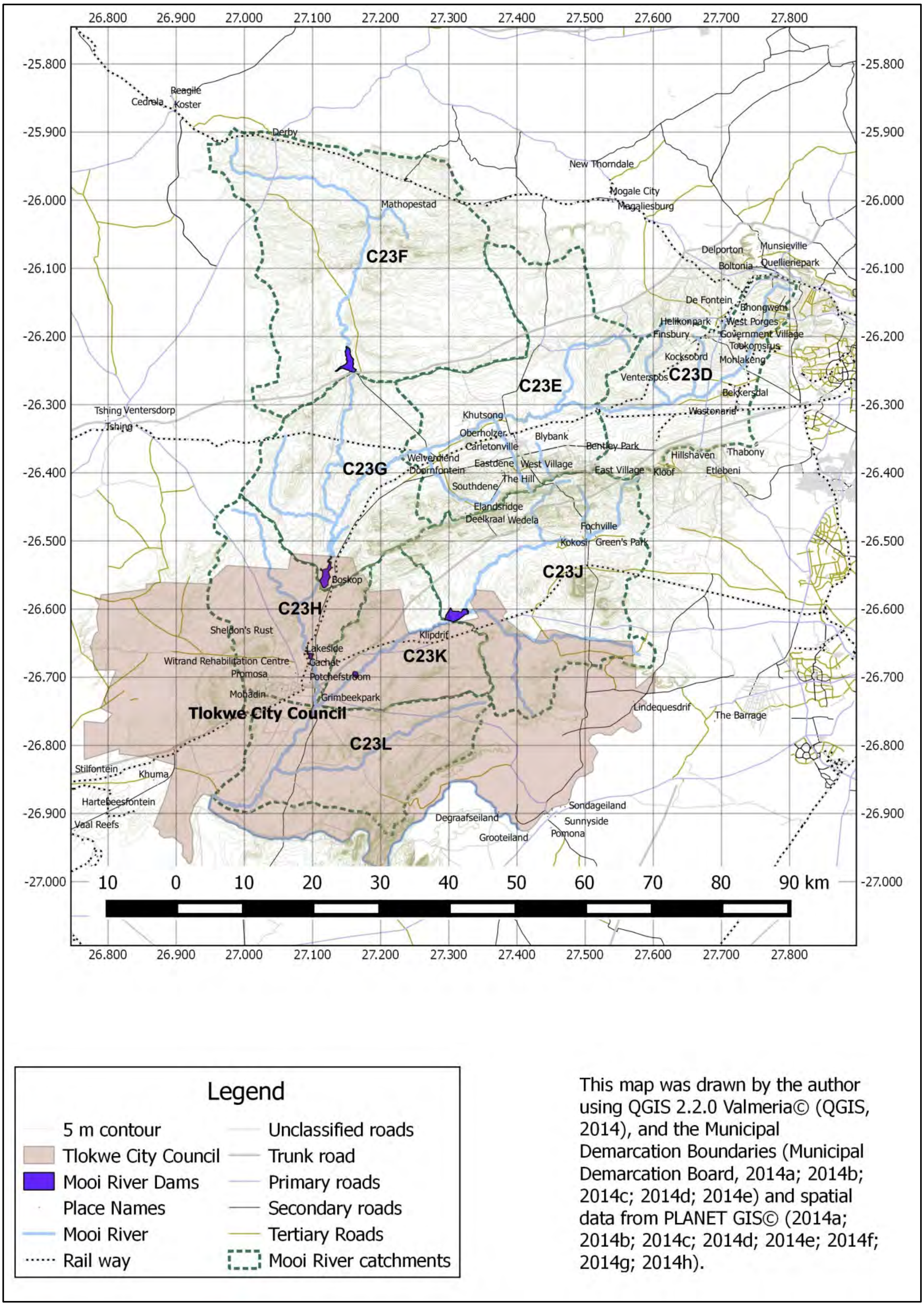
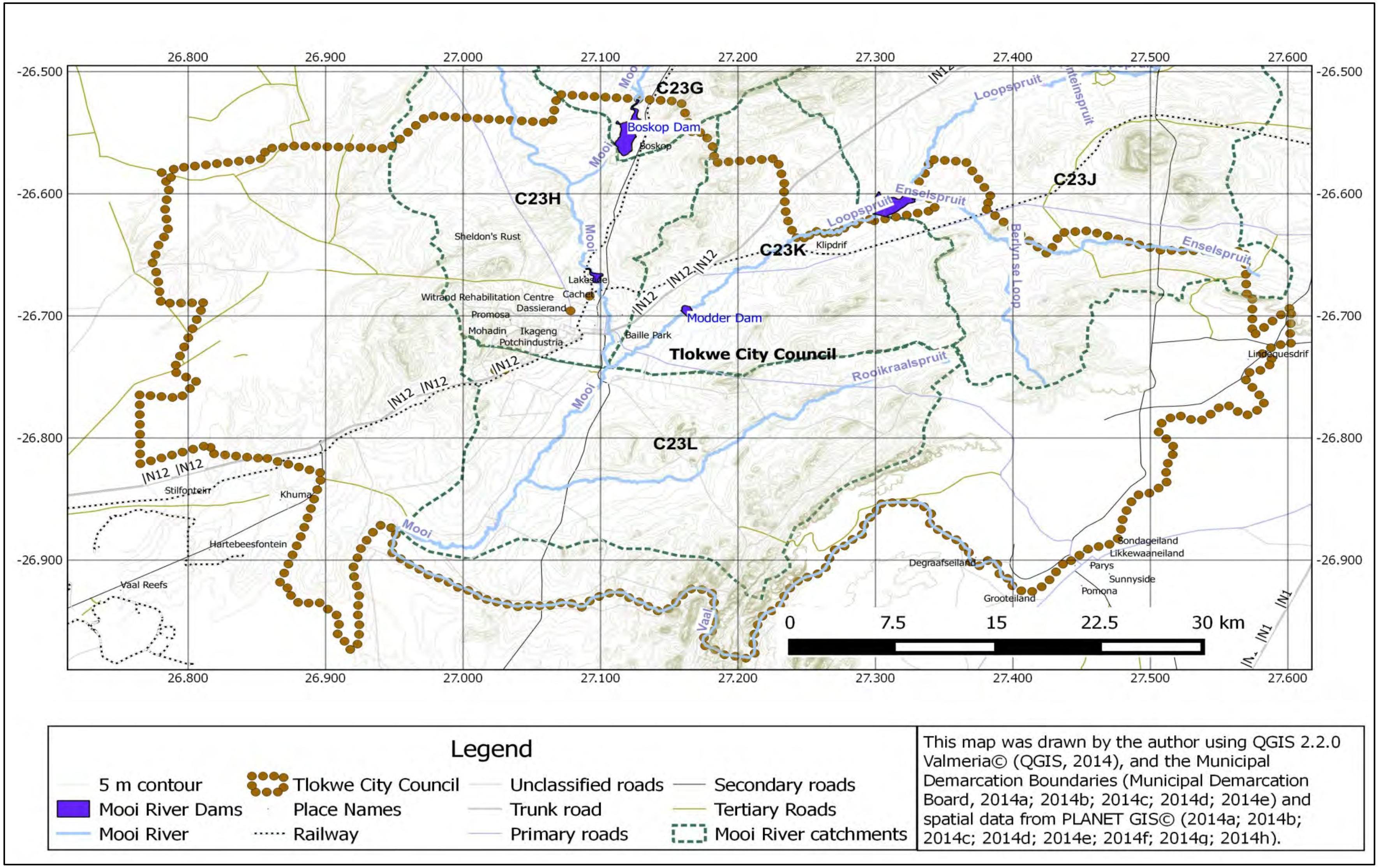
Appendices

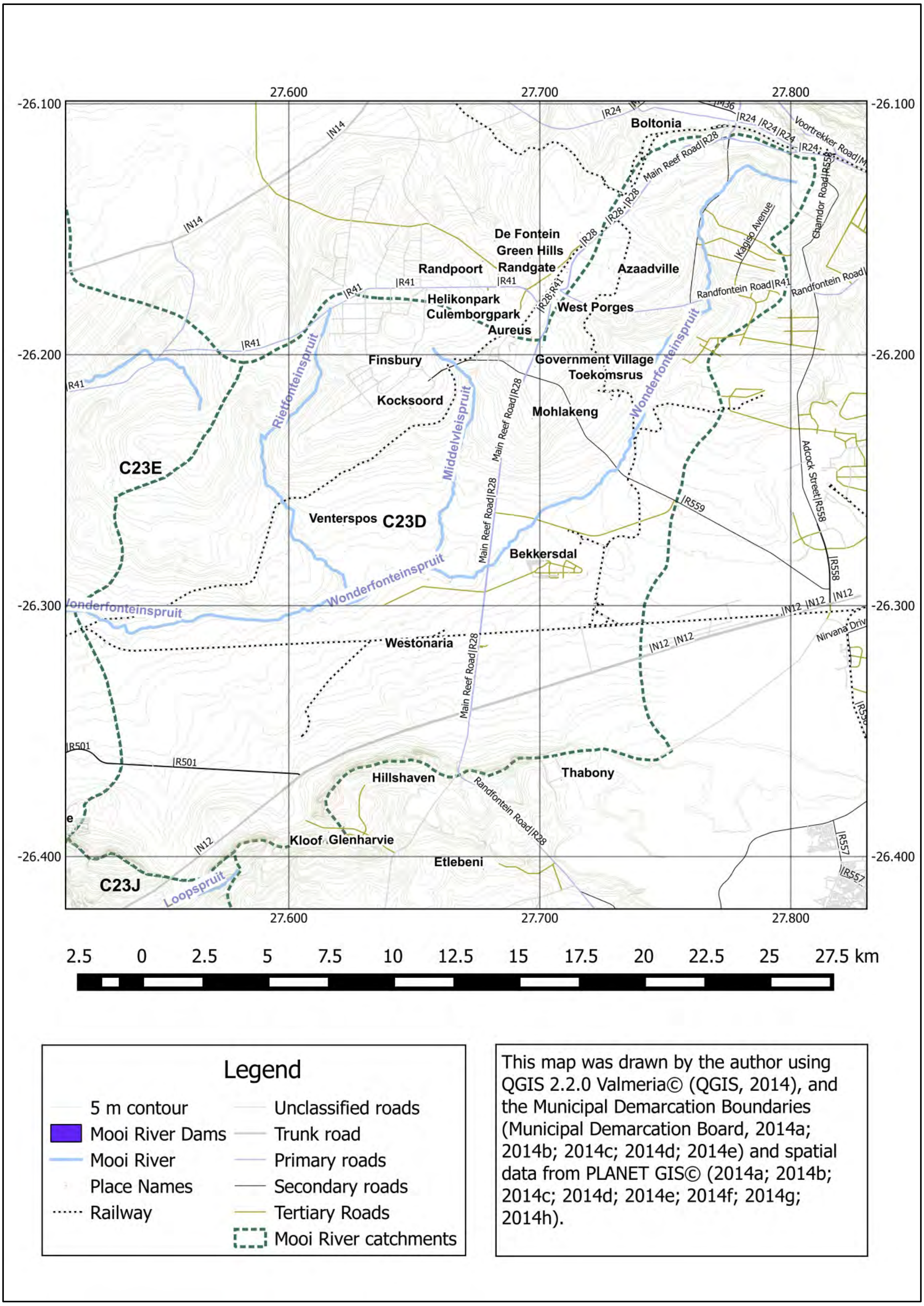
Appendix A



Map A 1: Map of the Mooi River Catchment



Map A 2: The Catchment area of the Tlokwe Local Municipality



Map A 3. The C23D Catchment Area

Appendix B

Appendix B

Appendix B Table 1: Functional areas constitutionally assigned to different spheres of government in Schedule 4 (Act 108 of 1996).

Table 1: **Only functional areas related to the effective management of a disaster are listed.** ***(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)***					
Key Used					
Role in effective disaster risk management **A**: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery; **Rel**: Relief; **R/D**: Reconstruction & Development					
Disaster risk potential **DRP**: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential					
Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
Disaster Management	**A;M; EWS; P; RRR; Rel; R/D**	**DRRP**			
Agriculture	**A;M; P; EWS;**	**DRP; DRRP**			

Table 1:

Only functional areas related to the effective management of a disaster are listed.

(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)

Key Used

Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
	R/D				
Airports other than international	**A;M; EWS; P; RRR; Rel; R/D**	**DRP; DRRP**	Municipal Airports	**A;M; EWS; P; RRR; Rel; R/D**	**DRP; DRRP**
Animal control & Diseases	**A;M; P; EWS; R/D**	**DRP; DRRP**			
Environment	**A;M; P; EWS; R/D**	**DRP; DRRP**			
Health Services	**A;M; P; EWS; RRR;R/D**	**DRP; DRRP**	Municipal Health Services	**A;M; P; EWS; RRR; R/D**	**DRP; DRRP**
Housing	**A;M; P; EWS;**	**DRP; DRRP**			

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Only functional areas related to the effective management of a disaster are listed.

(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)

Key Used

Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
	R/D				
Police	**A;M; P; RRR; EWS; R/D**	**DRRP**			
Pollution Control	**A;M; P; EWS;**	**DRP; DRRP**	Air Pollution	**A;M; P; EWS; R/D**	**DRP; DRRP**
Population Development	**A;M; EWS; P; RRR; Rel; R/D**	**DRP; DRRP**			
Public Transport	**A;M; P; EWS; R/D**	**DRP; DRRP**	Municipal Public Transport	**A;M; P; EWS; R/D**	**DRP; DRRP**

Table 1:

Only functional areas related to the effective management of a disaster are listed.

(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)

Key Used

Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
Public works in respect of provincial needs	**A;M; P; EWS; R/D**	**DRP; DRRP**	Municipal Public Works	**A;M; P; EWS; R/D**	**DRP; DRRP**
Regional Planning & Development	**A;M; EWS; P; RRR; Rel; R/D**	**DRP; DRRP**	Municipal Planning	**A;M; EWS; P; RRR; Rel; R/D**	**DRP; DRRP**
Soil Conservation	**A;M; P; EWS; R/D**	**DRP; DRRP**			
Urban and Rural Development	**A;M; EWS; P; RRR; Rel; R/D**	**DRP; DRRP**			
Welfare Services	**A;M; P; EWS;**	**DRP; DRRP**			

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Only functional areas related to the effective management of a disaster are listed.

(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)

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Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
	R/D				
Education	**A;M; P; EWS; R/D**	**DRP; DRRP**			
			Fire fighting	**A;M; P; RRR; EWS; R/D**	**DRRP**
			Building Regulations	**A;M; P; EWS; R/D**	**DRP; DRRP**
			Child Care Facilities	**A;M; P; EWS; R/D**	**DRP; DRRP**
			Gas &	**A;M; P; RRR; EWS; Rel; R/D**	**DRP; DRRP**

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(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)

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Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
			electricity reticulations		
			Storm water drainage	**A;M; P; RRR; EWS; R/D**	**DRP; DRRP**
			Water & sanitation services limited to potable waters supply systems and domestic waste	**A;M; P; RRR; EWS; Rel; R/D**	**DRP; DRRP**

Table 1:

Only functional areas related to the effective management of a disaster are listed.

(The table was developed by the author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.)

Key Used

Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of concurrent National Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 4 Part A: Functions			Schedule 4 Part B: Functions		
Functional Area	Role in effective disaster risk management	Disaster risk potential	Functional Area	Role in effective disaster risk management	Disaster risk potential
			water sewage disposal systems		

Appendix B Table 2: Functional area constitutionally assigned to different spheres of government in Schedule 5(Act 108 of 1996)

Table 2

Only functional areas related to effective disaster management are listed

(The table was developed by the Author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.

Key Used

Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Functional Areas of exclusive Provincial Legislative competence Assigned by The South African Constitutional (Act 108 of 1996). In Accordance with section 125			Functions assigned to the local government by the Constitution (Act 108 of 1996). In accordance with section 155 (6) (a) and (7).		
Schedule 5 Part A: Functions			Schedule 5 Part B: Functions		
Functional Area	**Role in effective disaster risk management**	**Disaster risk potential**	Functional Area	**Role in effective disaster risk management**	**Disaster risk potential**
Abattoirs	**A;M;P**	**DRP; DRRP**	Municipal Abattoirs	**A;M;P**	**DRP; DRRP**
Ambulance	**A;M;P;EWS;RRR; Rel**	**DRRP**			
Provincial Planning	**A;M; P; EWS; R/D**	**DRP; DRRP**			

Table 2

Only functional areas related to effective disaster management are listed

(The table was developed by the Author using the functional areas assigned to each level of government, and then identifying the possible aspects of disaster management that can be associated with each function and potential risk that can be associated with each function.

Key Used

Role in effective disaster risk management

A: Avoidance; **M**: Mitigation; **EWS**: Early Warning Systems, **P**: Preparedness; **RRR**: Response Rescue Recovery;

Rel: Relief; **R/D**: Reconstruction & Development

Disaster risk potential

DRP: Disaster Risk Potential; **DRRP**: Disaster Risk Reduction Potential

Provincial roads & traffic	**A;M; P; EWS; RRR; Rel; R/D**	**DRP;DRRP**	Municipal Roads	**A;M; P; EWS; RRR; Rel; R/D**	**DRP;DRRP**
Provincial recreation and amenities	**A;M;P; EWS; RRR; Rel**	**DRP; DRRP**	Local Amenities	**A;M;P; EWS; RRR; Rel**	**DRP;DRRP**
			Cemeteries , funeral parlours and crematoria	**P;RRR, R/D**	**DRP;DRRP**
			Cleansing	**RRR; R/D**	**DRP;DRRP**
			Fences and Fencing	**A;M;**	**DRP; DRRP**
			Refuse removal , refuse dumps and solid waste disposal;	**A;M;P; EWS; RRR**	**DRP;DRRP**
			Municipal parks and recreation	**A; M; P; EWS; RRR; Rel; R/D**	**DRP;DRRP**
			Traffic and parking	**A;M;P; EWS; RRR; Rel**	**DRP;DRRP**

Appendix B Table 3: The link between the Millennium Development Goals (MDG) and the Bill of Rights

Table 3		
The link between the Millennium Development Goals (MDG) and The Bill of Rights (UN, 2012: 8 -67; South African Constitution Act 108 of 1996; UN General assembly: 2000)		
MDG	MDG And Target	The Fundamental Right in The Bill of Rights (Act 108 of 1996)
1	Eradicate extreme poverty and hunger Target 1 - Halve between 1990 and 2015, the proportion of people whose income is less than one dollar a day Target 2 - Halve between 1990 and 2015 the proportion of people who suffer from hunger	Section 27(Right to health care , food, water and social security) & Section 28 (Right of the child)
2	Achieve Universal Primary education Target 3 - Ensure that by 2015, children everywhere , boys and girls alike, will be able to complete a full course of primary schooling	Section 28 (Rights of the child) & Section 29 (Right to education)
3	Promote gender equality and empower women Target 4 - Eliminate gender disparity in primary and secondary education preferably by 2005 and to all levels of education not later than 2015	Section 9 (Equality) (& Section 29 (Right to education)
4	Reduce child mortality Target 5 - Reduce by two thirds between 1990 and 2015 the under 5 mortality rate.	Section 27 (Right to health care, food , water and social security) & Section 28 (Right of the child)
5	Improve maternal health Target 6 - Reduce by three quarters between 1990 and 2015 the maternal mortality ratio.	Section 9 (Equality)& Section 27(Right to health care, food, ware and social security).

Table 3		
The link between the Millennium Development Goals (MDG) and The Bill of Rights (UN, 2012: 8 -67; South African Constitution Act 108 of 1996; UN General assembly: 2000)		
6	Combat HIV/AIDS and other diseases Target 7 - Have halted by 2015 and begun to reverse the spread of HIV/ AIDS Target 8 - Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.	Section 9 (Health), Section 10 (Right to human dignity), Section 11(Right to life) & Section 27 (Right to health care, food, water and social security).
7	Ensure Environmental sustainability Target 9 - Integrated the principles of sustainable development into country policies and programmes and reversed the loss of environmental resources. Target 10 - Halve by 2015 the proportion of people without sustainable access to safe drinking water. Target 11 - By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers.	Section 24 (Right to an environment that is not harmful to their wellbeing and to have the environment protected for present and future generations) , Section 26(Right to housing) & Section 27 (Right to food, water and social security)

Appendix C:

Appendix C1: Biological Hazards

1. Biological Hazards

Biological hazards are potential hazards resulting from living organisms and those that result from toxins and/or disease produced by bacteria, viruses, algae, fungi and parasites. These hazards are discussed in more detail below.

Bacteria: Some bacteria are highly contagious and can be spread through contaminated drinking water, water polluted by human and animal faecal and other waste, and in some instance can even be found in groundwater. Good sanitation, individual hygiene and treatment of water by boiling and use of bactericide such as chlorine can prevent and stop the spread of these bacteria. Concentrated populations with poor sanitation are more susceptible to epidemic outbreaks. The illnesses can result in the infected population becoming more vulnerable to other potential hazards. Example of typical bacteria epidemics are the regular cholera out breaks in Southern and South Africa. The 2001 cholera outbreak in Kwazulu Natal had recorded 12000 infections and 50 deaths by 2 January 2001(Barrow, 2001:Online); by 12 January 2001 it had spread to six provinces. The total deaths numbered 64 and the total infections numbered 18000 (BBC News, 2001:Online). The 2008 outbreak started in Zimbabwe and later spread to South Africa. By 2010, there were 98741 infections and 4,293 deaths reported in Zimbabawe. By December 2008, Vhembe district of Limpopo was declared a disaster area (Doctors Without Borders, 2009:Online) .In December 2008, it was found that the eastern part of the Limpopo river between Zimbabawe and South Africa tested positive for cholera (Gabara, 2008:Online). By January 2009, 15 deaths had been recorded in South Africa, and the number of cases were 2100 (AFP, 2009:Online). What is of a great concern is that when we have a Local Municipality with a blue drop status for water and faring well with green drop status, such as Tlokwe, certain parts of the community are still being exposed to leaking sewage (Boqo, 2012:5). Below are a few bacteria that must be taken into consideration when considering an effective disaster prevention system. As above, some of these bacteria epidemics themselves can have disastrous consequences, while some can be potential secondary hazards that could follow a primary hazardous impact such as flooding. A few of the common water borne bacteria, and there symptoms are provided in Table 1 below.

Appendix C1 Table 1: Water Borne bacteria

Organism	Symptoms	Comments	Reference
Camhylobacteria jejuni.	(Bloody) Diarrhoea.	Incubation period is 2 - 5 days. Incubation period is important in that the longer the period the further the infection can spread before the symptoms are manifested.	DOH 2011:18.
Enterhemorrhagic (E Coli 0156:H7 and other).	(Bloody) Diarrhoea.	Incubation period is 1 -10 days.	DOH 2011:19 Grosset,1997:43.
Enterotoxigenic (E Coli ETEC).	Diarrhoea and vomiting.	Incubation period is 6 to 48 hours.	DOH 2011:19.
Enteropathogenic (E. Coli EPEC).	Diarrhoea.	Incubation period is variable.	DOH 2011:19.
Enteroinvasive (E Coli EPEC).	(Bloody) Diarrhoea.	Incubation period is variable.	DOH 2011:19.
Salomenella Typhi.	Fever, headache sometimes Diarrhoea.	Incubation period is 7 to 14 days.	DOH 2011:20.
Shingella spp.	(Bloody) Diarrhoea.	Incubation period is 12 hours to 60 days - can be found in water with faecal matter..	DOH 2011:21.
Vibrio Cholerae.	Watery Diarrhoea and vomiting.	Incubation period is 1 to 5 days.	DOH 2011:22.
Yeresinia	Diarrhoea	Incubation period is 1 to 10	DOH

Appendix C1 Table 1: Water Borne bacteria			
Organism	Symptoms	Comments	Reference
entercolitica		days.	2011:22

Protozoa that are parasitic, these include the enteric protozoa (of which one of the major symptoms is diarrhoea) that are water borne, found in infested drinking water and recreational water that is infested, often by faecal waste that contains the infective stage of the parasite's life cycle. In its infective phase as oocytes or cysts, chlorine and iodine do not seem to have an impact on these parasites. Boiling and use of filters that will prevent the parasite from entering drinking water sources are the most effective means to purify contaminated water. These can manifest themselves as secondary hazards and all can cause diarrhoea. A few of the common parasites are provided Table 2 below**.**

Appendix C1 Table 2: Protozoa			
Organism	Symptoms	Comments	Reference
Cryptosporidiu m pravum.	Diarrhoea and vomiting (Disease: Cryptosporidiosis).	In the infective stage of the life cycle, as a sporulated oocyst it can infect drinking and recreational water.	DOH 2011:23 & CDC, 2011.
Cyclospora cayetanensis.	Diarrhoea.	In the infective stage of the life cycle non-infective Oocytes are shed in faecal matter, where drinking of the infected water can result in the oocyte infecting the gastro intestinal lining.	DOH 2011:23, CDC, 2010a & CFIA, 2012.
Entamoeba histolicitia.	(Bloody) Diarrhoea. Disease: Amebiasis - Worldwide the infection rate is between 40 -50	Either cysts or trophozoites are released in faecal matter. The parasite is spread by the faecal contaminated mediums	DOH 2011:23 & CDC, 2010b

Appendix C1 Table 2: Protozoa			
Organism	Symptoms	Comments	Reference
	million and there are annually approximately 40 000 deaths. Higher prevalence is found in developing countries and those with HIV (Ngata, *et al.*, 2012:717).	including water. The encystations occur in the small intestine from where the trophozoites migrate to the large intestine.	
Giardia lambila.	Disease caused is giardiasis of which diarrhoea is one of the symptoms. It is estimated that approximately 20% of the world population is chronically affected and in the US it is one of the most widespread water borne parasites (Mark & Anad, 2012).	The cysts are released in faecal matter. The parasite is spread by faecal contaminated mediums including water.	DOH 2011:23. Mark & Anad, 2012.

Viral: More than 100 species of viruses can be found in sewage. The diseases that can be caused include hepatitis, polio, meningitis and gastroenteritis. Viral matter of between 10^5 and 10^{11} can be found in one faecal stool of an infected person (Bosch, 1998:191). The virus in faecal matter (in the case of faecal matter been deposited on the ground), as disposed solid waste as untreated sewage can reach both ground and surface by land run-off and other point sources, exposing humans to infected water that may be used for agriculture, drinking and recreational purposes (Bosch, 1998:193). Norwalk virus is an example of a virus that has been associated with swimming in lakes and pools (Hedberg & Osterholm, 1993:205).It should be noted that many waterborne viruses are resistant to boiling, changes in pH, disinfectants and therefore water that conforms to bacterial standards can remain contaminated by certain types of viruses (Taylor, 2011:209), implying that water that has not specifically been treated for viral contamination can remain contaminated. In respect of disaster risks, lack of sanitation and raw sewage can assist in the spread of the disease. The importance of good water treatment, hygiene and good sanitation must be emphasized if a viral outbreak is to be prevented or reduced in respect of water borne viruses. A few viruses that can be transmitted by infected water mainly because of contamination by infested faeces are provided Table 3 below.

Appendix C 1 Table 3: Viruses			
Organism	Symptoms	Comments	Reference
Human rotavirus (HRV) Human Caliciviruses (HuCV), Saproviruses (Sav) Human Astro Viruses (HastV's) 7 Enteric Adeno viruses, & Noro viruses.	Gastroenteritis.	The enteric viruses are the most infectious and are released in large numbers. During the active phase of the disease faecal contamination of water and food sources are increased.	Taylor, 2011:207.
Hepatitis A viruses (HAV) & Hepatitis E viruses (HEV).	Hepatitis.	The virus can be spread by matter contaminated by infected faeces.	Taylor, 2011:207 and Geddes & Grosset, 2007:84-85 & CDC, 2008.
Polio Virus.	Polio.	The virus can be spread by	CDC, 2012

Appendix C 1 Table 3: Viruses			
Organism	Symptoms	Comments	Reference
		matter contaminated by infected faeces.	&Taylor, 2011:208.

Algae Blooms. In South Africa many water impoundments are found that can be contaminated by poorly and untreated sewage effluent and phosphates and other fertilisers used for agriculture purposes that gives rise to eutrophication (Pindihama *et al.*, 2011:1984, Harding, 2006:1; Oberholtser *et al.*, 2005:86, O'Keeffe *et al.*, 1994:287), Eutrophication is the process of nutrient enrichment, for example increase of Phosphates (O'Keeffe *et al*., 1994:286-287), and this gives rise to an environment that is suitable for the accelerated growth of algae that can results in a alga bloom. In South Africa, the species responsible for these blooms include cyanobacteria the blue/green algae. The excess algae can deplete the oxygen carrying capacity of water, accelerate eutrophication, block water plant filters and produce toxins, in general effecting sensitive ecosystems. The toxins produces include hepatoxin (Microcystins, nodularins & cylindrosermopsins) that affect the liver, neurotoxins (anatoxins and saxitoxins) that depress the function of the nervous system, and dermatoxin (lyngbyatoxin & aphlysiatoxia) hat influence the skin (Oberholster *et al.*, 2005:57-60). Although the organism can be destroyed it is the toxins that can cause acute poisoning in humans and deaths in animals (Pindihama *et al*., 2011:19885). It is difficult to remove the toxins from water through normal water treatment methods (Pindihama *et al.*, 2011; Harding, 2006:I; Oberhololtser *et al*., 2005:86). Pindihama *et al*., (2011: 19884) recommend slow sand filtrate, coagulation, membrane filtration, activated carbon, ozonation, nano- and reverse osmosis as the most effective methods to remove the toxins (Pidihama *et al*., 2011:19886). Pidihama *et al.*, (2011:19885) are experimenting with macrophytes (Nynphea nouchalia - blue lily and Persicaria decioens - slender knotweed as means for bioremediation of cytobacterial and toxins. The Ney York State department of conservation (2014:Online) and department of health (2014:Online), advise that boiling water, disinfectant such as chloride, UV treatment, and normal filtration may not be sufficient to protect humans from toxin when ingesting water. Although no human fatalities have been reported in South Africa, stock and game losses have been recorded (Pindihama *et al.,* 2011:9888; Harding, 2006:I; Oberholster *et al., 2005*). Algae blooms have the potential to produce enough toxins in water that is used by livestock to cause significant losses. The potential chronic effects of the toxins cannot be disregarded. This potential to cause livestock losses, and significantly affecting communities livelihoods, requires that these toxins be considered as a potential hazard.

Appendix C2:

2. South African National Standards for water quality SANS 241-2:2011

Department of water affairs in South Africa, has introduced water safety planning, a WHO concept, to ensure that all possible risks are managed to ensure the continued supply of safe drinking water (Department of Water Affairs-MILES, 2012:5,6). The performance measure and planning systems do not focus only on water quality standards; they focus on other standards that include customer services, institutional effectiveness, financial performance and asset management and water user efficiency (Department Of Water Affairs - MILES, 2012:8). The planning process makes provision for risk assessment and evaluation that includes operational monitoring and compliance monitoring (Department Of Water Affairs-MILES, 2012:10-11).

From the perspective of the management of the potential risk of disaster, it provides for the identification , assessment and monitoring of potential risks affecting water quality as well as process that would reduce water wastage (water quantity), within the water processing system. This process monitors the primary source of the water, prior processing of water by the water processing point, and the final water output from the system that is used by the consumers. In the process, a set of standards to assess the quality of water and the system process is included (Department Of Water Affairs-MILES, 2012:8; De Souza, 2012:20). The set of standards used is the SANS 241-1, 2011 and SANS 241-2, 2011 (Department Of Water Affairs-MILES, 2012a:13; Department Of Water Affairs-MILES, 2012:1-40; Swart, 2012:1-7, Department Of Water Affairs-MILES, 2011:1-3; De Souza, 2012) are for microbiological, physical aesthetics and chemical determinants, while the water safety planning and plan make provision for both hazard and risk assessment and identification, and critical control points which are steps or procedures at which controls can be applied, and hazards can be eliminated, prevented or reduced to acceptable levels (De Souza, 2012:8,20,20-32). The potential water hazards include firstly those that can result in acute impact on human health, secondly those that can result in chronic health effects in human, and thirdly organic or radioactive nuclide pollutants (Swart, 2012:3). Where water quality and quantity standards are not covered by SANS 241-1, 2011 and SANS 241-2, 2011, World Health Organisation standards are to be use.

Some of the possible shortcomings are outlined below.

- The handling storage and traditional use of water from communal taps. For example the tradition of certain ethnic groups to wash hands in the same containers at a funeral can increase the likely spread of E.Coli.
- The security of secondary and tertiary water reservoirs for treated water on the distribution points. For example, if access is possible to these reservoirs, or they are not secure they can become polluted by biological agents, toxins and chemicals.
- The heavy material can go into solution when the pH is low and may result in existing sediment with heavy metals within the reticulation system becoming dissolved and reaching unacceptable levels.
- The material used in part of the reticulation system may increase the release of toxic chemicals like lead from existing lead pipes within the reticulation system.
- When leaks within the reticulation system occur, polluted water and in some instances sewage can become part of the water in the reticulation system.
- The ability of present water treatment processes to eliminate all viruses, biological toxins must be taken into consideration.
- The effect of water quality resulting from a reduced reduction of water, leading to concentrate been formed and water reservoirs unable to cope with demands.

- The possible of pollutants in flood water to mix with processed water,
- Clarity on what is the primary water source, for example in the case of Tlokwe Local Municipality is it the east and west bank canals, or is it the first primary storage reservoir Boskop dam or both.
- The complication with the monitoring of groundwater sources that are used as primary sources of water.
- Does not provide an indication of possible creeping hazards, for example primary water resource becomes no longer suitable for human consumption as the result of heavy metal pollution over a long term.
- Does not provide for the consequences of sabotage and civil unrest where the articulation system and water processing plant can be targeted and destroyed
- Does not provide for the precautions to be taken if the access to sustainable safe potable water supply was suddenly reduced.

Despite the above concerns the water safety planning is arguably an integrated approach to identifying the potential hazards that can effect potable water quantity and quality. Therefore the SANS 241:2011 standards will be used as base lines in the study. The benefit of the guideline is where values do not exist the existing WHO standards (See WHO, 2012 (on pharmaceuticals in drinking water); WHO, 2011(Guidelines for drinking waters); on WHO, 2009 (on Water Safety Plan)) that can be used. The SANS 241, 2011 and 2006 is provide in the table below. The standards simplify hazard identification and rating, in that the quality meets or is better than the standard or it exceeds the standard and is no longer acceptable.

Appendix C2 Table: 1 SANS 241, 2011 Standards

Determinant	Risk	Unit	2011 Standard limit	2006 standard limit
Aluminium (Al)	Health	µg/L		< 300
Ammonia (N)	Operational	mg/L		< 1,0
Antimony (Sb)	Health	µg/L		< 10
Arsenic (As)	Health	µg/L		< 10

Appendix C2 Table: 1 SANS 241, 2011 Standards				
Determinant	Risk	Unit	2011 Standard limit	2006 standard limit
Bromodichloromethane		µg/L	≤ 0.06µg/L	
Bromoform		µg/L	≤0.1 µg/L	
Cadmium (Cd)	Chronic health	µg/L	≤ 3 µg/L	≤5 µg/L
Calcium (Ca)	Aesthetic/operational	mg/L		< 150
Chloride (Cl)	Aesthetic	mg/L		< 200
Chloroform		µg/L	≤ 0.3 µg/L	
Cobalt (Co)	Health	µg/L		< 500
Colour	Aesthetic	Pt		< 20
Conductivity	Aesthetic	mS/m	≤ 170	
Conductivity at 25 °C	Aesthetic	mS/m		< 150
Copper (Cu)	Health	µg/L		< 1 000
Cyanide (recoverable CN)	Health	µg/L		< 50
Dibromochloromethane		µg/L	≤ 0.1 µg/L	
Dissolved organic carbon (C)	Aesthetic/health	mg/L		< 10
Fluoride as F	Health	mg/L		< 1,0
Free Chlorine	Chronic health	µg/L	≤ 5 µg/L	
Iron (Fe)	Chronic health aesthetic/ operational	µg/L	≤ 2000 µg/L	< 2000
Lead (Pb)	Chronic health	µg/L	≤ 10 µg/L	≤ 20 µg/L
Magnesium (Mg)	aesthetic/ health	mg/L		< 70
Manganese (Mn)	Chronic health ,aesthetic	µg/L	≤ 500 µg/L	< 100

Appendix C2 Table: 1 SANS 241, 2011 Standards				
Determinant	Risk	Unit	2011 Standard limit	2006 standard limit
Mercury (Hg)	health	µg/L		< 1 1
Microcystin	Chronic health	µg/L	≤ 15 µg/L	
Monochloramine	Chronic health	µg/L	≤ 3 µg/L	
Nickel (Ni)	Chronic health	µg/L	≤ 70 µg/L	≤ 150 µg/L
Nitrate	Acute health	mg/L	≤ 11 mg/L	< 10
Nitrite	Acute health	mg/L	≤ 0,9 mg/L	< 10
Odour	Aesthetic	TON		< 5 5
pH value at 25 °C	Aesthetic/operational	pH		5,0 – 9,5
Phenols	Aesthetic/health	µg/L		< 10
Potassium (K)	Operational/health	mg/L		< 50
Selenium (Se)	Chronic health	µg/L	≤ 10 µg/L	≤ 20 µg/L
Sodium (Na)	Aesthetic/health	mg/L		< 200
Sulphate (SO4)	Health	mg/L		< 400
Taste	Aesthetic	FTN		< 5 5
Total Chromium (CR)	Chronic health	µg/L	≤ 50 µg/L	≤ 100 µg/L
Total Chromium as Cr	Health	µg/L		< 100
Total Dissolved Solids (TDS)	Aesthetic	mg/L	≤1200	< 1 000
Total trihalomethanes	Health	µg/L		< 200
Turbidity	Aesthetic/operational indirect health	NTU		< 1
Uranium (U)	Chronic health	µg/L	≤ 15 µg/L	
Vanadium (V)	Health	µg/L		< 200

Appendix C2 Table: 1 SANS 241, 2011 Standards				
Determinant	Risk	Unit	2011 Standard limit	2006 standard limit
Zinc (Zn)	Aesthetic/health	mg/L		< 5,0

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Appendix C3: Acid Mine Drainage

3. AMD (Acid Mine Drainage)

In 2002, approximately 7 -13.5 million litres per day of AMD water started decanting from an abandoned mine near Krugersdorp (Pratt & Hobbs, 2011:Online; Hobbs & Cobbing, 2007a:Online), having a significant impact on the environment, and resulted in a 16000 cubic meter void in the calcium carbonate rock near the Cradle of Humankind world heritage site. (Pratt, 2011:Online).

AMD is one of the single most important threats to the environment (Naidoo, 2007), and arises primarily when mineral pyrites (fool's gold or iron disulphide), comes into contact oxygenated water, converting it into an acidic water that has an increased solubility for heavy metals including Uranium increasing the toxicity of the water (Pratt, 2011; McCarthy, 2011).

It is commonly associated with the gold deposits in the Witwatersrand and is formed during the mining process. Through the process where mineral pyrites ("fools gold" or iron disulphate) comes into oxygenated water. This gives rise to a chemical reaction where the Metal Sulphide reacts with oxygen and water resulting in acid and metal in accordance with the formulae provided below.

$$\mathbf{2FeS^2 + 70^2 + 2H_20 \longrightarrow 2Fe^2 + 4S0_4 + 4H^+}$$

(Pyrite reacts with oxygen and water to produce ferrous iron and sulphate (**$2H_2SO_4$** sulphuric acid)).

$$\mathbf{FeS_2 + 14Fe^{3+} + 8H_20 \longrightarrow 15Fe^{2+} + 2S0_4^{2-} + 16H^+}$$

(Pyrite, Ferric iron and water react to produce, ferrous iron and sulphate (**$4H_2SO4$** Sulphuric acid)).

(Coil *et al.*, 2012; McCarthy, 2011; Gates and Blauvelt, 2011:1; Robertson and Shaw, 1999:3)

During mining extensive fragmentation of rocks occur, results in the increase of the surface area that can be exposed to oxygen and water, thereby increasing the ability to produce more acids.

As the pH of the water decreases becomes more acidic the solubility of heavy metals including Aluminium and Uranium increase, thereby increasing the toxicity of the water.

Gold bearing rock when exported to the surface goes through a reduction process to extract gold. The remaining crushed rocks are placed in heaps as slime dams or tailings, with a pyrite content of approximately 3%. Rainwater falling on the dumps oxidises the pyrites to form sulphuric acid, decreasing the pH of the water and increasing the toxicity of the runoff, causing diffuse pollution (Coil *et al.*, 2013).

Water is continuously seeping into the mining void through fissures, faults, the shaft itself etc., to prevent flooding this water is continuously pumped out and often treated, when mining stops, pumping stops, the water level rises, flooding the mine and latter decanting on the surface as AMD polluted with heavy metals, becoming point source pollution (McCarthy, 2011).

Water are treated by functioning mines using, lime to ↑ (increase) the pH and aerating the water with oxygen, the pyrites then oxidises, and flocculants cause the Fe with the heavy metals to precipitate, once the precipitation is dried it is disposed of on the tailings. The remaining treated water is clear, with a neutral pH, high in sulphate concentrate, has a high TDS and it is then discharged into exiting water system, thereby becoming a point of diffusion (McCarthy, 2011).

The acidic water can be neutralised by Calcium Carbonate in the dolomite (Robertson and Shaw, 1999:3).

From a disaster risk management perspective, firstly AMD can have a devastating effect on the environment. Secondly, as heavy metals including Uranium and Aluminium can be dissolved in the water at low pH, the toxicity of water will be increased. The reaction of dolomite ($CaMg(CO_3)$) ,Calcite ($CaCO_3$) or Magnesite (MgCO3) with the acid water to neutralise the pH can result in large voids be formed as the dolomite (Calcium Magnesium Carbonate) is dissolved.

The above demonstrates that the AMD can impact on dolomite in the next section sinkholes related with dolomite is discussed.

Appendix C4: Sinkhole and subsidence hazards

4. Sinkholes and subsidence's

Large dolomite aquifers underline large portion of the Mooi River between Klerkskraal Dam and Boskop Dam, the Wonderfontein Spruit water catchment that is one of the major tributaries of the Mooi River. The dolomite is composed of $CaMg(CO_3)2$, calcite ($Ca(H_2CO_3)$ and magnesite ($Mg(H_2CO_3)$), and can under the right conditions dissolve in the presence of H_20 (water) and $C0_2$ (carbon dioxide) (which forms a weak carbonic acid (H_2CO_3)) (DOWA, 2009:6; Heath, 2008:5; DOPW, 2003:1). In nature and in the absence of any major events, this process is slow, taking millions of years before erosion, subsurface solution cavities and caves are formed DOWA, 2009:4)

The process begins when water percolates through faults, fissures etc. into the sub surface dolomite causing erosion as the carbonic acid dissolves the dolomite, leaving large cavities below the ground surface with the potential of collapsing and forming sinkholes. The process of sinkhole formation can be triggered by surface water seepage (e.g. leaking water bearing services, including sewage and storm water systems) eroding the soil covering the dolomite rock and carrying material down into the underlying cave system, which breaks through "cave-ins" to the surface to cause a sinkhole (DOPW, 2003:2). Sinkholes can also form when the groundwater level is lowered (e.g. though boreholes, through mine dewatering) and this lower pore water pressure lowers ground bearing capacity (DOPW, 2003:2). The sinkhole can be from 1 to 100m in diameter and between 1m to 150m deep (DOPW, 2003:2). These can be very devastating when they occur, for example at least 59 people have known to have died, the estimated damage to date (for the last 50 years) is approximately R1.3 billion, and it cost approximately R200 000 to repair a sinkhole (excluding structural damage) (Heath, 2008:1) For example, in December 1962 a three story crusher plant disappeared in a sinkhole with no survivors (De Bruyn & Bell, 2005).

According to SANS 1936-2 (2011:4) dolomite risk management strategy is a process of using scientific planning, engineering, processes, procedures and measures to manage an environmental hazard, and encompasses policies and procedures set in place to reduce the risk of events (sink holes and subsidence's) occurring on dolomite land. A sinkhole is a feature that occurs suddenly and manifests itself as a hole in the ground, and a subsidence is a shallow, enclosed depression.

According to SANS 1936-2 (2011:6-7), the process is to first identify and quantify any hazards that might impact on the development of the land. Secondly, determine inherent hazard classes on the site (See table 4.1 & table 4.2).

Appendix C4 Table 4.1 Inherent Hazard category	
Category	Ground movement events anticipated per hectare in 20 year
Low	0 to 0,1 events: Return period of an event occurring in an area of 1 ha is greater than 200years
Medium	0,1 to 1 event: Return period of an event occurring in an area of 1 ha is between 200 and 20 years
High	> 1 event: Return period of an event occurring in an area less than once in 20 years.
Reference	SANS 1936-2:13; DOPW, 2003:3; Buttrick *et al.*, 2001:31

***Appendix C4 Table 4.2. Inherent Hazard Class (H =High, M= Medium, L=Low*)**						
Inherent Hazard Class	Small Sinkhole	Medium Sinkhole	Large Sinkhole	Very Large Sinkhole	Subsidence	Residential type & density
	<2m	2 m - 5m	5m -15 m	> 5m		
1	L	L	L	L	L	Residential, including cluster, high rise (60 units/ha)
2	M	L	L	L	M	Residential, including cluster, high rise (40 units/ha)
3	M	M	L	L	M	Selected residential - up to 18 units/ha

Appendix C4 Table 4.2. Inherent Hazard Class (H =High, M= Medium, L=Low)						
Inherent Hazard Class	Small Sinkhole	Medium Sinkhole	Large Sinkhole	Very Large Sinkhole	Subsidence	Residential type & density
	<2m	2 m - 5m	5m -15 m	> 5m		
4	M	M	M	L	M	Selected residential up to 18 units/ ha
5	H	L	L	L	H	Selected residential up to 10 units /ha
6	H	H	L	L	H	No residential development l
7	H	H	H	L	H	No residential development
8	H	H	H	H	H	No residential development
References	SANS 1936-2:14; Kirsten *et al.*, 2009:1024;Buttrick *et al.*, 2001:32					

Thirdly, this is followed by the determination of an appropriate dolomite designation area. (See Table 4.3)

Appendix C4 Table 4.3 Dolomitic Area Designation		
Designation	Description	Inherent Hazard class
D1	No precautionary measures	
D2	General precautionary measures to prevent concentrated ingress of water into the ground.	Class 1,2 ,3*,4*
D3	Additional precautionary measure to those pertaining to ingress of water into ground are required	Class 3,4,5*
D4	Risk of such a nature that no building can take place	Class 5,6,7,8

Appendix C4 Table 4.3 Dolomitic Area Designation		
Designation	Description	Inherent Hazard class
References	Buttrick *et al.*, 2001:33	
*	Depends on sub surface condition or stand density	

Fourthly select and design the appropriate foundations, structures and infrastructure according to the inherent hazard class (See table 4.3 above).

Fifthly, determine the precautionary measures to be taken (see table 4.3) above.

Sixthly, determine the risk management required to achieve and sustain a tolerable hazard rating.

The above hazard classification is complex, in the Dolomite hazard score card presented by Coetzee *et al.*, (2012:7) group their inherent risk classes into three hazard levels (See table 4.4):

Appendix C4 Table 4.4 Dolomite Hazard Scorecard (according to Coetzee et al.; 2012:7)		
Inherent dolomite risk class	Class	Risk Score
Class 1-2	Low	1
Class 3-4	Medium	2
Class 5 -8	High	3

The above is significant from a disaster risk perspective in that large portions of the upper Mooi River and Wonderfontein Spruit and part of the Tlokwe town area lie above dolomite, and secondly the impact of groundwater dynamics on the dolomite is unknown.

Appendix D:

Appendix D: List of digital maps used

List of digital maps used

Table D.1 Digital Maps Used in the study			
Source	**Last Access Date**	**Web Site**	**List Of map related files used in the study (with date of creation) It should be noted that in many instance various digital maps were used to assist in determining the accuracy of the spatial layers, and to determine where changes have occurred.**
Department of Water Affairs	23 October 2010	www.dwaf.gov.za/iwqs/gis_data/river/rivs500k.html	2002/09/17 10:42 AM dprimdrainage.meta 2002/09/17 10:40 AM dsnddrainage.meta 2002/09/17 10:39 AM dterdrainage.meta 2010/10/24 07:44 PM dwaf1.txt 2008/09/10 01:18 PM sde_other_SDE_dprim_conv.dbf 2008/09/10 01:18 PM sde_other_SDE_dprim_conv.prj 2008/09/10 01:18 PM sde_other_SDE_dprim_conv.sbn 2008/09/10 01:18 PM sde_other_SDE_dprim_conv.sbx 2008/09/10 01:18 PM sde_other_SDE_dprim_conv.shp 2008/09/10 01:18 PM sde_other_SDE_dprim_conv.shx 2010/04/11 09:58 PM sde_other_SDE_dprim_conv.zip 2008/09/10 01:18 PM sde_other_SDE_dsec_conv.dbf 2008/09/10 01:18 PM sde_other_SDE_dsec_conv.prj 2008/09/10 01:18 PM sde_other_SDE_dsec_conv.sbn 2008/09/10 01:18 PM sde_other_SDE_dsec_conv.sbx 2008/09/10 01:18 PM sde_other_SDE_dsec_conv.shp 2008/09/10 01:18 PM sde_other_SDE_dsec_conv.shx 2010/04/11 10:01 PM sde_other_SDE_dsec_conv.zip 2008/09/10 01:18 PM sde_other_SDE_dter_conv.dbf 2008/09/10 01:18 PM sde_other_SDE_dter_conv.prj 2008/09/10 01:18 PM sde_other_SDE_dter_conv.sbn

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			2008/09/10 01:18 PM sde_other_SDE_dter_conv.sbx 2008/09/10 01:18 PM sde_other_SDE_dter_conv.shp 2008/09/10 01:18 PM sde_other_SDE_dter_conv.shx 2010/04/11 10:04 PM sde_other_SDE_dter_conv.zip 2008/05/13 09:55 AM watermanarea_2004.meta 2010/04/11 10:01 PM watermanarea_2004.zip 2010/10/21 10:26 PM water_layer1.zip 2003/12/05 11:03 AM wmadwaf.dbf 2003/12/05 11:03 AM wmadwaf.shp 2008/09/08 02:29 PM wmadwaf.shp.xml 2003/12/05 11:03 AM wmadwaf.shx
Planet GIS	23 October 2010	www.planetgis.co.za/download.php	010/10/18 03:12 AM SA-administrative.att 2010/10/18 03:12 AM SA-administrative.ent 2008/10/10 08:56 PM SA-administrative.fcz 2010/10/18 03:12 AM SA-administrative.idx 2010/10/18 03:12 AM SA-administrative.ldb 2010/10/18 03:12 AM SA-administrative.map 2007/08/28 11:35 PM SA-administrative.mdb 2008/12/02 04:15 PM SA-cadastral-new.map 2010/10/18 03:38 AM SA-cadastral.att 2010/10/18 03:38 AM SA-cadastral.ent 2008/10/10 10:33 PM SA-cadastral.fcz 2010/10/18 03:38 AM SA-cadastral.idx 2010/10/18 03:38 AM SA-cadastral.map 2008/09/25 02:26 PM SA-contours-20m.att 2008/09/25 02:26 PM SA-contours-20m.ent

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			2008/09/25 02:26 PM SA-contours-20m.idx 2008/10/09 06:46 PM SA-contours-20m.map 2008/10/27 07:48 PM SA-contours-20m.zip 2008/09/25 02:26 PM SA-contours-5m.att 2008/09/25 02:26 PM SA-contours-5m.ent 2008/09/25 02:26 PM SA-contours-5m.idx 2008/10/09 06:46 PM SA-contours-5m.map 2008/10/27 07:48 PM SA-contours-5m.zip 2008/09/25 01:36 PM SA-landsat7.att 2008/09/25 01:36 PM SA-landsat7.ent 2008/09/25 01:36 PM SA-landsat7.idx 2008/09/25 01:36 PM SA-landsat7.map 2010/10/20 10:52 PM SA-openstreetmap.att 2010/10/20 10:52 PM SA-openstreetmap.ent 2008/10/21 07:26 PM SA-openstreetmap.fcz 2010/10/20 10:52 PM SA-openstreetmap.idx 2010/10/20 10:52 PM SA-openstreetmap.map 2010/10/18 03:13 AM SA-places.att 2010/10/18 03:13 AM SA-places.ent 2008/10/10 08:57 PM SA-places.fcz 2010/10/18 03:13 AM SA-places.idx 2010/10/18 03:13 AM SA-places.ldb 2010/10/18 03:13 AM SA-places.map 2007/09/16 02:34 PM SA-places.mdb 2010/10/18 04:57 AM SA-roads.att 2010/10/18 04:57 AM SA-roads.ent

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Source	**Last Access Date**	**Web Site**	**List Of map related files used in the study (with date of creation) It should be noted that in many instance various digital maps were used to assist in determining the accuracy of the spatial layers, and to determine where changes have occurred.**
			2008/10/10 08:57 PM SA-roads.fcz 2010/10/18 04:57 AM SA-roads.idx 2010/10/18 04:57 AM SA-roads.ldb 2010/10/18 04:57 AM SA-roads.map 2007/05/27 12:20 AM SA-roads.mdb 2008/10/09 06:55 PM SA-topo50.map 2008/12/03 12:26 PM SA.map 2010/10/18 04:21 AM GP-contours-20m.att 2010/10/18 04:21 AM GP-contours-20m.ent 2008/10/10 09:30 PM GP-contours-20m.fcz 2010/10/18 04:21 AM GP-contours-20m.idx 2010/10/18 04:21 AM GP-contours-20m.map 2010/10/18 04:22 AM GP-contours-5m.att 2010/10/18 04:22 AM GP-contours-5m.ent 2008/10/10 09:31 PM GP-contours-5m.fcz 2010/10/18 04:22 AM GP-contours-5m.idx 2010/10/18 04:22 AM GP-contours-5m.map 2010/10/18 04:23 AM GP-topo50.att 2010/10/18 04:23 AM GP-topo50.ent 2008/10/10 09:32 PM GP-topo50.fcz 2010/10/18 04:23 AM GP-topo50.idx 2010/10/18 04:23 AM GP-topo50.map 2010/10/18 04:48 AM NW-contours-20m.att 2010/10/18 04:48 AM NW-contours-20m.ent 2008/10/10 10:06 PM NW-contours-20m.fcz 2010/10/18 04:48 AM NW-contours-20m.idx

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			2010/10/18 04:48 AM NW-contours-20m.map 2010/10/18 04:49 AM NW-contours-5m.att 2010/10/18 04:49 AM NW-contours-5m.ent 2008/10/10 10:08 PM NW-contours-5m.fcz 2010/10/18 04:49 AM NW-contours-5m.idx 2010/10/18 04:49 AM NW-contours-5m.map 2010/10/19 11:13 PM NW-topo50.att 2010/10/19 11:13 PM NW-topo50.ent 2008/10/10 10:09 PM NW-topo50.fcz 2010/10/19 11:13 PM NW-topo50.idx 2010/10/19 11:13 PM NW-topo50.map
Bio Diversity GIS	23 October 2010	www.bgis.sanbi.org/nwi/map.asp	2010/04/14 02:31 PM RSA wetland types Metadata.pdf 2010/10/23 07:50 PM RSA_wetland_types_2010.dbf 2010/04/14 02:22 PM RSA_wetland_types_2010.prj 2010/10/23 07:50 PM RSA_wetland_types_2010.sbn 2010/10/23 07:50 PM RSA_wetland_types_2010.sbx 2010/10/23 07:50 PM RSA_wetland_types_2010.shp 2010/10/23 07:50 PM RSA_wetland_types_2010.shx
Sa Explorer Version 3.1	Obtained in 2008 (is no longer available)	No longer available SA Demarcation Board	2004/02/18 10:46 AM cadastral_parentfarms.shp 2003/12/11 10:41 AM CensusData_Placenames2001.shp 2003/12/11 11:56 AM Education_Schools2000.shp 2004/02/17 04:01 PM elections_votingstations2000.shp 2003/12/11 11:56 AM Energy_SubStations2001.shp 2003/12/11 11:56 AM Energy_TransmissionLines2001.shp 2003/12/11 11:58 AM Health_healthfacilities2003.shp 2003/12/11 11:56 AM Hydrology_DWAFDams.shp

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Source	**Last Access Date**	**Web Site**	**List Of map related files used in the study (with date of creation) It should be noted that in many instance various digital maps were used to assist in determining the accuracy of the spatial layers, and to determine where changes have occurred.**
			2003/12/11 11:56 AM Hydrology_DWAFRivers.shp 2003/12/11 11:56 AM Hydrology_DWAFWaterProjects.shp 2003/12/11 11:56 AM Hydrology_DWAFWaterSchemes.shp 2004/02/17 04:08 PM justice_courts.shp 2003/12/11 10:39 AM Justice_Prisons.shp 2004/02/18 08:10 AM locational_disestablishedtdcs.shp 2003/12/11 12:08 PM Locational_DisestablishedTLCs.shp 2004/02/17 04:05 PM locational_magisterialdistricts.shp 2004/03/25 02:55 PM Locational_ProvincialBoundary.shp 2004/02/17 04:07 PM locational_rsatowns.shp 2003/12/11 12:08 PM Locational_TAs.shp 2004/03/04 09:47 AM municipalities_categoryb.shp 2004/03/04 09:48 AM municipalities_categoryc.shp 2004/02/18 09:10 AM Municipalities_DMAs.shp 2004/02/17 04:03 PM municipalities_metro.shp 2004/02/18 10:11 AM municipalities_wards.shp 2004/02/18 10:59 AM PublicWorks_PublicWorksProjects.shp 2004/02/17 04:07 PM transport_airports.shp 2003/12/11 10:40 AM Transport_Mainroads.shp 2003/12/11 10:40 AM Transport_NationalRoads.shp 2003/12/11 10:40 AM Transport_Railways.shp 2004/02/17 04:02 PM transport_roads.shp
Demarcation Board	23 October 2010	www.demarcation.org.za (Provides	2010/07/20 12:34 PM DC 48.zip 2010/10/24 07:42 PM 0 demar1.txt

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	(Provides Maps in PDF format)	Maps in PDF format)	2010/07/20 03:29 PM Gauteng_A0.zip 2010/07/20 03:27 PM GT481.zip 2010/07/20 03:25 PM GT482.zip 2010/07/20 03:26 PM GT483.zip 2010/07/20 03:25 PM GT484.zip 2010/07/20 03:31 PM National_A0.zip 2010/07/20 03:29 PM NorthWest_A0.zip
NEIMS (National Education Infrastructure Information Management System)	23 October 2010 (Presently not available on public domain)	School Locations will be available on the National Department's web site for individual schools only	
Demarcation Board	2007	www.demarcation.org.za (Are no longer available in shape format)	2010/10/24 07:42 PM dem2.txt 2006/09/04 11:37 AM DistrictMunicipalities.dbf 2006/09/04 11:37 AM DistrictMunicipalities.prj 2006/09/04 11:37 AM DistrictMunicipalities.sbn 2006/09/04 11:37 AM DistrictMunicipalities.sbx 2006/09/04 11:37 AM DistrictMunicipalities.shp 2010/10/23 12:53 PM DistrictMunicipalities.shp.xml 2006/09/04 11:37 AM DistrictMunicipalities.shx 2006/01/27 10:15 AM gt.dbf 2006/01/27 10:15 AM gt.prj

Table D.1 Digital Maps Used in the study			
Source	**Last Access Date**	**Web Site**	**List Of map related files used in the study (with date of creation) It should be noted that in many instance various digital maps were used to assist in determining the accuracy of the spatial layers, and to determine where changes have occurred.**
			2006/01/27 10:15 AM gt.sbn 2006/01/27 10:15 AM gt.sbx 2006/01/27 10:15 AM gt.shp 2010/10/23 12:52 PM gt.shp.xml 2006/01/27 10:15 AM gt.shx 2006/11/27 11:24 AM LocalMunicipalities.dbf 2006/11/27 11:23 AM LocalMunicipalities.prj 2006/11/27 11:24 AM LocalMunicipalities.sbn 2006/11/27 11:24 AM LocalMunicipalities.sbx 2006/11/27 11:24 AM LocalMunicipalities.shp 2006/11/27 11:24 AM LocalMunicipalities.shp.xml 2006/11/27 11:24 AM LocalMunicipalities.shx 2007/07/09 04:26 PM National_A0_100dpi.pdf 2006/01/27 10:17 AM nw.dbf 2006/01/27 10:17 AM nw.prj 2006/01/27 10:17 AM nw.sbn 2006/01/27 10:17 AM nw.sbx 2006/01/27 10:17 AM nw.shp 2006/01/27 10:20 AM nw.shp.xml 2006/01/27 10:17 AM nw.shx 2007/04/02 11:22 AM Province_New.dbf 2007/04/02 11:22 AM Province_New.prj 2007/04/02 11:22 AM Province_New.sbn 2007/04/02 11:22 AM Province_New.sbx 2007/04/02 11:22 AM Province_New.shp 2007/04/02 11:22 AM Province_New.shp.xml

Table D.1 Digital Maps Used in the study			
Source	**Last Access Date**	**Web Site**	**List Of map related files used in the study (with date of creation) It should be noted that in many instance various digital maps were used to assist in determining the accuracy of the spatial layers, and to determine where changes have occurred.**
			2007/04/02 11:22 AM Province_New.shx 2007/04/02 11:22 AM Province_old.dbf 2007/04/02 11:22 AM Province_old.prj 2007/04/02 11:22 AM Province_old.sbn 2007/04/02 11:22 AM Province_old.sbx 2007/04/02 11:22 AM Province_old.shp 2007/04/02 11:22 AM Province_old.shp.xml 2007/04/02 11:22 AM Province_old.shx
South African Map Library	23 October 2010	www.maplibrary.org/stacks/Africa/South%20Africa/index.php	2007/08/20 04:07 PM read_me.txt 2007/08/20 04:10 PM read_me.txt6 2007/08/20 04:10 PM read_me.txt6gui 2007/08/20 04:11 PM read_me.txt8 2007/08/20 04:11 PM read_me.txt81 2007/08/20 04:11 PM read_me81.txt 2007/08/20 04:05 PM SOU-6.dbf 2007/10/04 02:23 PM SOU-6.shp 2007/10/04 02:23 PM SOU-6.shx 2007/08/20 04:05 PM SOU-6_boundaries.dbf 2007/10/04 02:23 PM SOU-6_boundaries.shp 2007/10/04 02:23 PM SOU-6_boundaries.shx 2007/08/20 04:07 PM SOU-6_guide.tif 2007/09/02 11:29 AM SOU-6_satellite.tfw 2007/09/02 11:29 AM SOU-6_satellite.tif 2007/08/20 04:05 PM SOU-8-1_boundaries.dbf 2007/10/04 02:23 PM SOU-8-1_boundaries.shp 2007/10/04 02:23 PM SOU-8-1_boundaries.shx

Table D.1 Digital Maps Used in the study			
Source	**Last Access Date**	**Web Site**	**List Of map related files used in the study (with date of creation) It should be noted that in many instance various digital maps were used to assist in determining the accuracy of the spatial layers, and to determine where changes have occurred.**
			2007/08/20 04:07 PM SOU-8-1_guide.tif 2007/09/02 11:29 AM SOU-8-1_satellite.tfw 2007/09/02 11:29 AM SOU-8-1_satellite.tif 2007/08/20 04:05 PM SOU-8.dbf 2007/10/04 02:23 PM SOU-8.shp 2007/10/04 02:23 PM SOU-8.shx 2007/08/20 04:05 PM SOU-8_boundaries.dbf 2007/10/04 02:23 PM SOU-8_boundaries.shp 2007/10/04 02:23 PM SOU-8_boundaries.shx 2007/09/02 11:29 AM SOU-8_satellite.tfw 2007/09/02 11:29 AM SOU-8_satellite.tif 2010/10/24 07:44 PM SOU.txt 2010/10/20 09:20 PM SOU_admin.kmz 2007/08/20 04:05 PM SOU_boundaries.dbf 2007/10/04 02:22 PM SOU_boundaries.shp 2007/10/04 02:22 PM SOU_boundaries.shx 2007/09/02 11:28 AM SOU_satellite.tfw 2007/09/02 11:28 AM SOU_satellite.tif

APPENDIX E

Appendix E:

Appendix E 1.

E1 : Important features and point sources along the Wonderfontein Spruit in quaternary catchment C23D

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) *Capacity*	Comments	Satellite image (Google Earth)
1.1	Origin of the Wonderfontein Spruit	C23D Mogale City (West Ran District Council)				The satellite image indicates the remains of mining tailings and existing and recent indications of urban development. The red tint in the water is possibly an indication of AMD	

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) ***Capacity***	Comments	Satellite image (Google Earth)
1.2	Tudor Dam	C23D Mogale City (West Ran District Council)		-26.130970 27.79609S 1748m	Filled with mine tailings	Filled with slime tailings, radiation level unacceptable	

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) ***Capacity***	Comments	Satellite image (Google Earth)
1.3	Lancaster Dam	C23D Mogale City (West Ran District Council		-26.130970 27.776581 1698m	Filled with mine tailings	Filled with slime tailings, radiation level unacceptable (Dry)	

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) ***Capacity***	Comments	Satellite image (Google Earth)
1.4	Lancaster Dam	C23D Mogale City (West Ran District Council)		-26.130970 27.776581 1698m	Filled with mine tailings	Filled with slime tailings, radiation level unacceptable (With water probably impacted on by AMD residue)	

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) ***Capacity***	Comments	Satellite image (Google Earth)
1.5	Kagiso Wetlands	C23D Mogale City (West Ran District Council)		-26.14254 27.762225 1683m	Possible inflows from Kagiso	Wetlands assist in the sedimentation of heavy metals and water purification. In some areas these wetland are 350m wide.	

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) ***Capacity***	Comments	Satellite image (Google Earth)
1.6	Kagiso Sewage Works	C23D Mogale City (West Ran District Council)		-26.182481 27.7722957 1662m	Processed Sewage water. Occasional raw sewage flows into river (35Ml discharged into the river)	The organic nature of the inflow assists in the maintenance of the wetlands	

	1.7
Description	Luipaardsvlei Dam
Catchment **Local Municipality**	C23D Johannesburg Metropolitan
Reference	
Coordinates **Altitude**	-26.215585 27.741187 1616m
Discharge (Per Day) ***Capacity***	***2100Ml***
Comments	Risk of pollution from the surrounding mine dumps, tailings and the reduction works.
Satellite image (Google Earth)	

	1.8
Description	Greunings Dam
Catchment **Local Municipality**	C23D Johannesburg Metropolitan
Reference	
Coordinates **Altitude**	-26.241027 27.733627 1604m
Discharge (Per Day) ***Capacity***	
Comments	Risk of pollution from the surrounding mine dumps and tailings
Satellite image (Google Earth)	

	Description	Catchment Local Municipality	Reference	Coordinates Altitude	Discharge (Per Day) ***Capacity***	Comments	Satellite image (Google Earth)
1.9	Wetlands above the Donaldson Dam	C23D Westonaria (West Rand District Council)				Assists in sedimentation of heavy metals and water purification.	

Satellite image (Google Earth)	
Comments	Receives water that has undergone natural sedimentation form the wetlands
Discharge (Per Day) ***Capacity***	26 Ml including water from the Western Mining Void ***1000Ml***
Coordinates **Altitude**	-26.282662 27.683631 1574m
Reference	
Catchment **Local Municipality**	C23D Westonaria (West Ran District Council)
Description	Donaldson Dam
	1.10

	1.11
Description	Pipeline between Donaldson Dam and Carletonville The pipe line is approximately 29 Km and transverses the dewatered Oberholzer Compartment and Bank compartments
Catchment **Local Municipality**	C23D Westonaria (West Rand District Council)
Reference	
Coordinates **Altitude**	-26.284186 27.679966 1571m
Discharge (Per Day) ***Capacity***	
Comments	Water is piped in a 1 meter diameter pipe. The water is not exposed to light and therefore cannot undergo natural purification.
Satellite image (Google Earth)	

Appendix E.2: Photos and satellite images of features in the C23D catchment area

Appendix E 2: Photos

Photo E2.1: The Lancaster Dam (Note the tailings which form the base and shores of the dam)

Photo E2.2: Wetlands below Lancaster Dam (The wetlands filter most of the heavy metals)

Photo E.2 3: Wetlands below the Lancaster dam (Note the mine tailings in the background, which are a potential source of pollutants).

Photo E2.4: Wetlands in the Kagiso on its banks (Note many pollutants from water draining into the river are absorbed by the plants in the wetlands)

Photo E2.5: Wetlands near the mouth of Luipaardsvlei Dam. (Note the Mine tailings in the background, which are a potential source of pollutants)

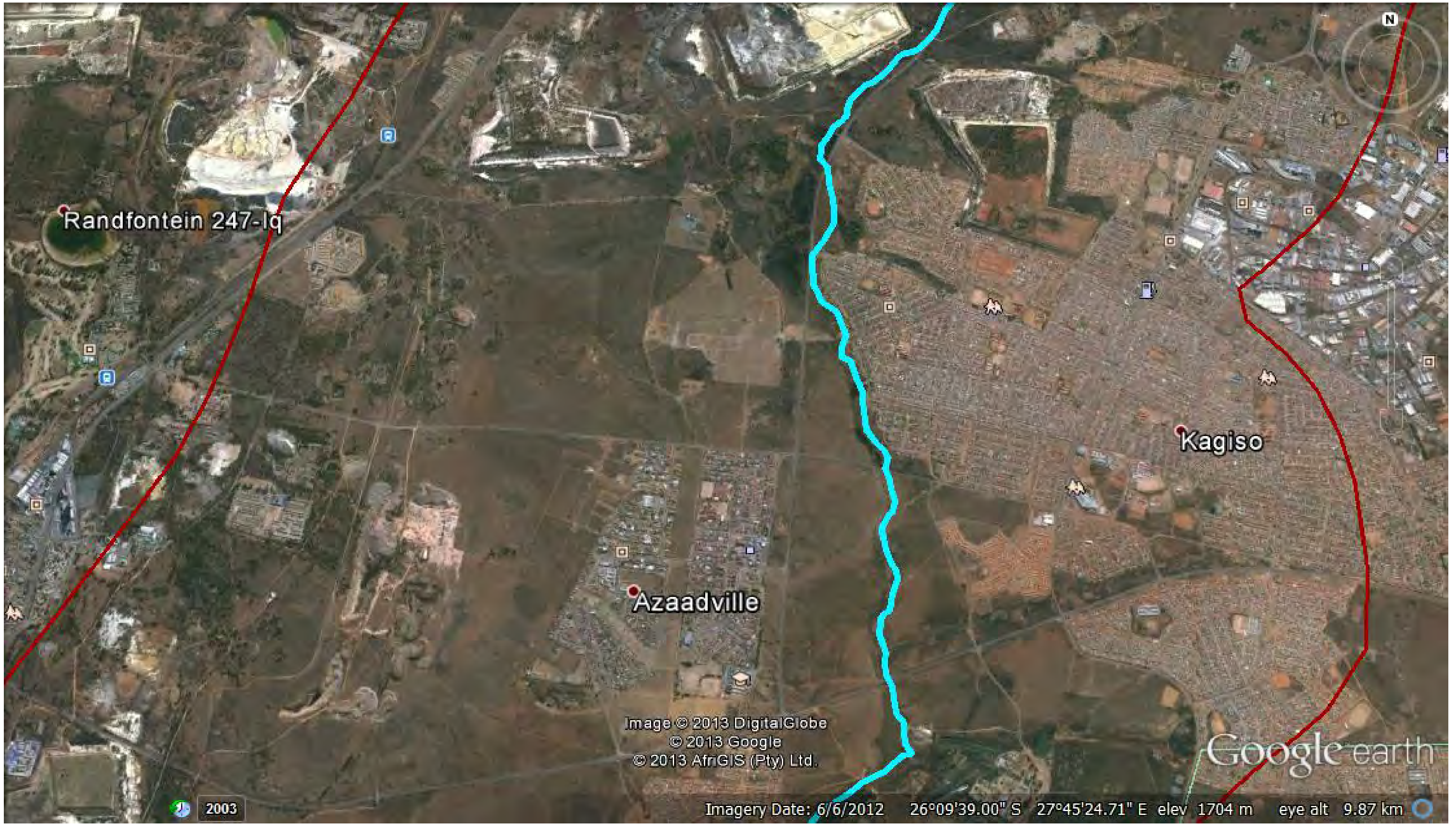
Photo E2.6: Wetlands and mine mailings near Greunings Dam (Note the mine tailings in the Background, which are a potential source of pollutants)

Photo E2.7: Wetlands at the mouth of Donaldson Dam (Despite the filtering ability of these wetlands high levels of heavy metals have been found in the dam**)**

Photo E2.8: The start of the +/- 30 km 1 metre diameter pipeline that conveys water from Donaldson Dam over the dewatered dolomite compartments to prevent filling of compartments and flooding of mines.

Appendix E 3: Satellite images of urban settlements along the bank of the Wonderfontein Spruit in the quaternary catchment C23D.

Settlement Image: E3.1 Azaadville and Kagiso



Settlement Image: E3.2 Rietvallei

Settlement Image: E3.3 Bekkersdal

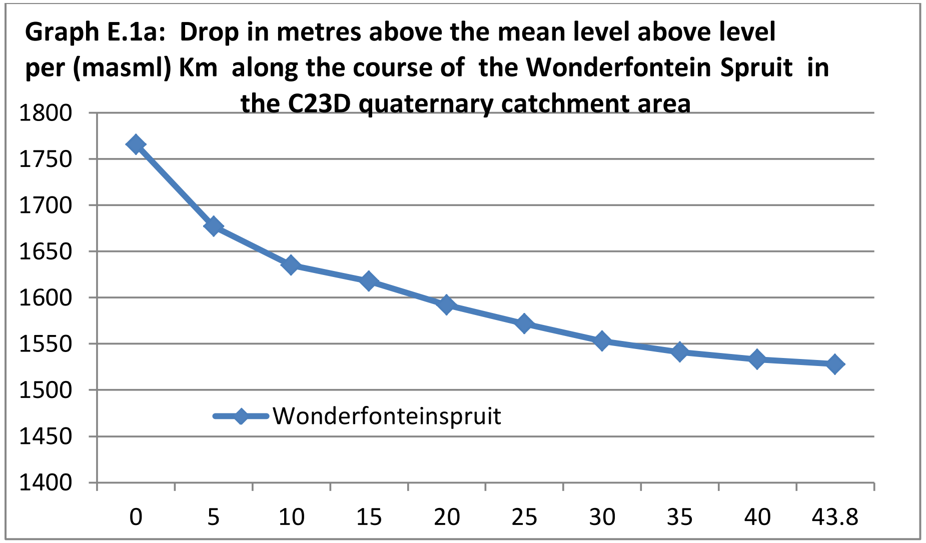
Appendix E: Part 4: Graphic representation of the water courses of the Wonderfontein Spruit and its major tributaries in the quaternary catchment C23D

Table E4.1. Wonderfontein Spruit from Lancaster dam (C23D)

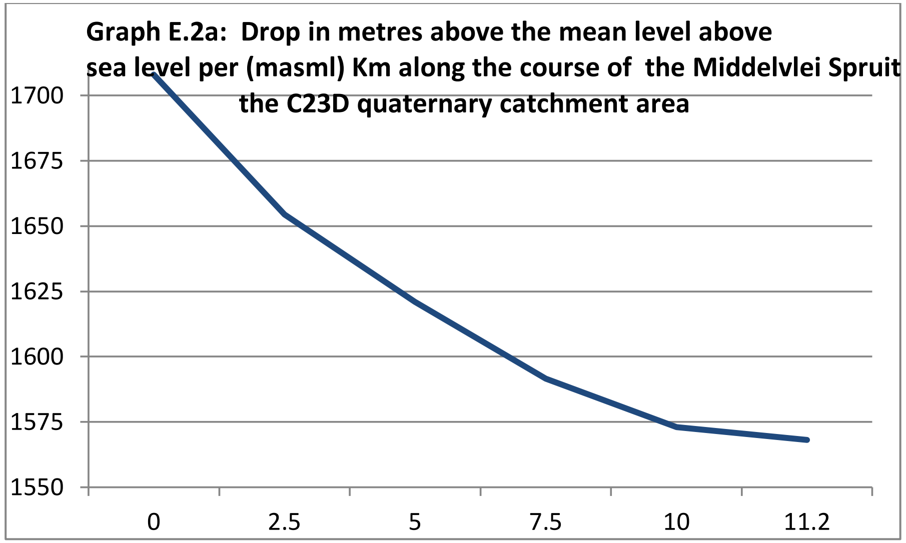
	Distance From origin in Km	Drop in altitude in m of the Wonderfontein Spruit in the C23D catchment area	Drop in metres over each 5 Km	Cumulative drop in meters
Lancaster Dan	**0**	1766	89	238
	5	1677	42	149
	10	1635	17	107
	15	1618	26	90
	20	1592	20	64
Pipeline Begins	**25**	1572	19	44
	30	1553	12	25
	35	1541	8	13
	40	1533	5	5
Blaaubank Farm	**43.8**	1528	0	0
Drop In altitude in m from origin to the convergent point		238	238	238
Drop in meters per kilometre of the river course		5.434	5.434	5.434

Table E4.2. Middelvlei Spruit from origin to inflow in the Wonderfontein Spruit (C23D)				
	Distance From origin in Km	**Drop in altitude in m of the Middelvlei Spruit in the C23D catchment area**	**Drop in metres over each 5 Km**	**Cumulative drop in metres**
Origin	0	1708	56	151
	2.5	1652	36	95
	5	1616	32	59
	7.5	1584	21	27
	10	1563	6	6
Inflow (Wonderfontein spruit)	11.2	1557	0	0
Drop In altitude in m from origin to the convergent point		151	151	151
Drop in meters per kilometre of the river course		13.482	13.482	13.482

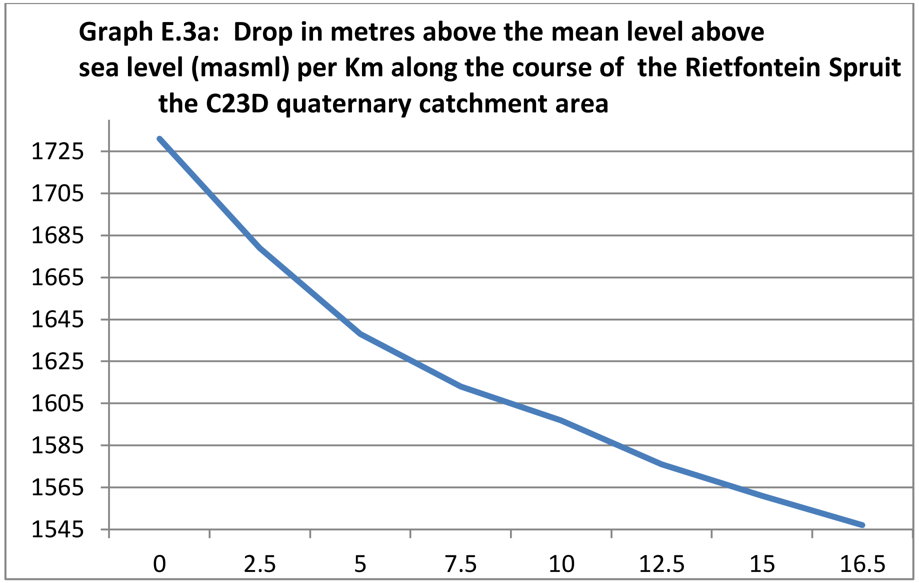
Table E4.3. Rietfontein Spruit from origin to inflow in the Wonderfontein Spruit (C23D)				
	Distance From origin in Km	**Drop in altitude in m of the Rietfontein Spruit in the C23D catchment area**	**Drop in metres over each 5 Km**	**Cumulative drop in metres**
Origin	0	1731	52	184
	2.5	1679	41	132
	5	1638	25	91
	7.5	1613	16	66
	10	1597	21	50
	12.5	1576	15	29
	15	1561	14	14
Inflow (Wonderfontein spruit)	16.5	1547	0	0
Drop In altitude in m from origin to the convergent point		184	184	184
Drop in metres per kilometre of the river course		11.152	11.152	11.152



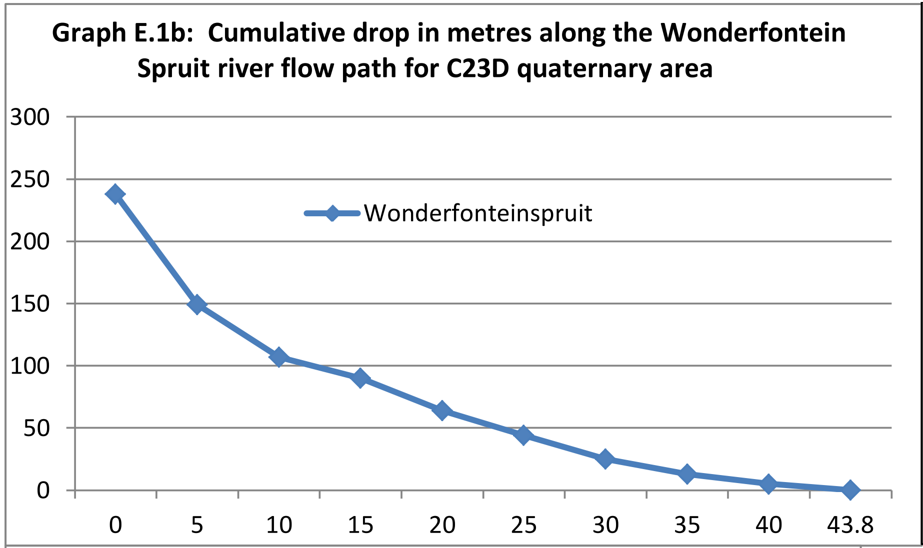
Graph E.1a: Drop in metres above the mean level above level per (masml) Km along the course of the Wonderfontein Spruit in the C23D quaternary catchment area

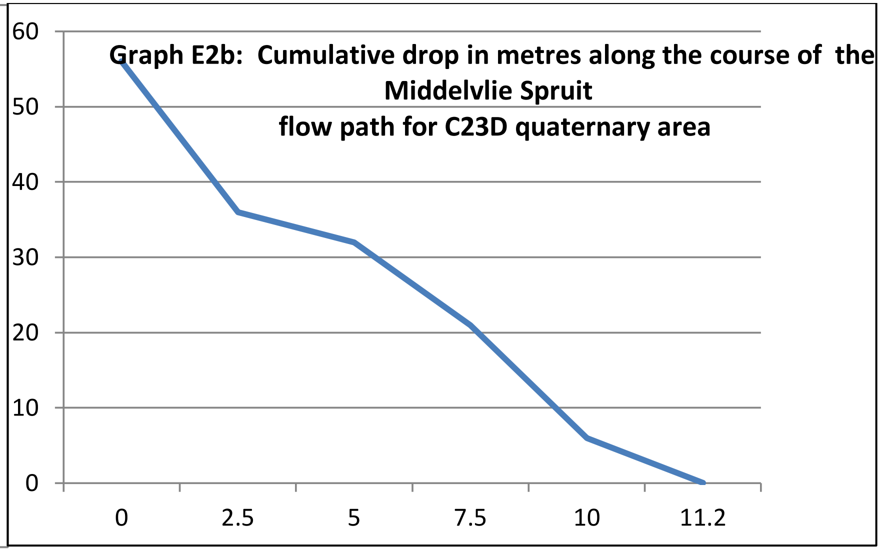


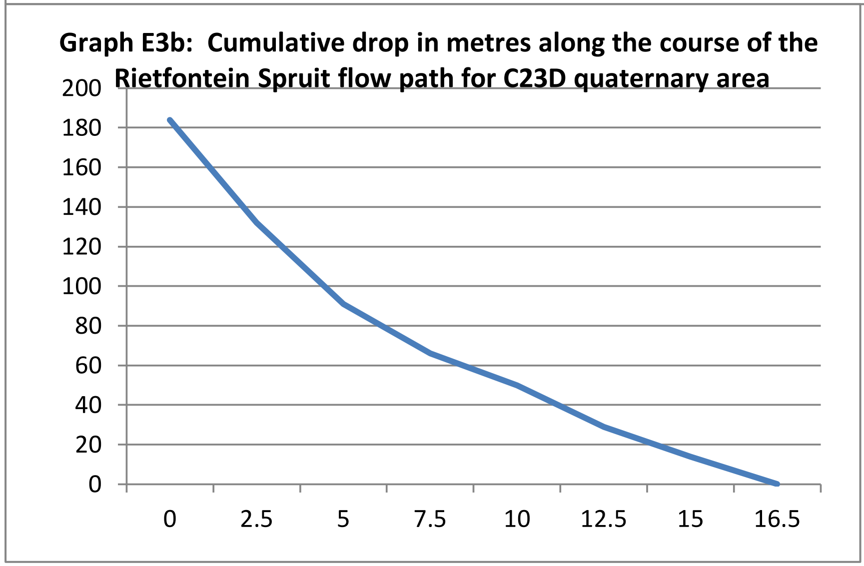
Graph E.2a: Drop in metres above the mean level above sea level per (masml) Km along the course of the Middelvlei Spruit the C23D quaternary catchment area



Graph E.3a: Drop in metres above the mean level above sea level (masml) per Km along the course of the Rietfontein Spruit the C23D quaternary catchment area


Graph E.1b: Cumulative drop in metres along the Wonderfontein Spruit river flow path for C23D quaternary area
Wonderfonteinspruit
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
43.8


Graph E2b: Cumulative drop in metres along the course of the Middelvlie Spruit
flow path for C23D quaternary area
60
50
40
30
20
10
0
0
2.5
5
7.5
10
11.2


Graph E3b: Cumulative drop in metres along the course of the Rietfontein Spruit flow path for C23D quaternary area
200
180
160
140
120
100
80
60
40
20
0
0
2.5
5
7.5
10
12.5
15
16.5

Appendic E: Part 5: Description of the river course in qauternary catchment C23D

Its origin is in the region of the Lancaster and Tudor dam on the farm Luipaardsvlei at 1766 meters above mean sea level, it then flows approximately 25 km before it conveyed another 28km in a meter pipeline, until the end of the Catchment area at 1528 meter above mean sea level. This implies a drop in altitude of 273 m, that is approximately 5.4 m per km. Table E5.1 Summary of the points of discharge and the river courses providing water in the in quaternary catchment C23D (Opperman, 2008:Onlie; NNR, 2007:Online; Coetzee *et al.*, 2006:Onlne; Le Roux, 2005:Online)

	Description	**Coordinates** **East** **South** **Altitude**	**Discharge (Per Day)**	**Capacity**	**Comments**
1	Tudor Dam	-26.130970E 27.79609S 1748m	Filled with mine tailings	None	Filled with slime tailings, radiation level unacceptable
2	Lancaster Dam	-26.130970 27.776581 1698m	Filled with mine tailings	None	Filled with slime tailings, radiation level unacceptable

	Description	Coordinates East South Altitude	Discharge (Per Day)	Capacity	Comments
3	Kagiso Wetlands	-26.14254 27.762225 1683m	Possible inflows from Kagiso		Wetlands assist in the sedimentation of heavy metals and water purification. In some areas these wetland are 350m wide.
3	Kagiso Sewage Works	-26.182481 27.7722957 1662m	Processed Sewage water. Occasional raw sewage flows into river (35Ml discharged into the river)		The organic nature of the inflow assists in the maintenance of the wetlands
4	Luipaardsvlei Dam	-26.215585 27.741187 1616m		2100Ml	Risk of pollution from the surrounding mine dumps, tailings and the reduction works.
5	Greunings dam	-26.241027 27.733627			Risk of pollution from the surrounding mine dumps, tailings

	Description	Coordinates East South Altitude	Discharge (Per Day)	Capacity	Comments
		1604m			
6	Wetlands above the Donaldson dam				Assists in sedimentation of heavy metals and water purification.
7	Donaldson Dam	-26.282662 27.683631 1574m	26 Ml including water from the Western Mining Void	1000Ml	Receives water that has undergone natural sedimentation form the wetlands

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http://books.google.co.za/books?id=P-

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