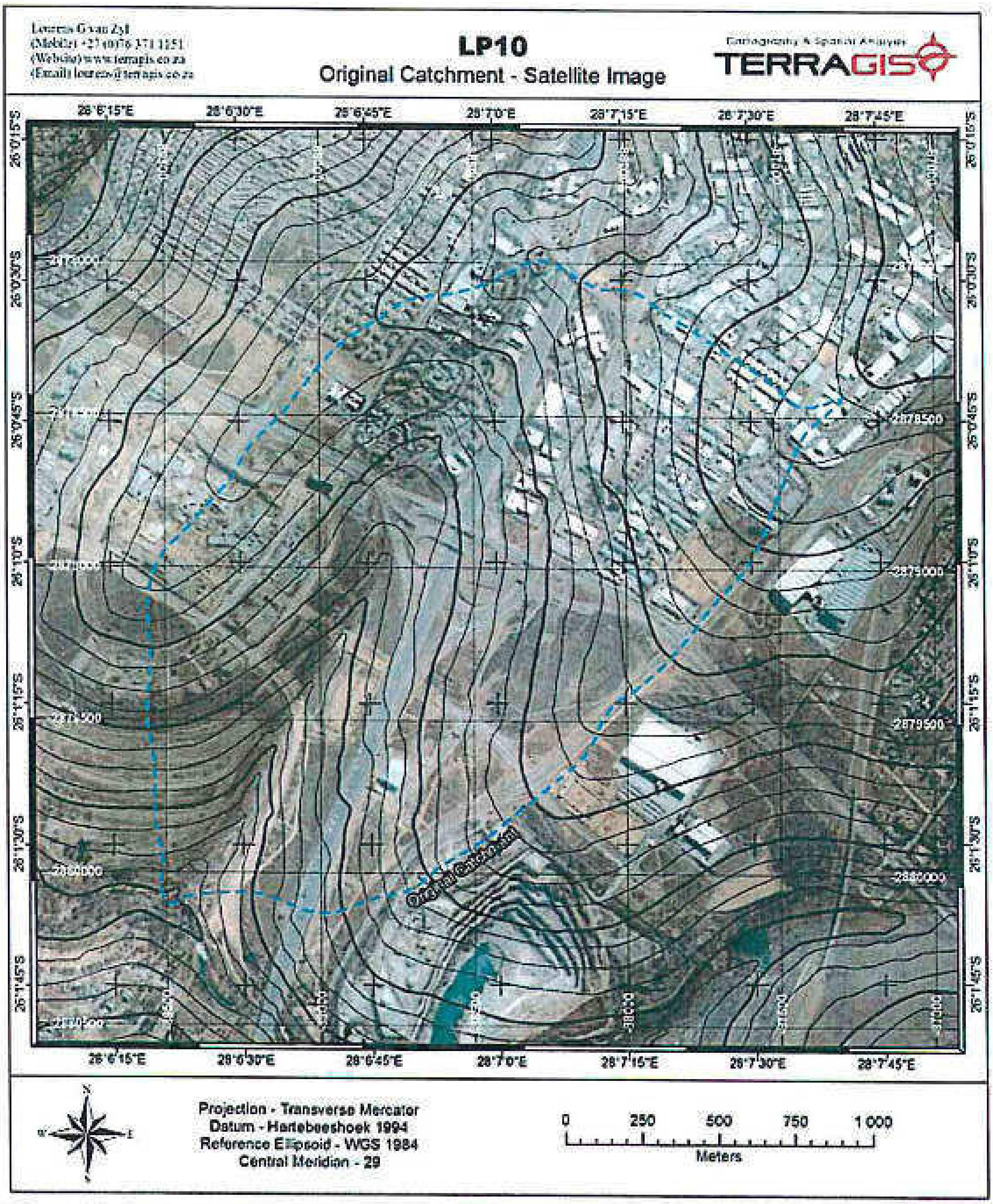

Figure 16 Contours and catchment of the wetland/watercourse under investigation

7.2 Aerial Photograph Interpretation

The aerial photograph interpretation was conducted in two stages namely 1) the interpretation of historical aerial photographs indicating the specific wetland conditions and changes and 2) the Google Earth images indicating specific activities and changes on the site.

7.2.1 Historical Aerial Photographs

The historical data collected for the site include aerial photographs of 1938, 1952, 1968, 1976, 1985 and 1991. **Figure 17** indicates the land status in 1938 with clear signs of crop production and other land uses within the headwaters of the wetland/watercourse. **Figure 18** indicates the changes from 1952 to 1968 with the construction of the N1 highway as well as Allandale Road in the late 60s. In **Figure 19** the intensification of urban developments in the headwaters of the wetland/watercourse is evident. None of the images indicate any significant wetland expression in the lower reaches of the watercourse leading to the conclusion that the headwater area constituted the more pronounced wetland area. This is in agreement with the discussion provided earlier on the typical wetland distribution trends found on the HHGD. Significant erosion scars are also not evident in the images.

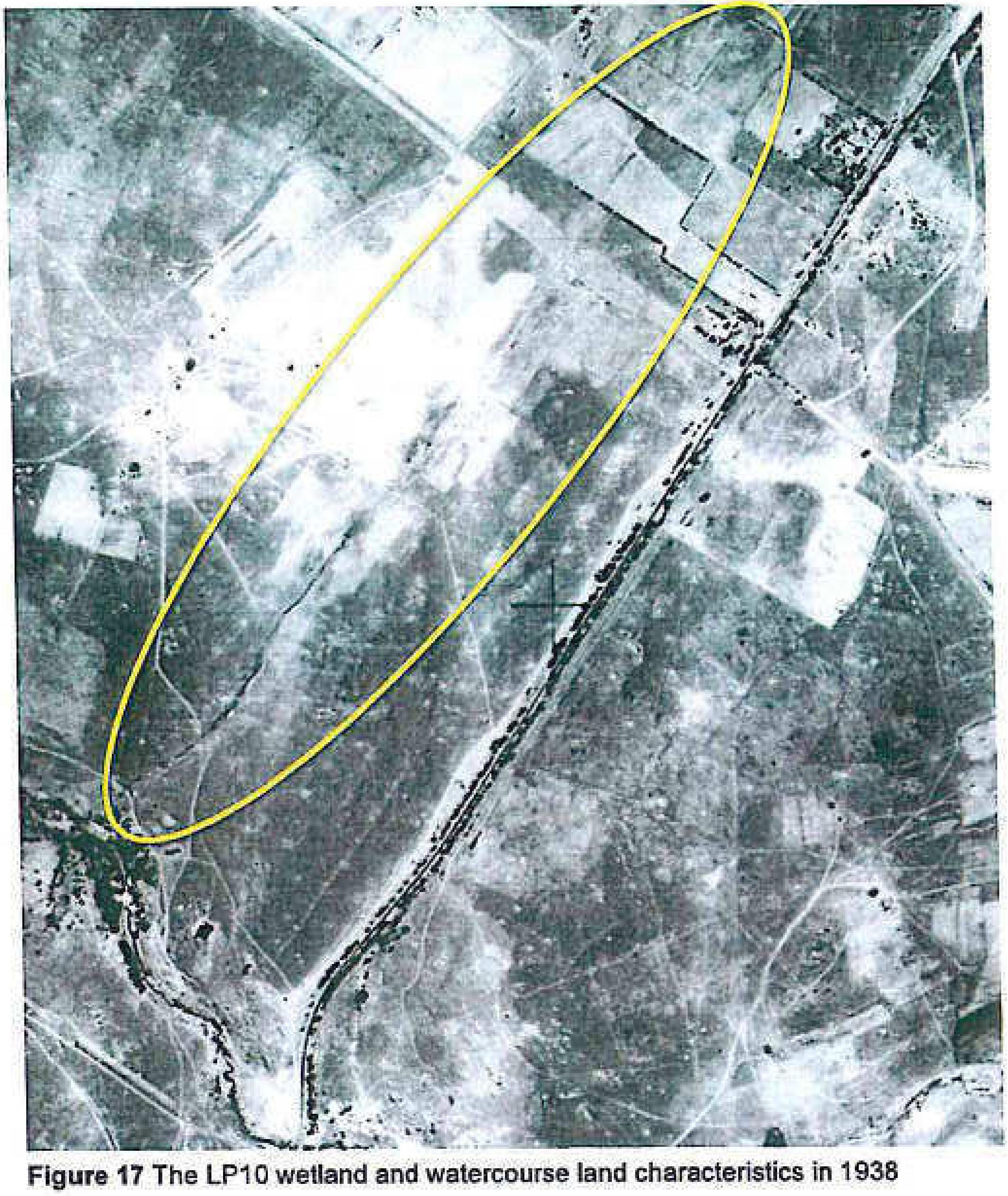

Figure 17 The LP10 wetland and watercourse land characteristics in 1938

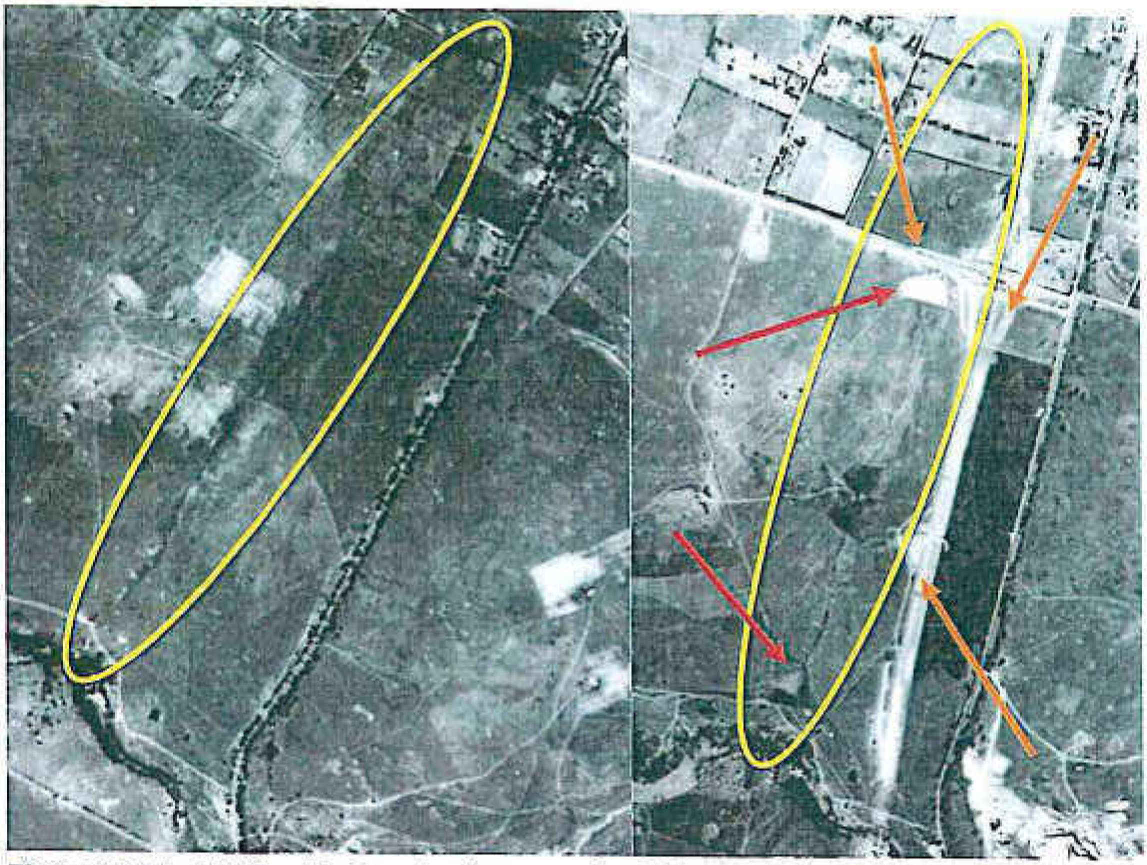

Figure 18 The LP10 wetland and watercourse land characteristics in 1952 (left) and 1968 (right) with dams (red arrows) and construction of the N1 highway and Allandale Road (orange arrows) evident in the latter

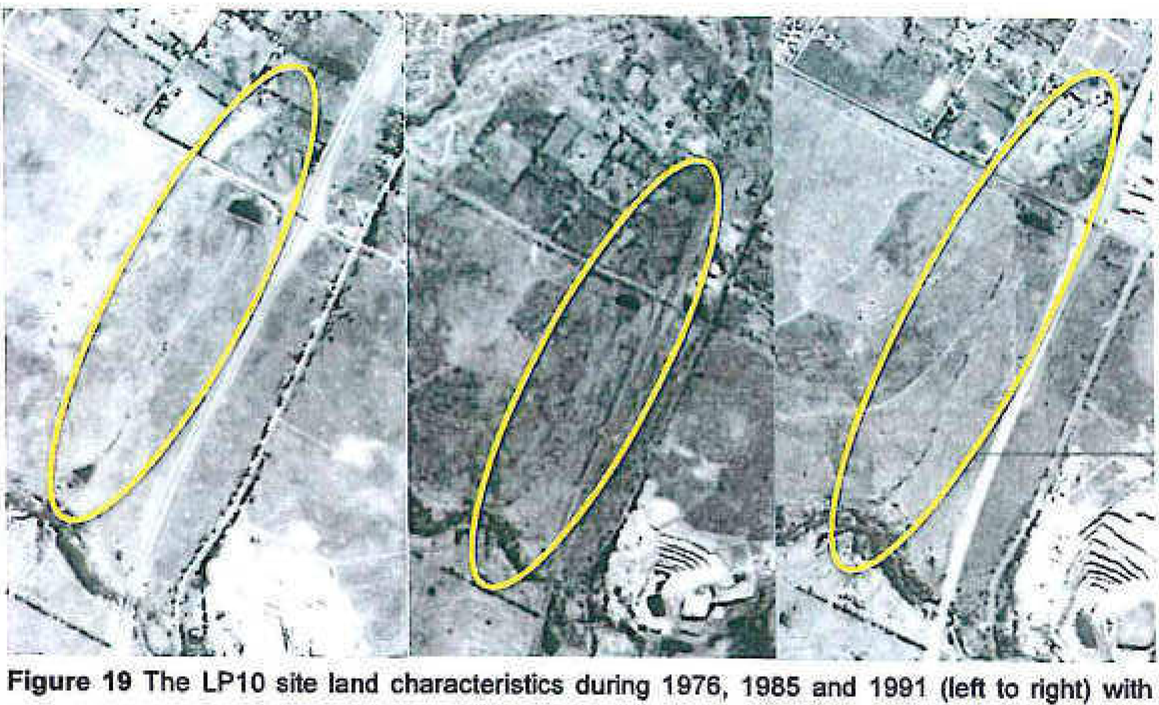

Figure 19 The LP10 site land characteristics during 1976, 1985 and 1991 (left to right) with the urban development intensification visible during the periods

7.2.2 Recent Google Earth Images

The Google Earth images of the site were used to identify specific impacts and their timing in high resolution. **Figures 20** to **24** indicate the rapid intensification of urban development for the entire watercourse since 2001.

Figure 20 Google Earth images from 2001/07/20 (top) and 2004/03/26 (bottom)

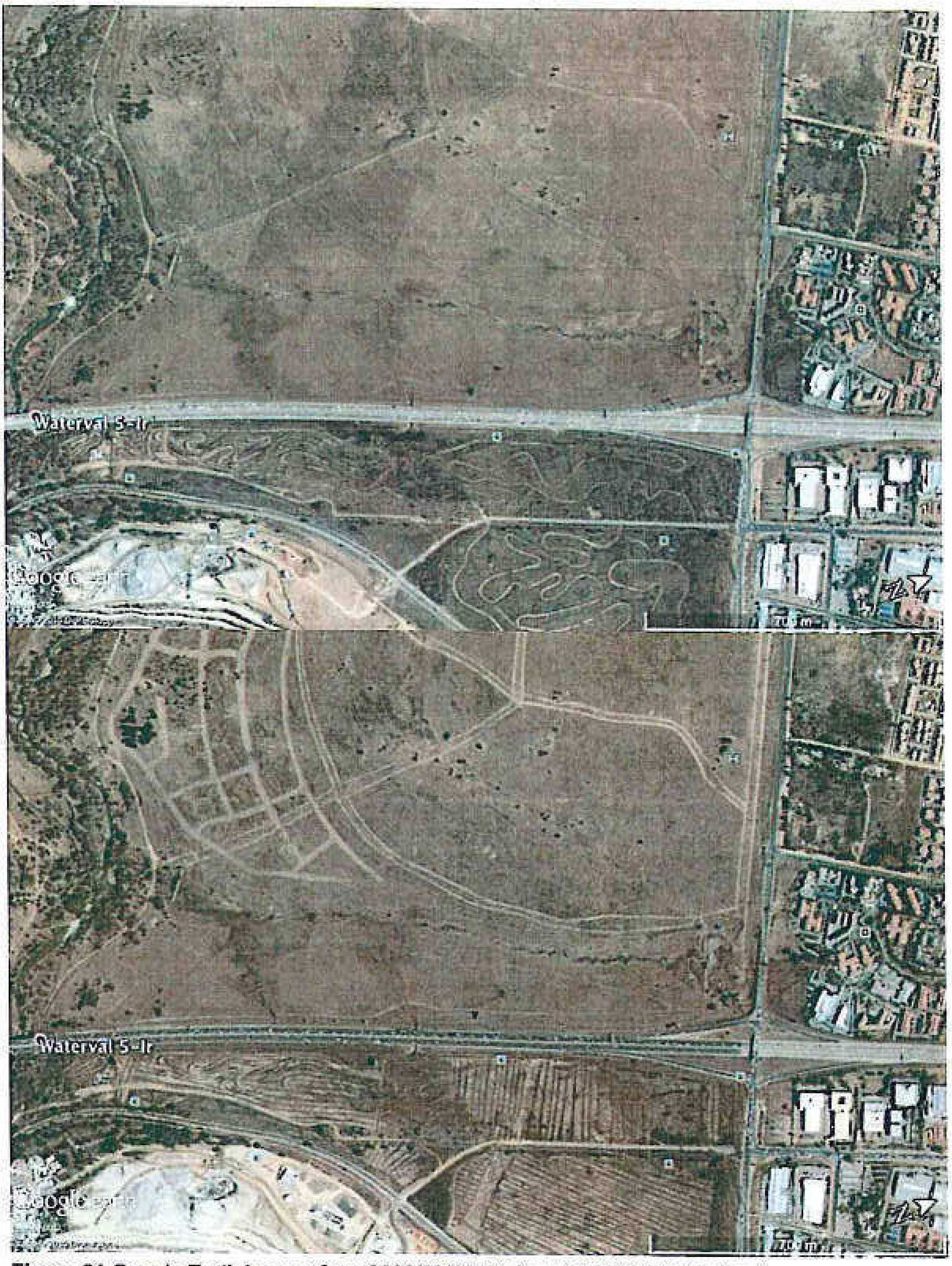

Figure 21 Google Earth images from 2006/08/10 (top) and 2008/09/07 (bottom)

Figure 22 Google Earth images from 2009/04/24 (top) and 2010/10/20 (bottom)

Figure 23 Google Earth images from 2011/07/02 (top) and 2013/07/14 (bottom)

Figure 24 Google Earth images from 2014/08/08 (top) and 2015/06/10 (bottom)

The erosion damage increase to the watercourse, as compounded by increased rapid storm water runoff from paved and sealed areas is evident in images from 2001 to 2014 (**Figures 25 and 26**).

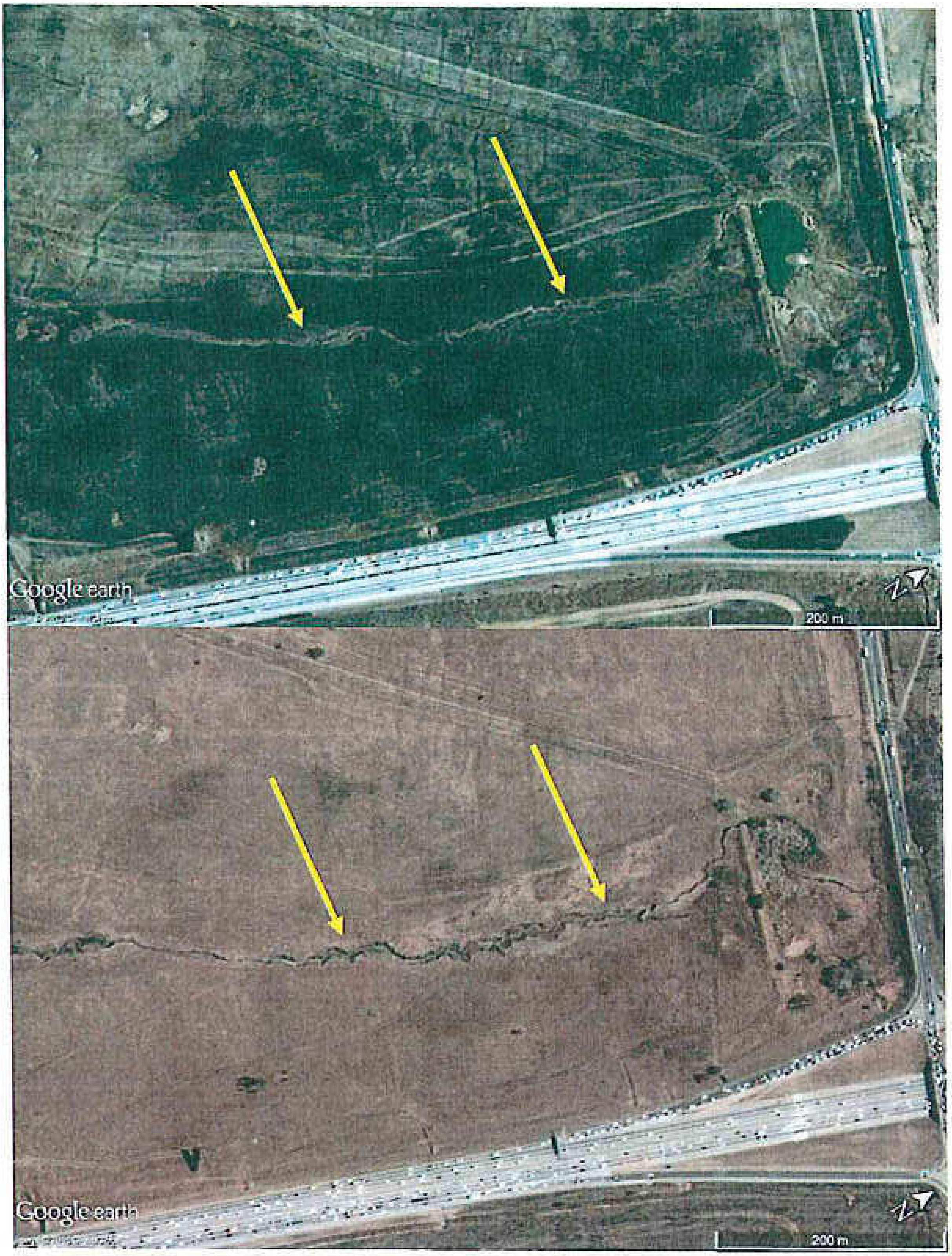

Figure 25 Google Earth images from 2001/07/20 (top) and 2006/08/10 (bottom) indicating erosion

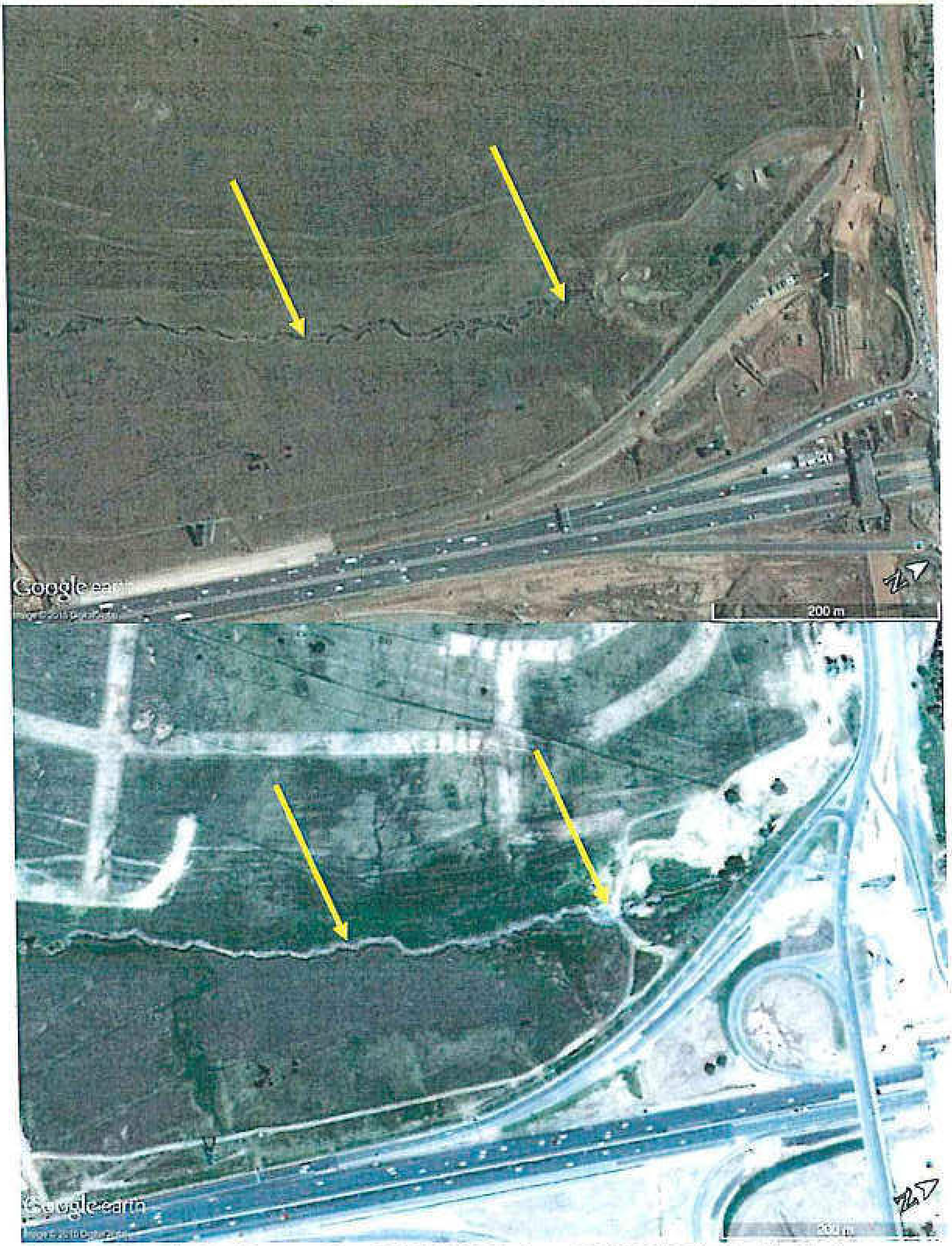

Figure 26 Google Earth images from 2009/05/07 (top) and 2010/12/15 (bottom) indicating erosion

Figure 27 Google Earth images from 2014/08/10 (top) and 2015/06/10 (bottom) indicating rehabilitation and stabilisation work within the watercourse

7.3 TERRAIN UNIT INDICATOR

From the contour data a topographic wetness index (TWI) (**Figure 28**) was generated for the site.

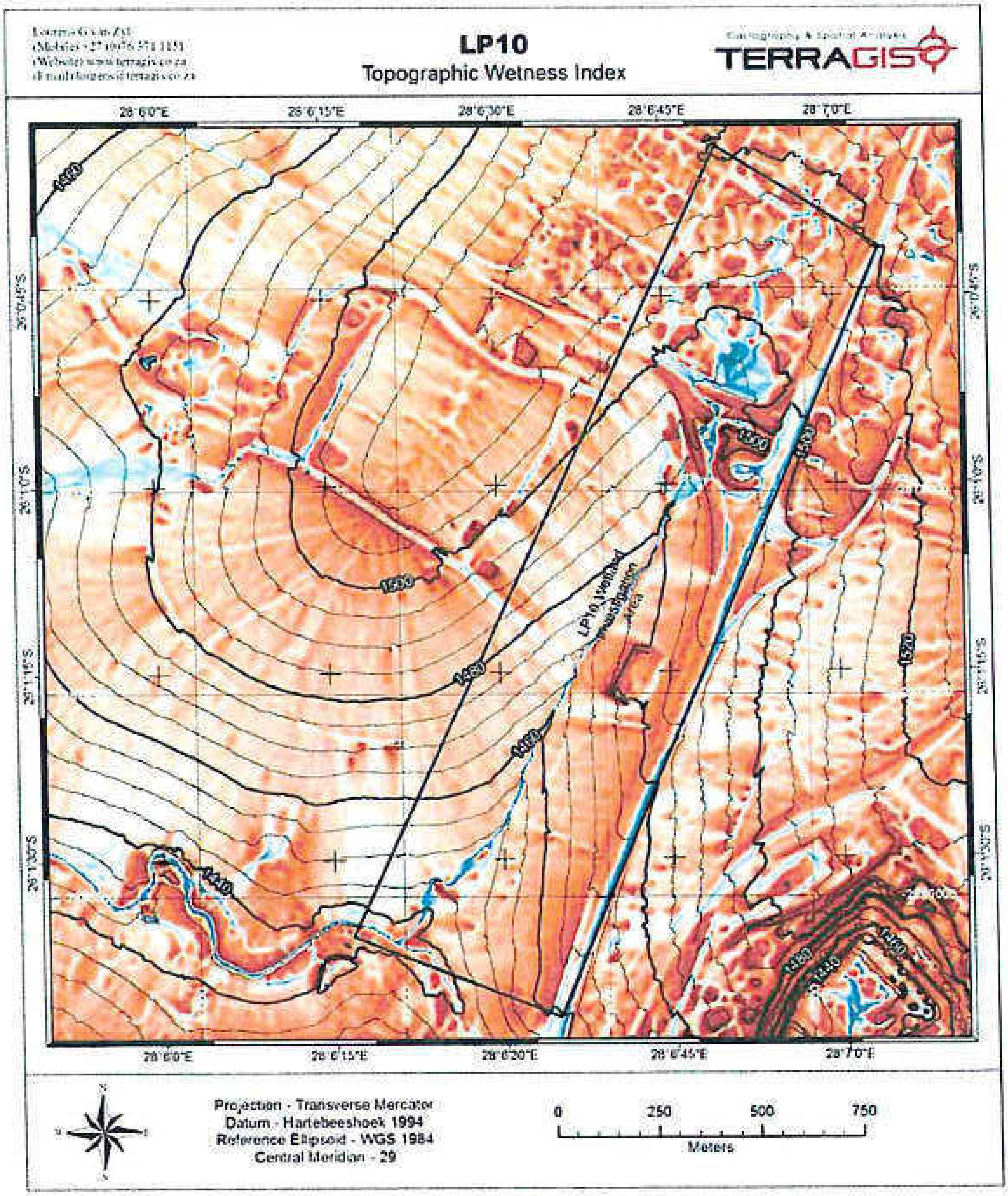

Figure 28 Topographic wetness index (TWI) of the survey site

From extensive experience on the field of hydropedology it is evident that the TWI provides a very accurate indication of water flow paths and areas of water accumulation that are often correlated with wetlands. This is a function of the topography of the site and ties in with the dominant water flow regime in the soils and the landscape (refer to previous section where the concept of these flows was elucidated). Areas in blue indicate concentration of water in flow paths with lighter shades of blue indicating areas of regular water flows in the soils and on the surface of the wetland / terrestrial zone interface.

The image indicates significant alteration in the catchment of the watercourse in the form of varied flow and water accumulation areas (north of Allandale Road). Under undisturbed conditions the flow paths are smoother due to diffuse water flows. Significant alteration of the watercourse is also evident but the data's age conceals the more recent drastic alterations on the site as observed in the more recent satellite images.

7.4 SOIL FORM AND SOIL WETNESS INDICATORS (AND VEGETATION)

A dedicated field verification exercise was conducted through the auguring of the soils within the wetland feature. The soils found on the site conform largely to the description provided in section 5.5 to 5.7. The soils within the drainage feature are predominantly high clay content swelling soils with vertic properties. Vertic soils are highly erodible once disturbed and this observation accounts for the rapid degradation of the watercourse once storm water volumes increased following surface sealing in the catchment.

7.5 ARTIFICIAL MODIFIERS

Most of the physical historical artificial modifiers on the site were addressed in the sections above. The driver of most of the modifications is the altered hydrology of and runoff from the urban structures in the catchment area. Additional impacts are the concentrated and increased storm water runoff from the extensive road network in the area (**Figure 29**). These impacts are expected to increase with increased sealing of the site's and catchment's open land areas.

8. WETLAND ASSESSMENT

8.1 PROPOSED DELINEATION AND BUFFER

Due to the highly impacted nature of the wetland on the site, taking into account all the historical modifiers as well as future authorised impacts, a delineation exercise would not yield any information of value and is therefore not provided. Similarly, due to the significant impacts a buffer is a meaningless property if it does not inform and guide dedicated storm water management and soil stabilisation interventions. The main aspects that have to be addressed are sediment generation and erosion.

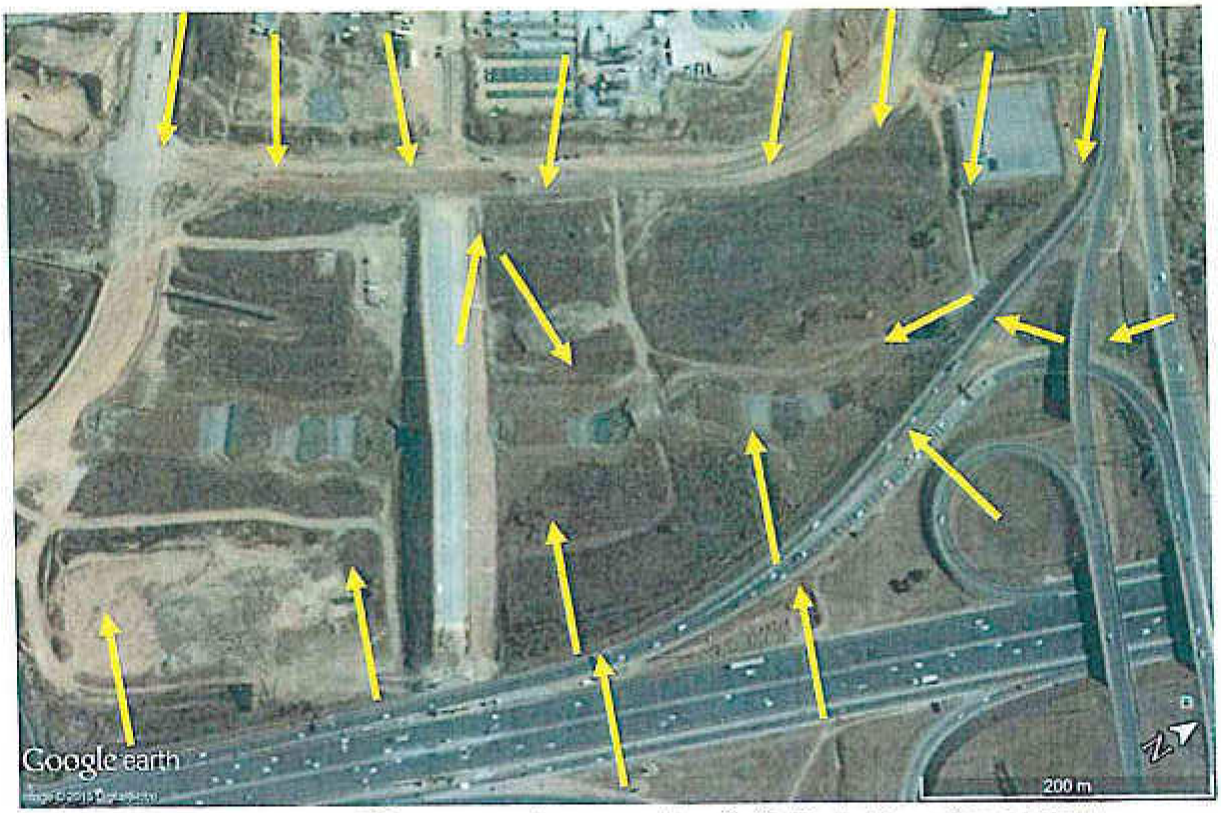

Figure 29 Storm water runoff increase and areas on the site (indicated by yellow arrows)

8.2 WETLAND CLASSIFICATION / TYPES

Based on the information generated in this document the wetland area is classified as a highly altered valley bottom wetland system with significant impacts on the original hillslope seeps and hydrological functioning.

8.3 WETLAND FUNCTIONALITY

The functionality of the wetland system has been highly compromised through human activities, building and urban infrastructure development within the catchment and destruction of wetland and drainage systems feeding into the drainage feature. The watercourse has been stabilised but in the process its functionality has been altered completely, albeit into a more positive water energy dissipation and sediment trapping function.

8.4 PRESENT ECOLOGICAL STATUS (PES) DETERMINATION

The PES determination requires a comparison between the reference state and the current state of the watercourse/wetland. As there is a drastic hydrological alteration due to the surrounding activities as well as the wetland rehabilitation exercise the reference state has been altered completely. A new reference state has been established and the success of such an intervention can only be determined through continued monitoring and maintenance of the constructed system.

9. MANAGEMENT REQUIREMENTS AND MITIGATION OF STORM WATER

It is imperative that the wetland (and other open soil areas on the site) be protected against increased erosion pressures through the implementation of the following:

1. Adequate storm water mitigation throughout the construction site (from start to completion) to prevent large pulses in storm water.
2. Sediment containment structures throughout the site to prevent sediment runoff and accumulation in the wetland area.

It is not the purpose of this document to provide detailed designs for mitigation measures as these should be generated by a suitably qualified engineer in conjunction with a suitably qualified wetland soil specialist. There are a few general pointers though that should be adhered to namely:

1. Subsurface lateral flow of water leads to the interception of such water once foundations are sunk into the soils and weathered rock / hard plinthite. Adequate drainage structures should be constructed to prevent damp problems in structures arising within the soil profiles and landscape start filling with water once rainfall increased during summer months.
2. In many areas it has been found that the water moving downslope in the fractured rock is under positive pressure (due to gravity) with a consequent squirting out from severed preferential flow structures. This implies that in some areas water ingress into foundations and basements can occur from below (leading to the expression of a "wet basement syndrome" as mentioned under section 5.8). Structures constructed in areas with such risks should have additional water removal mechanisms implemented at the structure / ground interface. These can include dedicated containment and drainage features. Where cut and fill operations take place with a consequent large volume of "overburden" material over the soil a specific capillary break layer with associated drainage should suffice.
3. Surface sealing of the landscape through roads, parking areas, roof covered areas and general soil compaction leads to accelerated and increased surface water runoff. In order to mitigate the potential large volumes over a large area numerous small containment structures with choked outflows should be constructed throughout a site. The fewer these structures are the larger other structures have to be to contain the said water. As a minimum requirement these structures should be adequate and enough to contain the standard storm water runoff from a site before it reaches the wetland /drainage feature area.
4. Several soft engineering approaches exist for the successful mitigation of storm water. If these are incorporated into the design and layout of development sites impacts on the wetlands and drainage features can be successfully mitigated.
5. In terms of both the NWA (National Water Act) and NEMA (National Environmental Management Act) landowners have a duty to protect water resources, watercourses and wetlands. In addition, CARA (Conservation of Agricultural Resources Act) and the municipal bylaws address storm water aspects that are of importance to land owners and managers. Insufficient attention to storm water related impacts during the design phase of a