

# An Awareness Plan for the Tlokwe Dolomite Risk Management Strategy

**D Muller**  
**10633472**

Dissertation submitted in fulfilment of the requirements for the degree *Magister Scientiae* in *Geography and Environmental Management* at the Potchefstroom Campus of the North-West University

Supervisor: Prof IJ van der Walt

Co-supervisor: Dr M Wiggill

May 2017



## ACKNOWLEDGEMENTS

In the research and completion of this study I wish to acknowledge the following:

- My heavenly Father who has sustained me and blessed me abundantly. To him be the glory forever.
- My best friend and most beloved husband Francois Muller who gives my life purpose and is my safe place to fall always. Your support and motivation has enabled me to spend so much time behind my desk! I love you with all of my heart.
- My most cherished children who fill my life with utter joy. Thank you Pierre Muller for endless hugs and dark chocolate. I am so extremely proud of my philosopher son. Louise-Mari Muller for being an example and inspiration of overcoming unsurmountable obstacles by sheer tenacity and inner strength-your soul is beautiful. Adriaan de Lange for copious amounts of sweet tea, strong coffee and patience.
- My parents Peet and Norma Smith without whom I would not have been able to study and who still sustain me in so many ways. You are loved.
- My parents-in-law Pieter and Johanna Muller for their support and Johanna Muller for her constant motivation and love.
- Dr Stephan Pretorius and Stephan Potgieter who has the vision to invest and promote an inter-disciplinary approach to the management of projects, and has provided me with the opportunities to redefine the boundaries of dolomite risk awareness.
- Stephan Potgieter for your willingness and grace in accommodating this study and providing me with time and support to complete it.
- The AGES team for making the interdisciplinary approach a reality.
- My dear colleagues Hanneke Pretorius, Willem Meintjes, Fred Calitz and Pieter Pretorius for your pivotal assistance and input in this study. Nkateko Ndobe for keeping all the ducks in a row and the data organised. Sankie Monyane for your humour and admin skills.
- Prof. Kobus van der Walt for not only motivating the whole of South Africa to love and know the natural environment but has believed in me and this research subject.
- Dr. Marlene Wiggill whose attention to detail, academic guidance and excitement about her field of study is truly inspirational.
- Dr Ilse Aucamp for her motivation and mentorship on personal and project level, input on the mitigation of risk by means of awareness, when all of us were still at sea, and for showing me that information sharing among practitioners to the benefit of affected communities is essential for social scientists.

- Willie Maphosa, spokesperson of the Ventersdorp/Tlokwe Local Municipality for his support as well as being an example of how to be objective and respectful even in politics.

## **ABSTRACT**

Vulnerable communities residing on dolomitic land in the jurisdiction of the Tlokwe City Council are faced with the hazard of possible sinkhole formation and the associated risk of losing lives or damage to infrastructure and homes. The anthropogenic factors leading to dolomite instability and sinkhole formation can be mitigated by creating dolomite risk awareness with institutional and affected stakeholders. Dolomite risk awareness actions were therefore implemented as part of the Tlokwe Dolomite Risk Management Strategy.

This study researched the causes of sinkhole formation the effect on stakeholders and the evolution of the dolomite awareness actions, which were implemented as part of the Dolomite Stability Investigation phases as well as the phases of the Dolomite Risk Management Strategy, through interviews and feedback of stakeholders by means of door-to-door campaigns, workshops and focus groups. This implementation capacitated the affected community and decision makers to take ownership of the hazard and become partners in mitigating the risk associated with dolomite and sinkholes.

As part of this implementation, dolomite risk awareness material was developed, which included an awareness documentary and leaflets. Forums, door-to-door awareness, a dolomite helpline, workshops and media engagement were used as vehicles to implement dolomite risk awareness. Based on perceived gaps and responses from stakeholders, the dolomite risk awareness actions were supplemented and aligned with community expectations and needs.

In conclusion to this study, gaps were identified and recommendations made for implementation of a dolomite risk awareness plan for similar projects. A conceptual framework for the compilation of a dolomite risk awareness plan was proposed to serve as a tool for the implementation of the various phases of a Dolomite Risk Management Strategy.

### **Key words:**

Dolomite Risk Awareness Plan Dolomite Risk Management Strategy Dolomite risk awareness  
Anthropogenic Factors Dolomite risk mitigation Dolomite affected stakeholders

## OPSOMMING

Kwesbare gemeenskappe wat op dolomietiese grond binne die jurisdiksie van die Tlokwe Stadsraad woon, word bedreig deur die moontlike vorming van sinkgate en die gepaardgaande risiko ten opsigte van lewensverlies en skade aan infrastruktuur en eiendom. Die antropogeniese faktore wat tot onstabiele dolomiet en sinkgatvorming bydra, kan teengewerk word deur institusionele en geaffekteerde belanghebbendes bewus te maak van die risiko wat dolomiet inhou. Dolomietrisiko-bewustheidsaksies is gevolglik as deel van die Tlokwe Dolomietrisikobestuurstrategie geïmplementeer.

Hierdie studie is 'n ondersoek na die evolusie van die dolomiet-bewustheidsaksies wat geïmplementeer is as deel van die fases van die Dolomietstabiliteitsondersoek sowel as die fases van die Dolomietrisikobestuurstrategie. Deur-tot-deur veldtogte, forums en werksinkels is gebruik om data in te samel aangaande persepsies en tekortkomings in dolomiet risiko-bewustheid. Die implementering van bewustheidsaksies het die geaffekteerde gemeenskap en besluitnemers in staat gestel om eienaarskap te neem van die gevaar en om vennote te word in die vermindering van die risiko wat met dolomiet en sinkgate gepaard gaan.

As deel van hierdie implementering is dolomietrisiko-bewustheidsmateriaal ontwikkel wat onder andere 'n bewustheidsdokumentêre video en -inligtingsblaadjies ingesluit het.

Forums, deur-tot-deur-bewusmaking, 'n dolomiethulplyn, werksinkels en mediaskakeling is gebruik om dolomietrisikobewustheid te kweek. Die dolomietrisikobewustheidsaksies is aangevul en belyn met die verwagtinge en behoeftes van die gemeenskap met in agneming van die waargenome tekortkomings in die dolomietbewusmaking asook in reaksie op die terugvoer van belanghebbendes.

Hierdie studie het tekortkomings uitgewys en aanbevelings gemaak wat implementeer kan word in toekomstige dolomiet projekte. Die studie kulmineer in 'n konseptuele raamwerk vir die saamstel van 'n dolomietrisikobewusmakingsplan wat as instrument kan dien om gedurende die verskillende fases van die Dolomietrisikobestuurstrategie te implementeer.

### **Sleutelwoorde:**

Dolomietbewusmaking    Dolomietbestuurstrategie    Dolomietrisiko    Dolomietrisiko-bewusmaking    Antropogeniese faktore    Dolomietgeaffekteerde belanghebbendes

# TABLE OF CONTENTS

<b>ACKNOWLEDGEMENTS .....</b>	<b>I</b>
<b>ABSTRACT .....</b>	<b>III</b>
<b>OPSOMMING .....</b>	<b>IV</b>
<b>PREAMBLE .....</b>	<b>XV</b>

## CHAPTER 1

<b>INTRODUCTION.....</b>	<b>1</b>
<b>1.1 Background .....</b>	<b>1</b>
<b>1.2 Problem Statement.....</b>	<b>2</b>
<b>1.3 Specific Research Questions .....</b>	<b>3</b>
<b>1.4 General research objective .....</b>	<b>3</b>
<b>1.5 Specific research objectives.....</b>	<b>3</b>
<b>1.6 Research approach and methods .....</b>	<b>4</b>
1.6.1 Literature Study .....	4
1.6.2 Empirical study .....	5
<b>1.7 Ethical considerations .....</b>	<b>6</b>
<b>1.8 Chapter layout .....</b>	<b>6</b>

## CHAPTER 2

<b>DOLOMITE RISK IN BUILT ENVIRONMENTS.....</b>	<b>8</b>
<b>2.1 Introduction .....</b>	<b>8</b>
<b>2.2 Chemical Composition, weathering and dissolution of dolomite .....</b>	<b>8</b>
2.2.1 Chemical composition.....	8

2.2.2	Weathering and dissolution.....	9
2.2.3	Dolomite Instability .....	10
<b>2.3</b>	<b>Hazards associated with dolomite .....</b>	<b>10</b>
2.3.1	Karst formation .....	10
2.3.2	Subsidence.....	10
2.3.3	Sinkholes.....	11
2.3.4	Anthropogenic factors.....	12
<b>2.4</b>	<b>Anthropogenic Susceptibility of built environments .....</b>	<b>14</b>
2.4.1	Communities underlain by dolomite .....	15
 <b>CHAPTER 3</b>		
<b>TLOKWE COMMUNITIES LIVING ON DOLOMITE .....</b>		<b>20</b>
<b>3.1</b>	<b>Introduction .....</b>	<b>20</b>
<b>3.2</b>	<b>The historical development of Ikageng, Mohadin and Promosa .....</b>	<b>22</b>
3.2.1	Ikageng.....	22
3.2.2	Promosa .....	23
3.2.3	Mohadin.....	23
3.2.4	The Tlokwe Dolomite Risk Management Strategy as response to the occurrence of dolomite in TCC built areas .....	33
<b>3.3</b>	<b>Engagement of stakeholders as part of the Tlokwe DRMS .....</b>	<b>35</b>
3.3.1	Imperative to provide dolomite risk awareness to affected communities in TCC.....	35
3.3.2	Legal framework for engaging dolomite affected stakeholders.....	36
3.3.3	Levels of engagement of stakeholders .....	38

3.3.4	Objectives of communicating the risk to stakeholders.....	39
3.3.5	Stakeholder identification and mapping .....	40
3.3.5.1	Local authorities: District and local Municipalities .....	42
3.3.5.2	Government Departments and organs of state .....	42
3.3.5.3	Directly affected Communities .....	42
3.3.5.4	Service Providers .....	43
3.3.5.5	External Stakeholders.....	43
3.3.6	Stakeholder Maps.....	44

## **CHAPTER 4**

	<b>DOLOMITE RISK AWARENESS IN BUILT AREAS.....</b>	<b>48</b>
<b>4.1</b>	<b>Introduction .....</b>	<b>48</b>
<b>4.2</b>	<b>Lessons not learnt from the past .....</b>	<b>48</b>
<b>4.3</b>	<b>Mitigating the risk of dolomite and sinkholes .....</b>	<b>49</b>
<b>4.4</b>	<b>DRMS Phase A.....</b>	<b>51</b>
4.4.1	DRMS Phase A: DSI research processes.....	51
4.4.2	The foundation for a Risk Awareness Plan .....	51
4.4.3	Vulnerable Stakeholders.....	52
4.4.4	The DRMA's .....	55
4.4.5	Sarafina subsidence event.....	58
4.4.6	Institutional awareness .....	58
<b>4.5</b>	<b>DRMS Phase B.....</b>	<b>58</b>
4.5.1	Phase B: DSI research processes and outcomes .....	60

4.5.2	Initial steps in risk awareness .....	60
4.5.3	There's a new drill in town (Drilling Phase 1) .....	63
4.5.4	The Social Map.....	65
4.5.5	The Media .....	68
4.5.6	The Dolomite Management Desk.....	69
4.5.7	We are not alone: Karst Worldwide.....	69
4.5.8	Phase B research awareness leaflet.....	73
4.5.9	Drilling Phase 2 .....	78
4.5.10	Radio .....	78
4.5.11	Campaign Tlhalefa .....	78
4.5.12	The Ikageng Reservoir resettlement .....	81
4.5.13	The subsurface model .....	81
4.5.14	Workshops .....	83
4.5.15	General awareness .....	83
4.5.16	Alignment with Infrastructure survey .....	84
4.5.17	The Kanana subsidence event .....	85
4.5.18	Political climate.....	86
4.5.19	The Media revisted .....	87
4.5.20	Phase B leaflet 2: Dolomite risk awareness and the way forward .....	91
4.5.21	Dolomite Management Desk processes.....	93
<b>4.6</b>	<b>DRMS Phase C1 .....</b>	<b>93</b>
4.6.1	DRMS implementation and mitigation processes.....	94
4.6.2	Risk Communication Workshop.....	94

4.6.3	Media Partners .....	95
4.6.4	Ward Councillor Workshop .....	96
4.6.5	Door-to-door resumes.....	96
4.6.6	Political Impasse.....	100
4.6.7	Schools Program .....	100
4.6.8	Dolomite ambassadors .....	100
4.6.9	Research outcomes on Dolomite Management Desk .....	101
4.6.10	Dolomite desk revisited.....	104
4.6.11	Dolomite Documentary .....	104
4.6.12	External stakeholders .....	105
4.6.13	Monitoring.....	105
4.6.14	The Reverend Phethlu street sinkhole .....	105
4.6.15	Dolomite roles and responsibilities.....	106

## **CHAPTER 5**

	<b>CONCLUSION AND RECOMMENDATIONS.....</b>	<b>108</b>
<b>5.1</b>	<b>Introduction .....</b>	<b>108</b>
<b>5.2</b>	<b>Conclusions.....</b>	<b>108</b>
5.2.1	Considering the hazards and risks associated with karst in built environments.....	108
5.2.2	Stakeholders to be engaged in dolomite risk awareness .....	109
5.2.3	Dolomite risk awareness actions .....	109
5.2.4	Measuring effectiveness of the dolomite risk awareness actions .....	110
5.2.5	Political context.....	110

5.2.6	Regional risk awareness.....	111
5.2.7	Dolomite risk awareness team.....	111
5.2.8	Perceptions of risk awareness levels .....	112
5.2.9	Vulnerability of dolomite affected communities .....	112
<b>5.3</b>	<b>Recommendations.....</b>	<b>114</b>
5.3.1	Participatory engagement.....	114
5.3.2	Focus groups.....	114
5.3.3	TCC Institutional Memory .....	115
5.3.4	Approach to DRAP .....	115
5.3.5	Vulnerability of affected communities.....	115
5.3.6	Trusted and transparent risk awareness .....	116
<b>5.4</b>	<b>Framework for Dolomite Risk Awareness Plan .....</b>	<b>116</b>
	<b>REFERENCES.....</b>	<b>0</b>

# LIST OF TABLES

Table 1-1: Research objectives and chapter summary ..... 7

Table 2-1: Sinkhole classification (Waltham *et al.*, 2007)..... 11

Table 2-2: Sinkhole sizes ..... 11

Table 2-3: Sinkhole Fatalities in South Africa ..... 13

Table 2-4: Inherent Hazard Classification ..... 14

Table 4-1: Residents affected by dolomite..... 54

Table 4-2: Community related activities and land use on dolomite ..... 55

Table 4-3: Principles of Community Participation..... 62

Table 4-4: Countries with karst (Williams & Fong, 2008) ..... 70

Table 4-5: Karst areas in South Africa (National Home Builders Registration Council  
(NHBRC), 2014)..... 72

Table 4-6: Risk Awareness Mitigation..... 103

Table 5-1: Categories and dimensions of vulnerability within dolomite affected  
communities..... 113

# LIST OF FIGURES

Figure 2-1: Sinkhole at Carletonville reservoirs ..... 12

Figure 2-2: The occurrence of dolomite in South Africa (AGES, 2013e) ..... 16

Figure 2-3: Occurrence of dolomite in North West Province (AGES, 2013e) ..... 17

Figure 2-4: Dolomite risk equation as amended by the inclusion of anthropogenic factors  
(own depiction)..... 19

Figure 3-1: Distribution of dolomite in Tlokwe City Council (AGES, 2013a) ..... 21

Figure 3-2: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 24

Figure 3-3: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 25

Figure 3-4: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 26

Figure 3-5: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 27

Figure 3-6: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 28

Figure 3-7: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 29

Figure 3-8: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 30

Figure 3-9: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 31

Figure 3-10: Timeline of settlement development in context of dolomite information and  
guidelines for development (Pretorius, 2016) ..... 32

Figure 3-11: TCC Strategic Planning for DRMPr adapted from AGES (2014)..... 34

Figure 3-12: Levels of stakeholder engagement based on IAP2 (International Association for Public Participation, 2000) .....	39
Figure 3-13: Components of TCC stakeholder engagement components.....	40
Figure 3-14: SANS 1936 (2012) dolomite risk management levels (own representation).....	41
Figure 3-15: Stakeholder Mapping Framework (own depiction) .....	45
Figure 3-16: Stakeholder Tier Mapping (own depiction).....	46
Figure 4-1: Ikageng Average Household Income (DEMACON, 2013).....	52
Figure 4-2: Ikageng Levels of Education (DEMACON, 2013) .....	53
Figure 4-3: Ikageng Unemployment Levels (DEMACON, 2013) .....	53
Figure 4-4: Inherent Hazard Class Zones.....	56
Figure 4-5: Dolomite Risk Management Areas (AGES, 2014) .....	57
Figure 4-6: Integrative Risk Awareness Framework .....	59
Figure 4-7: Social Awareness map (AGES, 2012).....	66
Figure 4-8: World Karst Map (Williams & Fong, 2008).....	71
Figure 4-9: Sinkhole formation (Source: watermatters.org).....	75
Figure 4-10: Dolomite risk awareness leaflet 1 (AGES, 2013c) .....	76
Figure 4-11: Poster on reverse of leaflet 1 (AGES, 2013c).....	77
Figure 4-12: TCC Social Awareness Map.....	80
Figure 4-13: Sarafina Subsurface model .....	82
Figure 4-14: Kanana Subsidence .....	86
Figure 4-15: Potchefstroom Herald 31 October 2014 .....	89
Figure 4-16: Potchefstroom Herald 14 November 2014.....	90
Figure 4-17: Dolomite Risk Awareness leaflet .....	92
Figure 4-18: DMD Building application flowchart .....	93

Figure 4-19: Dolomite risk managed in Tlokwe ..... 95

Figure 4-20: Door-to-door Campaign Ward planning ..... 97

Figure 4-21: Door-to-door Campaign Verification Map..... 98

Figure 4-22: Dolomite Risk Awareness 2015 summary ..... 99

Figure 4-23: Dolomite Risk Awareness leaflet 3 ..... 107

Figure 5-1: Proposed Conceptual Framework for DRAP ..... 117

## PREAMBLE

*"In the winter night of 3 August 1964 the Carletonville community was struck by disaster, when the Oosthuizen family, as well as their domestic worker, was buried alive, with their house and all, in a massive sinkhole. It can be considered as the sinkhole incident, which made Carletonville well known in and outside of South Africa, but one, which at the same time caused fear.*

*Mr. Johannes Marthinus Oosthuizen (36), attached to the Blyvooruitzicht Gold Mine, his wife Hester and their three children, Jacoba (12), Johannes (8) and Marianne (6), came back from a lovely holiday at Amanzimtoti, during the weekend of 1 August 1964. Their house in the Westdene-suburb of the Blyvooruitzicht goldmine had a dilapidated appearance and this was part of the reason the family was not enthusiastic to return home to a "normal" life. For Mr. Oosthuizen it was however not possible to adhere to the pleas of his wife and children to stay for a few extra holiday days. Mr. Oosthuizen quoted various responsibilities before his leave would come to an end as his defence against the pleading eyes of his family.*

*By the Sunday morning, family members, the Strydom's and the neighbours (the Macmasters, Brits, and Kriels), came to greet various members of the Oosthuizen family and to enquire about their holiday in Amanzimtoti. Mrs. Oosthuizen on more than one occasion indicated that she finds it difficult to adapt in the dilapidated house, which filled her with fear.*

*At approximately two o'clock the Sunday night a neighbour of the Oosthuizen's, Mr. Brits, was busy looking for a pill against restlessness when he heard a noise outside, which sounded to him like wagon-wheels on a rough road. Through his bedroom window he saw that the light of the Oosthuizen family was on, but nothing was visible which could shed light on the wagon-wheel noise he heard. Seconds later the noise could be heard again this time significantly louder than the previous wagon-wheel noise he heard. Mr. Brits had to see how the house of his neighbour's house collapsed like paper and how the house disappeared in a 15-20 meter sinkhole. Mrs. Oosthuizen's shouts could be heard clearly above the noise.*

*Hereafter the suburb was alive with activity. Mr. and Mrs. Brits with their children quickly evacuated their house which stood on the edge of the 150 meter open hole which was rapidly cracking up. The Kriels were in this*

*stadium panicking since a part of their house broke away from the rest. The Kriels just managed to escape through a bedroom window, when part of their house fell into the sinkhole. The Macmaster's and the mother of Mrs. Macmaster had to escape through a window when ground movement lead to all exits of their house being blocked. Few possessions could be saved.*

*In the following days it was not possible for rescue workers to remove the corpses from the rubble. The situation leads to panic, shock, and sympathy of the whole shocked community and in the family circles of the Oosthuizen's. The Blyvooruitzicht Gold Mining Company had to find urgent accommodation for approximately 170 households. Caravans brought in from everywhere were placed near the recreation club of the mine, where a number of households were accommodated for a period of time, and this temporary accommodation was even known as separate Church areas in the various Churches. For many others the massive sinkhole was only an attraction which they had to see due to curiosity.*



**Image 1: Aerial view Blyvooruitzicht Sinkhole 1964**

*Four ministers from the NG Church delivered the memorial service for the Oosthuizen family and their maid on 5 August 1964 at Carletonville. It was well attended. A Monument was erected on the hill overlooking the area where the Westdene suburb stood. The fitting inscription on the monument reads, "God himself laid them to rest".*

*It should however be noted that this incident did not result in the highest loss of human life due to a sinkhole incident. At the West-Driefontein reduction plant, two years prior to the Oosthuizen incident a total of 31 people lost their lives due to a sinkhole incident. The reduction building of seven storeys disappeared into the massive sinkhole. It could be asked why an incident of this magnitude received less attention than the Oosthuizen incident. The reason for this could be the fact that the reduction plant incident was treated as a mining incident, with people at work losing their lives. In contrast the Oosthuizen incident involved a family, including children losing their lives while sleeping."*

(Source: [www.merafong.co.za/monuments.htm](http://www.merafong.co.za/monuments.htm) )



**Image 2: Blyvooruitzicht Sinkhole 1964**

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

According to the Department of Public Works (2010:7), a high-risk dolomitic area is defined as an area where more than one sinkhole per hectare will most likely form. The term 'dolomitic land' is used to describe areas underlain directly or at shallow depth (i.e. <100m) by the rock type dolomite (Department of Public Works, 2010:5). The landforms and processes found in dolomitic areas are referred to as "karst" (Department of Water Affairs and Forestry, 2006:3). Karst terrains are formed through weathering processes over millions of years and form cavities and cave systems (Department of Water Affairs and Forestry, 2006:3). The potential danger of dolomite lies in the fact that it is soluble in water. "Rainwater and percolating ground water gradually dissolves the rock over time as it seeps through joints, fractures and fault zones in the rock" (Department of Public Works, 2010:5).

This karst landscape can be buried under younger deposits as well as weathered deposits of karst formation which can collapse or move into the cavities resulting in ground movement (Buttrick *et al.*, 2001:27). When structures are built on areas where dolomitic land is present, the possibility of sinkholes forming becomes meaningfully elevated.

In South Africa, "38 people have died in sinkholes that have occurred under sports clubs, factories and homes and financial losses have exceeded R1 billion. In excess of 1000 sinkholes have occurred on the West Rand, 800 south of Pretoria, Centurion and Atteridgeville and approximately 150 on the East Rand" (Department of Public Works, 2010:6). In Ikageng, Promosa and Mohadin<sup>1</sup> various sinkholes have formed in the past few years with great associated risk to residents and to the Tlokwe City Council (TCC)<sup>2</sup>.

The TCC appointed AGES (Pty) Ltd<sup>3</sup> to develop a risk management programme to manage and mitigate the risk related to dolomite within its jurisdiction (Council Resolution C122/2012-06-19, MM Resolution 75/2009-05-09, Council Resolution C120/2010-06-09, Council Resolution 244/2011-11-29, MM Resolution 163/2011-11-24).

The South African National Standards (SANS) 1936-4 (2012) regulate any development on dolomite in South Africa. It prescribes that the local authority of areas underlain by dolomite must establish and implement a Dolomite Risk Management Programme (DRMP). A DRMP consists of a Dolomite Risk Management Strategy (DRMS) and Dolomite Risk Management

---

<sup>1</sup> Ikageng, Promosa and Mohadin are residential areas within the jurisdiction of the Tlokwe City Council.

<sup>2</sup> Tlokwe City Council is a local municipality in the Kenneth Kaunda district, North-West province, South Africa.

<sup>3</sup> AGES is Africa Geo-Environmental Engineering and Science (Pty.) Ltd. with offices in Potchefstroom, Polokwane, Johannesburg, Pretoria and East London, South Africa.

plan (DRMP).

Two main factors contribute to the risk with regard to development on dolomitic land that need to be addressed in a DRMP. The first includes all aspects of the physical environment such as geology, geohydrology and engineering geology (Potgieter, 2012:35). According to Tihansky (1999:1), this scientific understanding is key to assigning meaningful risk to both property and environment and thereby formulating effective land and water resource management strategies. The second factor relates to the anthropogenic environment which focuses on existing infrastructure development, land use planning and the social structure within the study area (Potgieter, 2012:35). The focus on anthropogenic factors is confirmed by specifications in the SANS (1936-4:2012) pertaining to the inclusion of an awareness program.

Buttrick *et al.* (2014:131) point to recent failures of precautionary measures due to gaps in awareness, training, and economic and social issues. Buttrick *et al.* (2014:131) also indicate that these gaps negate the positive impact of science and engineering intervention on dolomitic land. Historically dolomitic risk was addressed on a purely technical level but recent risk based approaches indicate that the vulnerability of the community is exacerbated by a lack of risk communication (Buttrick *et al.*, 2014:131).

A community faced with a potential environmental disaster risk can be vulnerable to its effects. Dwyer *et al.* (2004:12) explain that vulnerability refers to different people or groups' capacity to cope, resist and recover from a disaster or adverse condition. (Hewitt, 2014) explains that this can be viewed as the conditions that influence the protection of people, rather than the severity of a damaging event. Vulnerability can be reduced by communicating about all risks in order for a community to take ownership of managing and mitigating the risk.

If a community receives timely information regarding the management of the potential environmental disaster risk, their vulnerability to the risk can be reduced. Wisner *et al.* (2012:24) describes an environmental disaster risk as a “function of the magnitude, potential occurrence, frequency, speed of onset and spatial extent of a potentially harmful event or process. It is also a function of people’s susceptibility to loss, injury or death.” An environmental disaster risk therefore refers to a potentially harmful event that may cause great loss in terms of property as well as human life.

## **1.2 Problem Statement**

According to Wiggill (2013:6), vulnerability to risk can increase if communities at risk do not follow advice presented by government. This communication should emanate from a trust relationship between government and affected communities (Wiggill, 2013:7). Risks like karst formation that may develop slowly or may occur on a large spatial scale can often be tinged by uncertainty and diluted by other factors affecting perceptions (Glynn, 2015:9). These risks are

perceived as diffuse and require strategically planned two-way communication within the framework of a trusting government-community relationship.

In compiling the TCC DRMS the requirements of the SANS (1936-4:2012) should be incorporated. Within each phase of the dolomite stability investigation and geohydrological assessment, awareness actions should be planned and implemented. The awareness actions should be aligned with the scientific and technical aspects of the investigation and the mitigation actions proposed in the DRMS.

The general research question to be addressed in this dissertation is: How should the Tlokwe City Council communicate the risk associated with dolomite to all affected stakeholders in their municipal jurisdiction?

### **1.3 Specific Research Questions**

1. Which hazards associated with dolomite pose a risk to residents living in areas underlain by dolomite?
2. Who are the stakeholders affected by dolomite in the TCC?
3. What planned awareness actions were implemented during the research, reporting and mitigation phases of the DRMS?
4. What are the gaps in awareness and dolomite risk communication that occur during the different phases of the DRMS and how should it be addressed?
5. What recommendations for dolomite risk communication and awareness can be made to proactively address the vulnerability of people living on dolomite?

### **1.4 General research objective**

To determine how the Tlokwe City Council should communicate the risk associated with dolomite to all affected stakeholders in their municipal jurisdiction.

### **1.5 Specific research objectives**

1. To determine which hazards associated with dolomite pose a risk to residents living in areas underlain by dolomite by conducting a literature study.
2. To specify who the stakeholders affected by dolomite in the TCC are by conducting a literature study and studying the Tlokwe Dolomite case study.
3. To determine what planned awareness actions should be implemented during the research, reporting and mitigation phases of the DRMS by analysing and interpreting

feedback from various stakeholder groupings and responding to gaps perceived in the Tlokwe Dolomite case study.

4. To determine what the gaps in awareness and dolomite risk communication during the different phases of the DRMS is and how it should be addressed, by studying the responses and feedback from the various stakeholder groupings in the Tlokwe Dolomite case study.
5. To suggest recommendations, based on literature and the findings of the study, for dolomite risk communication and awareness to proactively address the vulnerability of people living on dolomite

## **1.6 Research approach and methods**

This study is conducted with a qualitative approach. Qualitative research is exploratory and employs methods such as in-depth interviews with individuals in order to gain insight into their views and opinions on certain subjects (Malhotra, 2008:42). The aim of qualitative research is to identify, analyse, and study themes and patterns from collected data. The significance and importance of these patterns are determined by the research question (Malhotra, 2008:170). Qualitative research is also flexible and can be adapted by the researcher as the study progresses (Babbie & Mouton, 2002:80; Malhotra, 2008:79-81).

### **1.6.1 Literature Study**

The objective of a literature overview is to identify the most important literature in the field of risk communication and environmental risk awareness regarding the occurrence and impact of dolomite on affected communities. A literature study with regard to dolomitic stability and the effects thereof in built areas as well as dolomite risk communication, and risk communication actions associated with the different phases of the Tlokwe DRMS, was conducted.

The following data bases were consulted: Ferdinand Postma-library catalogue, SACat, EBSCOhost: Academic Search Premier Business Source Premier; Communication & Mass Media Complete; EconLit; MCB Emerald; Jstor; Sage Publications; NEXUS; ScienceDirect; SA ePublications; Internet search engines. It has been determined that there exists enough information in order to complete this study. The literature search indicated a gap in research and literature on dolomite risk awareness and the mitigation of dolomite risk by means of awareness actions.

## 1.6.2 Empirical study

### 1.1.1.1 Case Study

A qualitative case study design was implemented where, as Maree (2007:75) describes this type of research, a contemporary phenomenon is studied within its real-life context while the boundaries between the phenomenon and context are not clearly evident and in which various sources of evidence are incorporated. Maree (2007:75) also postulates that case study research presents a multi-perspective analysis in which not only the views of selected participants are considered but also other relevant groups and role players while describing the interactions between them. “The proximity to reality, which the case study entails, and the learning process that it generates for the researcher will often constitute a prerequisite for advanced understanding. In this context, one begins to understand Beveridge’s (1951) conclusion that there are more discoveries stemming from the type of intense observation made possible by the case study than from statistics applied to large groups” (Flyvbjerg, 2006:10).

The case study approach utilised in this study is exploratory and descriptive. An exploratory case study is used when there is no single set of outcomes for an intervention (Baxter & Jack, 2008:548). A descriptive case study describes an intervention in the context in which it happens (Baxter & Jack, 2008:548). A narrative approach will be followed in describing the case study. This approach represents a dynamic interaction between the research objectives, theory, experience, narratives and reflections on interventions and responses to interventions (Bell, 2003a:95).

The evidence used in a case study is well suited for a narrative approach. Green *et al.* (2006:116) present the common sources of evidence in doing a case study as being:

- documents (newspapers, letters, e-mails, reports);
- interviews (open-ended conversations with key role players);
- direct observations;
- participant observations (being identified as a technical role player but also filling a real-life role in scene being studied); and
- physical artefacts.

The abovementioned sources have all been utilised as anchors in describing the evolution of the dolomite risk awareness process as it unfolds in the conceptualisation and implementation of the DRMS. The sources will be analysed by means of content and thematic analysis.

Following the flow of the awareness actions reflected in AGES’s reports and in practice, a dialectic process involving a broad spectrum of stakeholders was initiated, resulting in an awareness plan and eventually a conceptualised model of addressing the vulnerability of

stakeholders affected by dolomite.

In the narrative description of each phase, the actions as part of the Social Awareness Framework (SAF) is implemented to align with the technical research actions. This process has two very prominent characteristics. First, the implementation of actions functions as an iterative process. Redeployment of tools and approaches will be alternated with different stakeholder groupings, contexts and levels of resistance. The second characteristic is that it is a two-way approach. This indicates that the planned actions may be diverted into other strategies, and constant input from within the community or any stakeholder groupings may lead to rethinking of plans and actions, and the deployment of innovative or emergency actions. The SAF and later the Dolomite Risk Awareness Plan (DRAP) constantly accommodates, complies and adjusts according to the current political and social context. It is never haphazard, impulsive or random but rather responds with mitigation on the narratives, events and input into the process. The guideline is always the planned framework, but it is supported and enhanced by informed deviations and repetitions.

This will be an exploratory study as there is a gap in research on environmental risk communication and awareness actions for stakeholders affected by dolomite. Awareness actions were informed by literature within the disaster management, risk awareness and public participation spheres.

### **1.7 Ethical considerations**

In this descriptive study the ethical considerations associated with project implementation were adhered to. In reporting the outcomes of the research the anonymity of project participants will be ensured. The views of all stakeholder groupings will be considered respectfully and reported objectively within the contextual framework.

### **1.8 Chapter layout**

Chapter 2 will provide a description of the hazards associated with dolomite and the formation of sinkholes. Chapter 3 will delineate the stakeholders affected by the dolomite hazard in the TCC that need to be engaged by means of dolomite risk awareness actions. Chapter 4 will track the dolomite risk awareness actions developed parallel with the technical actions that form part of the respective phases of the DRMS. In Chapter 5 the conclusions of this research will be presented in conjunction with recommendation for the design and implementation of a DRAP. The research objectives as addressed within the respective chapters of this study are summarised in Table 1-1 below:

**Table 1-1: Research objectives and chapter summary**

<b>Research Problem</b>		
<b>Chapter 1</b>	How should the Tlokwe City Council communicate the risk associated with dolomite to all affected stakeholders in their municipal jurisdiction?	Defining the problem and definitions
<b>Research Context</b>		
<b>Chapter: 3.1 3.2</b>	The Tlokwe City Council DRMS process and history and context of TCC dolomite.	Defining the problem through context.
<b>Research Questions and outcomes of research</b>		
<b>Chapter 2.1 2.2 2.3</b>	1. Which hazards associated with dolomite pose a risk to residents living in areas underlain by dolomite?	Addressing the research questions within a case study.
<b>Chapter 2.3.2 3.1 3.3.5-3.3.10 3.4 4.3.3</b>	2. Who are the stakeholders affected by dolomite in the TCC?	Description of dolomite risk awareness actions and responses.  Gaps in risk awareness actions.
<b>Chapter 4.3 4.4.3-4.5.14</b>	3. What planned awareness actions should be implemented during the research, reporting and mitigation phases of the DRMS?	Response to gaps in dolomite risk awareness actions.
<b>Chapter 4.2 4.3.6,4.4,4.4.4 4.4.5,4.4.7 4.4.10-4.4.12 4.4.15-4.4.20 4.5.3,4.5.6-4.5.8 5.1.3-5.1.6</b>	4. What are the gaps in dolomite risk awareness that occur during the different phases of the DRMS and how should they be addressed?	
<b>Recommendations</b>		
<b>Chapter 5.2.1-5.2.7 5.3</b>	5. What recommendations for dolomite risk awareness can be made to proactively address the vulnerability of people living on dolomite?	Providing possible framework model for dolomite risk awareness defined by this case study.

## **CHAPTER 2**

### **DOLOMITE RISK IN BUILT ENVIRONMENTS**

#### **2.1 Introduction**

In the previous chapter, the background, research questions and objectives, as well as the research methodology for the study at hand were described. In response to the research question - namely which hazards associated with dolomite pose a risk to residents living in areas underlain by dolomite - this chapter will examine the hazards associated with dolomite and sinkholes and the risks accompanying this hazard. The focus will be on the risk that dolomite and sinkholes present in built areas, focusing on areas under TCC jurisdiction.

Sunday, the 3<sup>rd</sup> of August 1964 a sinkhole swallowed the home of the Oosthuizen family in the Blyvooruitzicht Township near Carletonville. The family of five and their domestic worker perished and disappeared in the abyss forever (GSSA, 2011). This event shocked a nation and opened up the awareness of the hazards associated with unstable dolomitic areas to residents previously unaware of the time bomb under their homes, schools and churches. Knowledge of the hazards associated with dolomite in built areas was always known to mining companies and geologists alike, but now the topic was open for discussion and in the public domain.

In developing an awareness plan to communicate the hazards associated with dolomite to residents there also has to be a commitment to the scientific information that define and quantify the risk to residents (Morgan *et al.*, 2002:34). This entails studying the scientific literature and reports on dolomite and sinkholes to understand the phenomenon in such a way that it can be contracted into the essential data appropriate for conveying the hazards and associated risks clearly.

This is an intellectual approach that relies on natural science and expert inputs (Walaski, 2011:43). This approach can be complicated and lengthy and is not suited to all risk awareness contexts. In the case of the TCC dolomite, the development of the DRMS and the subsequent research period ensured enough time and data to compile a comprehensive and reviewed “expert model” (Morgan *et al.*, 2002:20-21). For the purpose of this study, the expert model is called a Scientific Information and Data Framework. This framework will form the basis of the messages and knowledge material developed to assist in mitigating the risk associated with dolomite and sinkhole formation in built areas which have been described in Chapter 4 of the study at hand.

#### **2.2 Chemical Composition, weathering and dissolution of dolomite**

##### **2.2.1 Chemical composition**

Dolomite is a sedimentary rock that formed in shallow oceanic conditions during the Archaean

to Paleoproterozoic period approximately 300 million years ago (Department of Water Affairs, 2009:4). In the South African context dolomite was referred to initially by President T. F. Burgers, the second president of the Republic of Transvaal of the ZAR in 1871 when he found the Wonderfontein Eye (Wagener, 1984).

Dolomite is a calcium-and magnesium-rich carbonate mineral expressed through the chemical combination  $\text{CaMg}(\text{CO}_3)_2$  (Pretorius, 2012a:5), while the rock type dolomite actually refers to dolomitic limestone (Department of Water Affairs, 2009:6). This dolomitic rock is mineral dolomite mixed with calcite (calcium carbonate,  $\text{CaCO}_3$ ) and magnesite (magnesium carbonate,  $\text{MgCO}_3$ ) (Department of Water Affairs, 2009). The dolomite occurring within TCC forms part of the Malmani Subgroup of the Chuniespoort Group that forms part of the Transvaal Supergroup (Department of Water Affairs, 2009:6) and has alternating bands of insoluble chert and dolomite (Richardson, 2013:9). Meintjes (personal communication, 2016) indicated that limestone is the first precipitation where after dolomite forms, with chert forming as secondary product. Within the dolomite rock there is a network of fractures, joints and faults that form passages for water to infiltrate the rock (Richardson, 2013:13).



Image 2-1: Dolomite the mineral (left) and dolomite the rock (right)

### 2.2.2 Weathering and dissolution

Rain or water that infiltrates the dolomitic rock is charged with carbon dioxide as it passes through the soil and forms carbonic acid which in its flow gradually dissolves the dolomite by leaching of the carbonates, which causes the joints, faults and fractures to widen and eventually form networks of cavities (Richardson, 2013:13). As the water percolates through the horizontal layers of material, the material that are the least densely compacted weathers away first, forming voids in between the competent material (Pretorius, 2012a:6). The dissolution of dolomite to form cave systems and cavities may take thousands or more years (Meintjes, 2016:7).

### **2.2.3 Dolomite Instability**

The stability of dolomite refers to the inherent susceptibility for the formation of sinkholes and subsidences, the magnitude and the frequency with which they can occur within a specific context of triggering mechanisms such as the geology, geomorphology and geohydrology of the area (Buttrick *et al.*, 2014:123).

## **2.3 Hazards associated with dolomite**

### **2.3.1 Karst formation**

The dissolution of dolomite rock forming cavities, voids and cave systems is called karst features (Buttrick *et al.*, 2001:27). This network of caves is typically buried underneath layers of weathered material or products of the weathered dolomite (Buttrick *et al.*, 2001:27). These residual weathered layers can also consist of wad (“weathered after dolomite”) (Meintjes, 2016:8). Wad is a blue-grey or black and fine grained, highly compressible and erodible silty clay (Buttrick, 1986).

The processes that govern the karstification process can be attributed to the following (Klimchouk & Aksem, 2005; Gutiérrez *et al.*, 2007:1010,1011):

- the mineralogy and lithology of evaporates and aquifers;
- the texture and the structure of the soluble rock and aquifers;
- the saturation index, temperature, volume and chemical composition of the water being exposed to the evaporates;
- the groundwater conditions and its flow; and
- variations in piezometric levels (water table fluctuations).

This highly weathered dolomite terrains are known by geologists as karst terrains. Karst terrains are rich in a variety of plants and animals and are well known for its fresh underground water sources.

### **2.3.2 Subsidence**

When wad and other residues come into contact with water it collapses or dissolves and flow into the cavities and cave systems. This dissolution of the cave roof leads to ground movement on the surface (Buttrick *et al.*, 2001:27). These ground depressions are usually sub-circular and can be hundreds of meters wide and very deep (Gutiérrez *et al.*, 2007:1008). These depressions can usually be identified by concentric cracks along the borders (Pretorius, 2012a:8).

### 2.3.3 Sinkholes

Sinkholes can be formed by a variety of processes such as bedrock dissolution, rock or soil collapse (Waltham *et al.*, 2007:26). When one of these processes occur the sediment can be washed into the ground lowering the ground surface or the dissolution of the rock may lead to the collapse of the ground forming a hole in the ground surface (Waltham *et al.*, 2007:26). Sinkholes can lead to damage to infrastructure and buildings with great financial implications and loss of lives (Gutiérrez *et al.*, 2007:1008). Buttrick *et al.* (2001:27) describes this process as a catastrophic movement of the surface of the ground that can happen within seconds and without prior warning signs. Smaller sinkholes (5 m to 20 m in diameter) are usually a result of ingress of water, while larger sinkholes (more than 20 m in diameter) are usually the result of dewatering (Buttrick & Roux, 1993:291).

Waltham *et al.* (2007:27) classify sinkholes as follows:

**Table 2-1: Sinkhole classification (Waltham *et al.*, 2007)**

Sinkhole Classification	Description
Solution sinkhole	Very large, occurs through natural lowering of the floor through dissolution of soluble rock.
Collapse sinkhole	Rapid collapse of the roof of the cavity, falling inward.
Caprock sinkhole	Rapid collapse of insoluble material overlying soluble rock cavities, falling in cavity.
Dropout sinkhole	Rapid collapse of overlying soil into fissures in soluble rock underneath the insoluble material.
Suffusion sinkhole	Non-cohesive material washed into fissures in soluble rock over a prolonged period.
Buried sinkhole	Soil filled surface dissolution

(Adapted from: Waltham *et al.*, 2007).

In South Africa the prevalent sinkhole types are collapse and caprock sinkholes (Pretorius, 2012a:8). The effect of these sinkholes is that they collapse in a catastrophic way without warning signs (Gutiérrez *et al.*, 2007:1008). Sinkholes can also be classified according to their surface manifestation or size. In Table 2-2 below the classification according to Buttrick (2014:124) is represented:

**Table 2-2: Sinkhole sizes**

Maximum diameter of surface manifestation	Terminology
< 2 m	Small-size sinkhole/subsidence
2-5 m	Medium-size sinkhole/subsidence
5-15 m	Large-size sinkhole/subsidence
>15 m	Very large-size sinkhole/subsidence

(Adapted from: Buttrick *et al.*, 2014)

Figure 2-1 depicts the scale of sinkhole formation in the presence of leaking infrastructure at the Carletonville reservoir in June 2016. This sinkhole would be classified as very large when implementing the guidelines in Table 2-2 above.



Figure 2-1: Sinkhole at Carletonville reservoirs

#### 2.3.4 Anthropogenic factors

Human activities that represent the anthropogenic susceptibility in areas with high inherent susceptibility include all actions that would introduce the ingress of groundwater, the abstraction of water from dolomitic aquifers, or destabilisation of the overburden on unstable dolomitic areas, which can result in the formation of sinkholes or subsidences (Department of Water Affairs, 2009:5). Water leaks that erode the soil cover, groundwater abstraction and fluctuation of the groundwater table all lead to the instability of dolomite (Department of Water Affairs, 2009:5). Activities that usually coincide with development disturb the metastable conditions that were prevailing in the karst through the following possible scenarios:

- artificial altering of natural drainage patterns;
- induced water concentration;
- flow velocities are either retarded or enhanced; and
- superficial soil material disturbed and permeability affected (Buttrick & Roux, 1993:291).

In order to illustrate the effects of anthropogenic factors on dolomite stability, Buttrick *et al.* (2011:1133,1134) studied the co-occurrence of sinkhole and subsidence events with service types such as bulk pipelines and storm water systems as well as buildings from 1984 to 2004, and some of the findings were:

- 167 events occurred on 108 km of water and bulk pipelines (1.35 events per kilometre of pipeline).
- 255 events were reported along 225 km of storm water pipelines (1.14 events per kilometre storm water pipes).
- 38% of all events recorded coincide with structures and affects the stability and integrity of the buildings.
- 220 331 m<sup>2</sup> buildings were lost as a resulting of 246 events.

This study by (Buttrick *et al.*, 2011:1133, 1134) focuses on the coincidence of infrastructure on dolomite that also leads to the loss and damage of infrastructure. This is supported by Roux (1984) in a study of 10 sinkholes on the western side of Pretoria, where it was found that all the sinkholes were induced by anthropogenic factors.

Tragically, the impact of anthropogenic factors on dolomite also claims lives. The following table (2-3) from Buttrick and Roux (1993:292) illustrates this:

**Table 2-3: Sinkhole Fatalities in South Africa**

Event	Date	Fatalities	Sinkhole diameter
West Driefontein	12 December 1962	29	>55m
Blyvooruitzicht	3 August 1964	5	>55m
Verwoerdburg (Centurion)	1970	3	5m
Venterspost	24 October 1970	1	>5m
Carletonville	29 July 1980	1	>5m

Subsequently the effect of anthropogenic factors on the risk posed to vulnerable communities will be examined in more detail in 2.1. of this chapter.

## 2.4 Anthropogenic Susceptibility of built environments

When assessing the risk of a hazard such as dolomite scientists use the traditional risk equation (Bell, 2003b:206):

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability} \times \text{Exposure (damage)}$$

The hazard component in this formula refers to the risk associated with a hazard such as unstable dolomite as a function of the inherent susceptibility. Buttrick *et al.* (2014:131,132) suggest that the definition of this hazard be broadened to include the anthropogenic susceptibility. When assessing the inherent classification of areas underlain by dolomite the anthropogenic factors have not been included. Of the sinkholes that form, 99% can be attributed to anthropogenic factors within a site deemed to exhibit high inherent susceptibility (Buttrick *et al.*, 2014:131).

Engineering geological dolomite stability investigations are generally undertaken prior to development to determine the inherent hazard classes as defined by the following hazard classification areas and their definitions (table 2-4):

**Table 2-4: Inherent Hazard Classification**

Inherent Hazard Class	Characterization of area
Class 1 Areas	Areas characterized as reflecting a low inherent susceptibility of sinkhole and subsidence formation (all sizes).
Class 2 Areas	Areas characterized as reflecting a medium inherent susceptibility of small-size sinkhole and subsidence formation
Class 3 Areas	Areas characterized as reflecting a medium inherent susceptibility of medium-size sinkhole and subsidence formation
Class 4 Areas	Areas characterized as reflecting a medium inherent susceptibility of large-size sinkhole and subsidence formation.
Class 5 Areas	Areas characterized as reflecting a high inherent susceptibility of small- size sinkhole and subsidence formation.
Class 6 Areas	Areas characterized as reflecting a high inherent susceptibility of medium-size sinkhole and subsidence formation.
Class 7 Areas	Areas characterized as reflecting a high inherent susceptibility of large- size sinkhole and subsidence formation.

Class 8 Areas	Areas characterized as reflecting a high inherent susceptibility of very large-size sinkhole and subsidence formation.
---------------	--

(Buttrick *et al.*, 2014)

When considering classification in built areas the anthropogenic factors are pivotal to the assessment. Dolomite Risk Management Areas (DRMA) are used as a means to qualify and quantify the inherent susceptibility classification in conjunction with the anthropogenic susceptibility of each zone. Each DRMA is linked to a specific classification in conjunction with applicable mitigation and management measures. In older areas where Dolomite Stability Investigation (DSI) has not been conducted, this becomes very problematic as the hazard of non-compliant and aging infrastructure cannot be quantified (Pretorius, 2012a).

#### **2.4.1 Communities underlain by dolomite**

About 10 percent of the earth's dry land is underlain by dolomite. In South Africa, the distribution of dolomite is not as vast, but highly concentrated urban development took place on some of the dolomite (Meintjes & Muller, 2016). Of the 234 local municipalities in South Africa, 40 are affected by dolomite to some extent and in these 40 municipalities, approximately 4 to 5 million people work and live on dolomite (Meintjes & Muller, 2016). The first area or basin covers large areas of the Northern Cape Province and parts of the North-West Province. This basin is called the Griqualand West basin. The second basin where dolomite occurs is in the Transvaal basin, which covers large parts of the North-West, Limpopo, Gauteng and Mpumalanga Provinces. It stretches from the Orkney-Stilfontein area, to Potchefstroom, and towards Ventersdorp and Carletonville. From Carletonville it reaches towards Pretoria, some parts of Soweto and towards the East Rand. The Limpopo Province between Mokgalakwena and Thabazimbi as well as parts of Mpumalanga Province in the Graskop-Sabie area are also affected by dolomite (Meintjes & Muller, 2016). Figure 2-2 indicates the occurrence of dolomite in South Africa and figure 2-3 indicates the occurrence of dolomite in the North-West province.

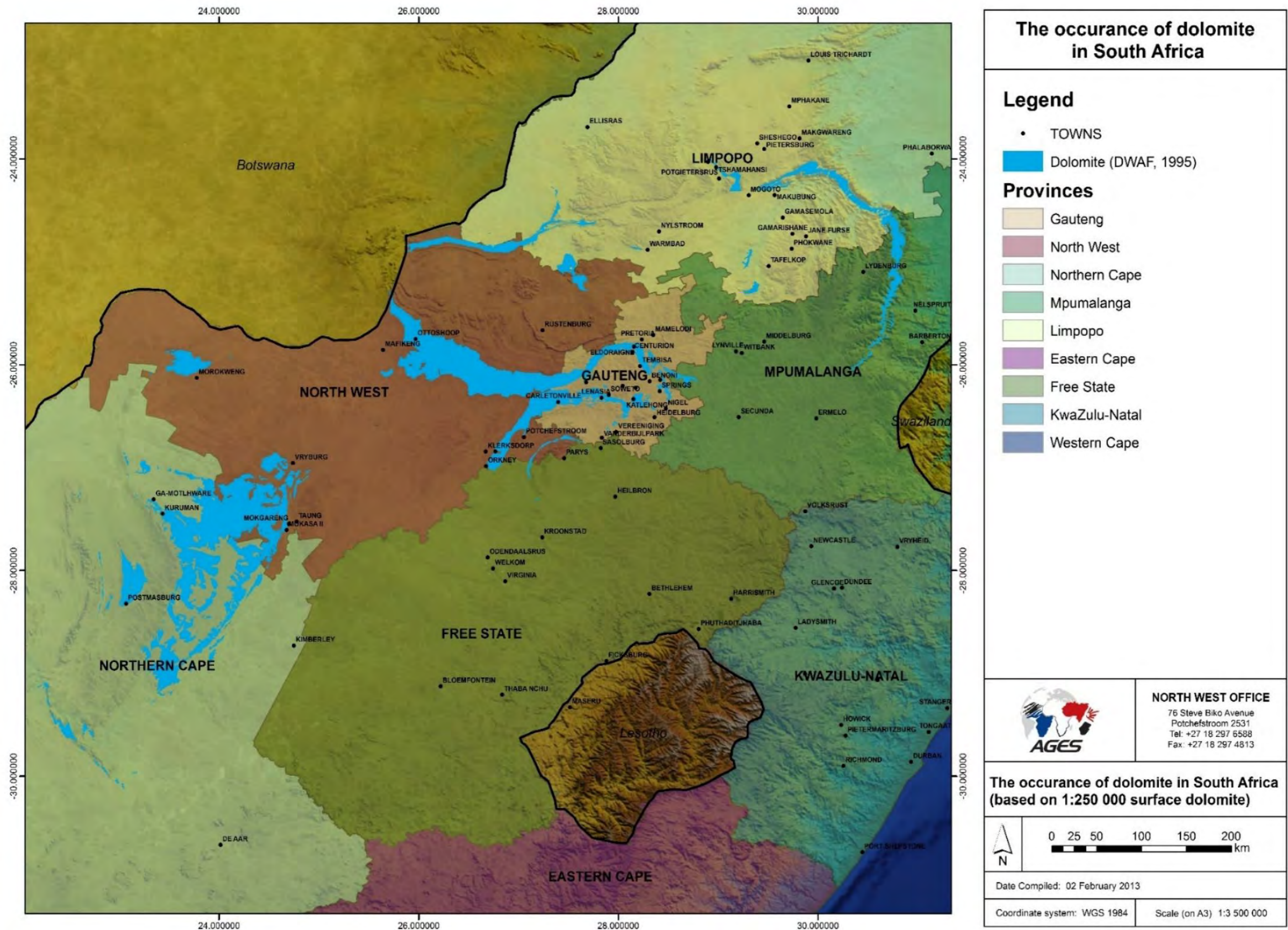


Figure 2-2: The occurrence of dolomite in South Africa (AGES, 2013e)

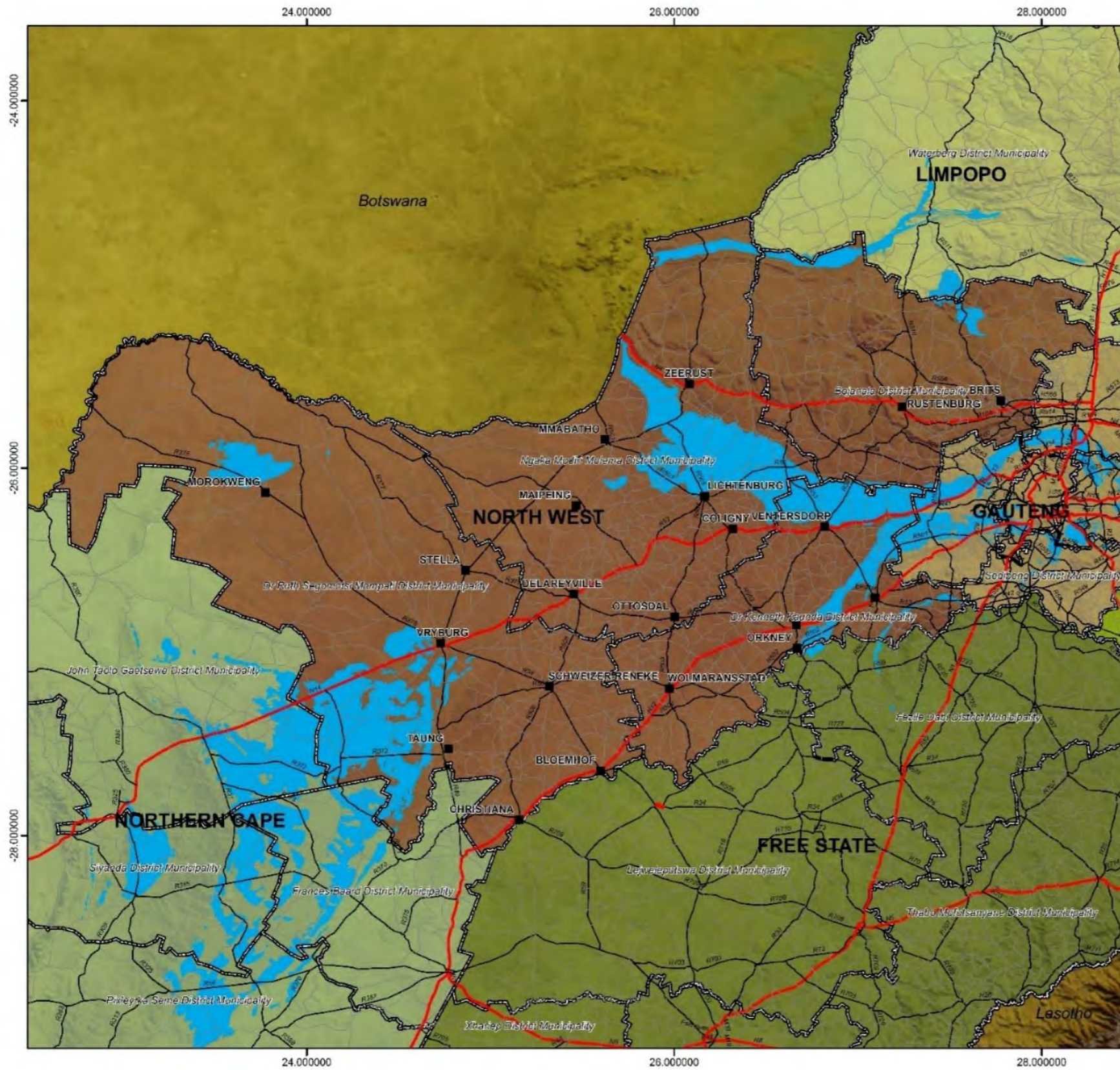


Figure 2-3: Occurrence of dolomite in North West Province (AGES, 2013e)

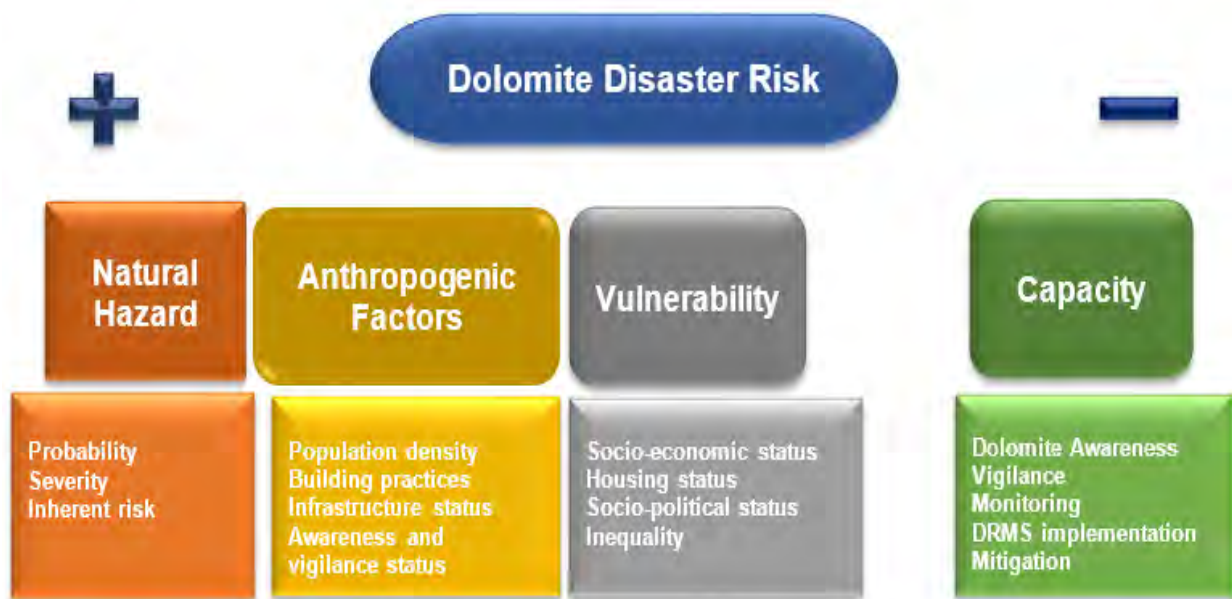
Dolomite has become a political issue because of the unfortunate urbanization that has taken place on it (Buttrick & Roux, 1993:292). As the availability of land is always a burning issue, settlement on dolomitic land has placed immense strategic and financial pressure on government. Due to rapid urbanization the normal route of town planning and land allocation cannot take place at a fast enough pace to keep up with the development of informal settlements in the dolomite affected areas (Buttrick & Roux, 1993:292). The effect of this trend is that engineering geological investigations on dolomite must be conducted in retrospect and under difficult conditions (Buttrick & Roux, 1993:293). In these built environments, the process of research and communication of risk becomes a strategic and sensitive issue.

The worst case scenario described by Buttrick and Roux (1993:293) is that water leaks and failure of overburdened infrastructure, because of high population density and low cost development, may lead to increased probability of events and higher fatalities due to population density. The occurrence of an event such as the Blyvooruitzicht sinkhole (1964) may potentially claim 300 to 400 lives, as high density areas houses up to 1,680 people per hectare (Buttrick & Roux, 1993:293).

Considering the significant impact of anthropogenic factors on dolomite stability accompanied by the vulnerability of the communities most affected by its hazards, the inclusion of anthropogenic factors in any risk equation regarding dolomite is essential. The greater the vulnerability of the community, the greater the anthropogenic impact will be (Buttrick & Roux, 1993:293). Throughout this research the focus on capacitation of communities underlain by dolomite and the effect thereof on their vulnerability, as well as anthropogenic susceptibility of the affected area, will be highlighted. The capacity of the community has been added to the traditional risk equation to illustrate the balancing effect of capacitation through awareness and vigilance.

The inherent susceptibility of the dolomitic hazard cannot be controlled but the vulnerability of the affected community can be reduced through capacitation. By focusing on the capacity building aspect of the equation the anthropogenic susceptibility will also be greatly impacted. The following equation expanding on the traditional risk equation is proposed and is visualised in figure 2-4:

$$\text{Risk} = F_n \frac{\text{Dolomitic Hazard} \times \text{Vulnerability} \times \text{Anthropogenic Susceptibility}}{\text{Capacity}}$$



**Figure 2-4: Dolomite risk equation as amended by the inclusion of anthropogenic factors (own depiction).**

The declining levels of service delivery and aging infrastructure contribute to the anthropogenic susceptibility of the built environment underlain by dolomite. The risk presented by the inherent susceptibility and impacted by the anthropogenic susceptibility will be amplified by the vulnerability of communities underlain by dolomite. The risk can be mitigated by capacitating vulnerable affected communities. In the following chapter the settlement of communities adjacent to dolomitic areas in TCC jurisdiction will be chronicled. Chapter 3 will also report on the engagement of stakeholders in the mitigation of risk. The role of capacity building as part of the mitigation of risk will be addressed in Chapter 4 of the study at hand.

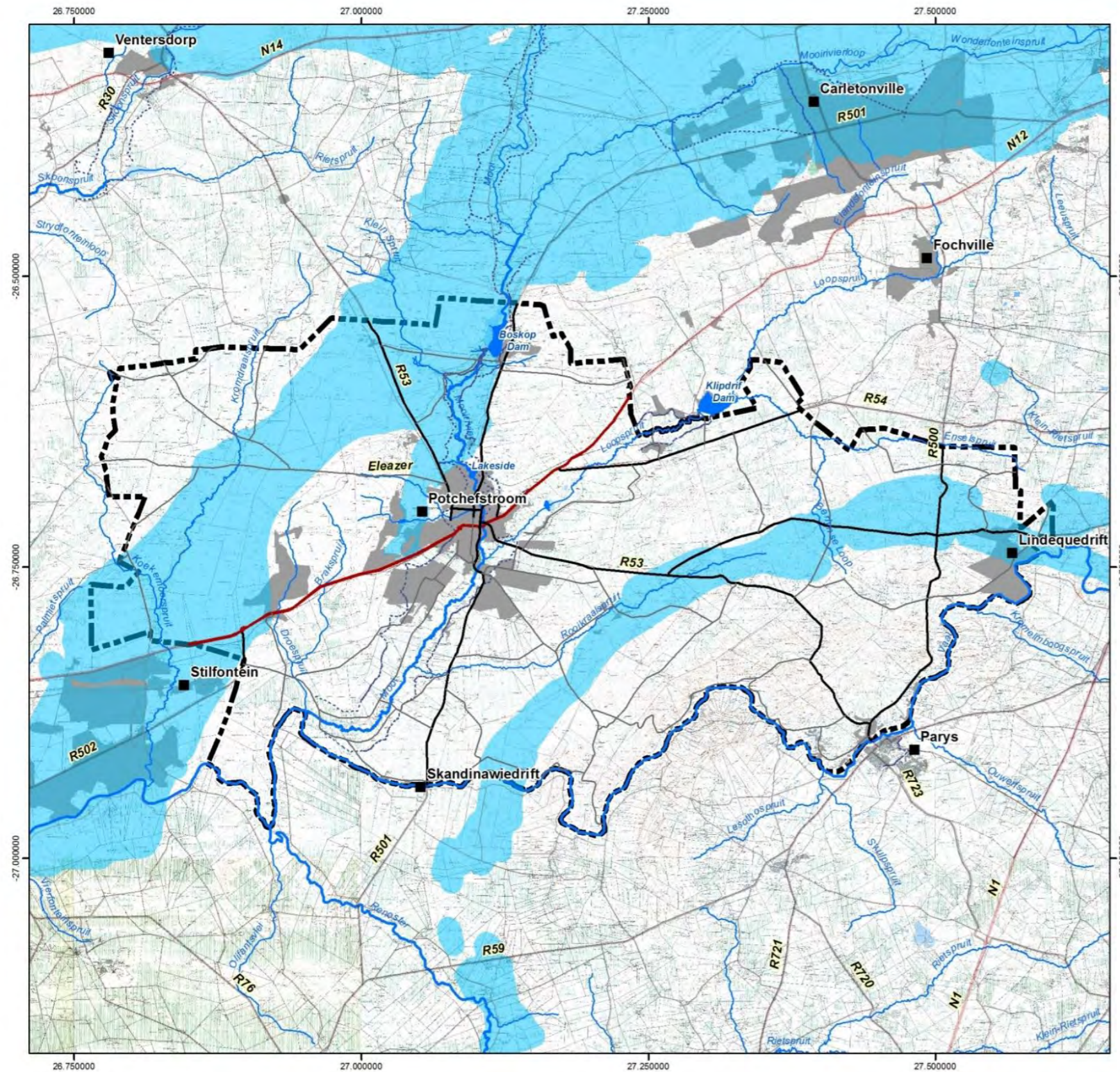
## CHAPTER 3

### TLOKWE COMMUNITIES LIVING ON DOLOMITE

#### 3.1 Introduction

In the preceding chapter the risk posed by dolomite and sinkholes in built areas were defined in terms of the inherent susceptibility as well as the anthropogenic susceptibility. In Chapter 3 the research question enquiring as to who the stakeholders are that have to be engaged in the TCC case study, will be addressed. The settlement of communities adjacent to and subsequently on dolomitic land will be elucidated. Following this explanation, the focus will be on the engagement of stakeholders within the context of the TCC DRMS.

The Tlokwe City Council (TCC) forms part of the Dr Kenneth Kaunda District Municipality in the North-West Province of South Africa. In the TCC dolomite is located to the west of Potchefstroom in portions of the Ikageng, Promosa and Mohadin townships (AGES, 2013e). Figure 3-1 illustrates the occurrence of dolomite in TCC jurisdiction. These areas have traditionally been demarcated respectively for Black, Coloured and Indian residents by the Apartheid government. The history and process are significant for the comprehension of many narratives and attitudes associated with the DRMS and risk awareness actions, as will be observed in Chapter 4 of this study.



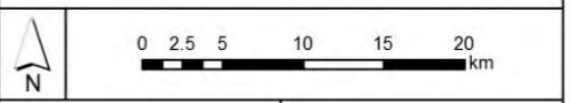
**Tlokwe City Council,  
Dolomite Risk Management Strategy**



- Legend**
- Towns
  - Settlements
  - Dolomite Affected Area
  - Canals
  - Primary Rivers
  - Secondary Rivers
  - Dams
  - Tlokwe City Council
- Roads**
- National
  - Primary
  - Secondary

**AGES**

**NORTH WEST OFFICE**  
 76 Steve Biko Avenue  
 Potchefstroom 2531  
 Tel: +27 18 297 6588  
 Fax: +27 18 297 4813



Date Compiled: 2013/06/30      Compiled by: H Pretorius  
 Datum: WGS 1984      Scale (on A3): 1:350 000

Figure 3-1: Distribution of dolomite in Tlokwe City Council (AGES, 2013a)

During Phase 1 of the DRMP, Kobus du Pisani (2013) contributed to the DRMS by summarizing the historical development of Ikageng, Promosa and Mohadin, which gives an indication of the motivation for developing these areas in this specific location.

## **3.2 The historical development of Ikageng, Mohadin and Promosa**

### **3.2.1 Ikageng**

In the 1870's Potchefstroom saw the beginning of segregation according to race (Du Pisani, 2013). The South African Republic (ZAR) issued notices that the coloureds should be settled in a separate part of town. They were Afrikaans-speaking coloureds, slaves that were freed and Xhosa-speaking people. The area in Potchefstroom where black residents were resettled to was called Makweteng. In honour of the supervisor of this location, it was renamed in 1945 as Willem Klopperville. Shortly thereafter, the need arose to extend this location. However, it was decided to rather relocate the current location so that extensions could be made. An area west of Potchefstroom, adjacent to the Department of Defence was identified for this purpose. A third of this land belonged to the Department of Defence and they were not enthusiastic about letting it go (Du Pisani, 2013).

In 1949 the Potchefstroom municipality gained permission to build the location. The Minister of Native Affairs appointed a committee to investigate alternative sites and conduct public participation. They agreed that the site earmarked by the municipality was suitable to build a location on. In the new location there was space for 6,000 stands to house 40,000 people. The government intervened and forced the Department of Defence to include their adjacent property in the new location (Du Pisani, 2013).

Land surveying and spatial planning was conducted, but no mention was made of the existence of dolomite. Geological surveys had been done in this area and the existence of dolomite with its associated risks was known, but no legislation existed for township development to comply with risk quantification on dolomite. The first houses were completed in 1954 and the area was renamed to Ikageng. By the early 1960's the resettlement from Willem Klopperville to Ikageng was completed (Du Pisani, 2013).

The end of the Apartheid regime and abolishment of the Group Areas Act meant that influx control was also abolished. Beginning from the 1980's there was a huge influx of informal settlers into Ikageng. This meant that town planning and service delivery could not keep up with this added pressure. From 1994 Ikageng was enlarged with 4 extensions and three more was added by 2008. These extensions were established without prior geological and geohydrological investigation (Du Pisani, 2013).

### **3.2.2 Promosa**

During the 1950's most coloured residents of Potchefstroom lived in Willem Klopperville alongside the black residents. After the black residents were relocated to Ikageng the suggestion was to proclaim Willem Klopperville as a coloured area. The newly formed *Waaksaamheidskomitee* (Vigilance committee), headed by Reverend Mieder Olivier decided that this would not be desirable in the all-white Potchefstroom. Van Rensburg (2006:133-149) concluded that Reverend Olivier viewed the resettlement as an investment in the future of his people and essential to their survival. Du Pisani (2013) notes that shortly after the 1962 municipal election the municipality was in agreement that the coloureds should also be relocated to an area west of Potchefstroom, adjacent to the *Piekniekpoortje* dam.

This area was named Promosa to indicate the promise of a new beginning with better living conditions. The families that were relocated were given R10 if they owned a house on their stand, and an additional resettlement fee of R10 (not even covering 2 months' rent in Promosa) (Van Rensburg, 2006:133-149). At this stage coloureds from other rural towns were centrally urbanised by government and Promosa was earmarked as one of the locations to receive a portion of the 10, 000 coloureds.

The residents were forcefully removed and not included in any consultation process. They also complained about the quality of the buildings, which were sub-standard. They felt that they were definitely in a worse situation than before (Du Pisani, 2013).

### **3.2.3 Mohadin**

Since the 1880's Indian businessmen had moved into Potchefstroom, settling close to the centre of town, in an area known as the Asiatic bazaar. In 1958, the Group Areas Act Board decided to settle all Indians in the vicinity in the Asiatic Bazaar. The *Waaksaamheidskomitee* resurfaced to oppose this decision as well. The group objected to such an extent that the Group Areas Act Board revised their decision to support the municipality's proposal of an area adjacent to Promosa at the *Piekniekpoortje* dam. This resettlement began in 1970 and Mohadin Extension 1 was proclaimed (Du Pisani, 2013).

The development of Ikageng, Mohadin and Promosa are tracked in the following slides (figure 3-2 to 3-12), representing a timeline within the context of dolomite information, significant sinkhole events and guidelines for development as from 1939 up to the present (Pretorius, 2016):

# TIMELINE OF SETTLEMENT DEVELOPMENT IN TLOKWE IN CONTEXT OF DOLOMITE INFORMATION AND GUIDELINES FOR DEVELOPMENT (1939 – PRESENT)



*History of settlement research report conducted by Prof Kobus du Pisani (2013)  
Published Geological Maps: 1:250 000 Wes Rand 2626 Geology Map (1986);  
Dolomite Affected Area AGES (2013)*

Figure 3-2: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

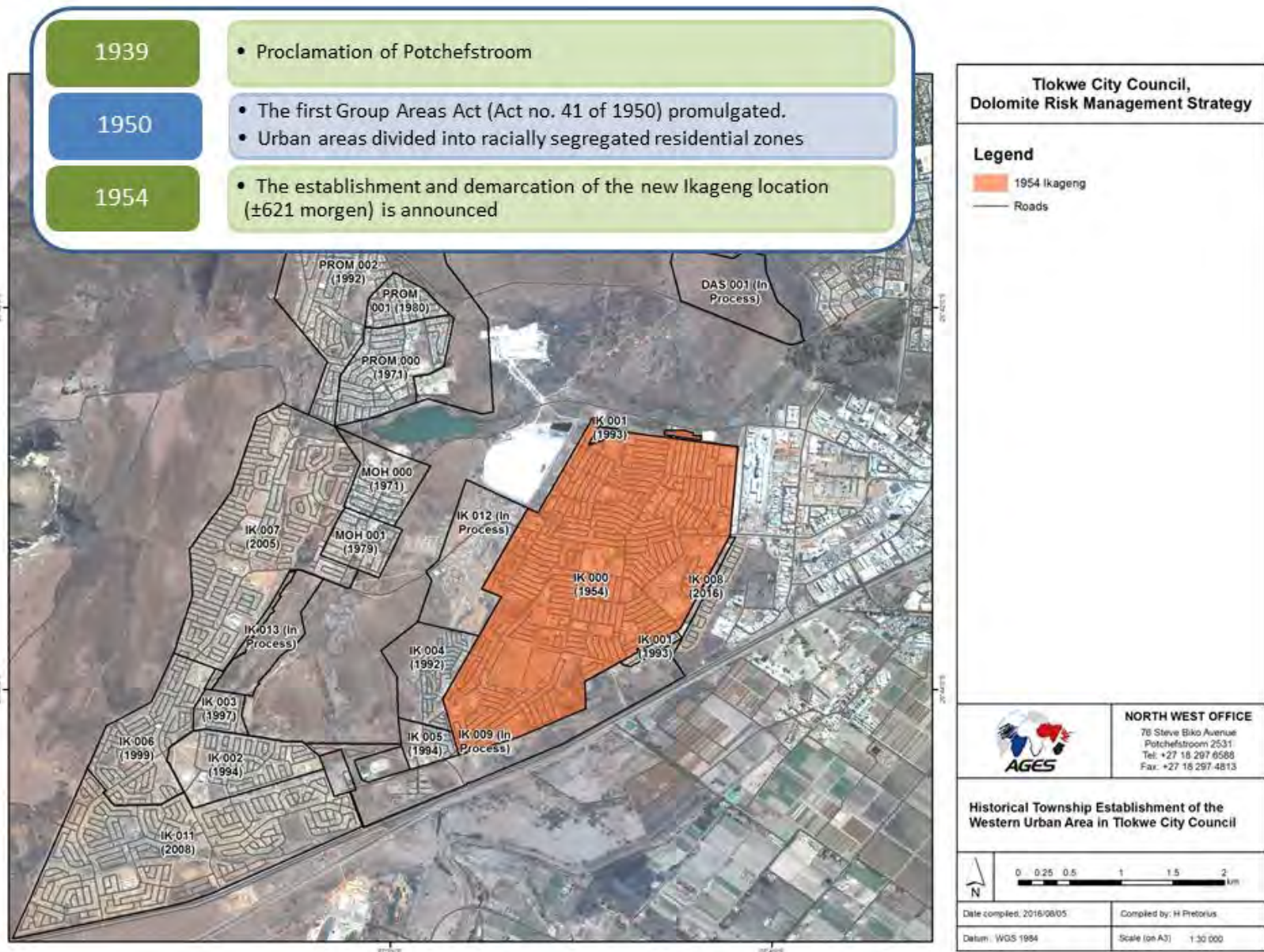


Figure 3-3: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

1962	<ul style="list-style-type: none"> <li>• West Driefontein Sinkhole: crusher plant and 31 mineworkers disappear into sinkhole</li> </ul>
1964	<ul style="list-style-type: none"> <li>• Dewatering of compartments</li> <li>• Blyvooruitzicht Sinkhole: Oosthuizen family disappears into sinkhole</li> </ul>



Figure 3-4: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

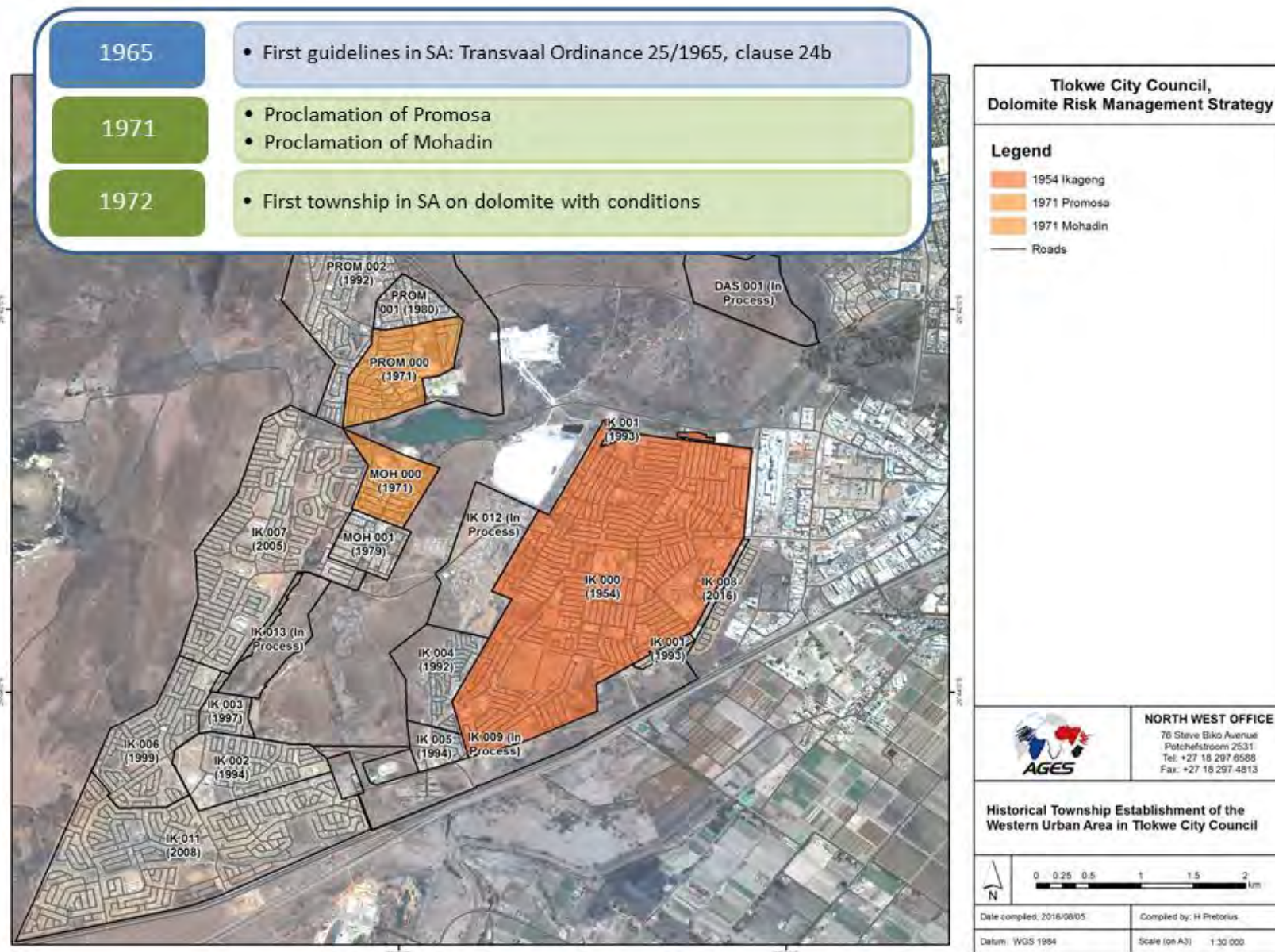


Figure 3-5: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

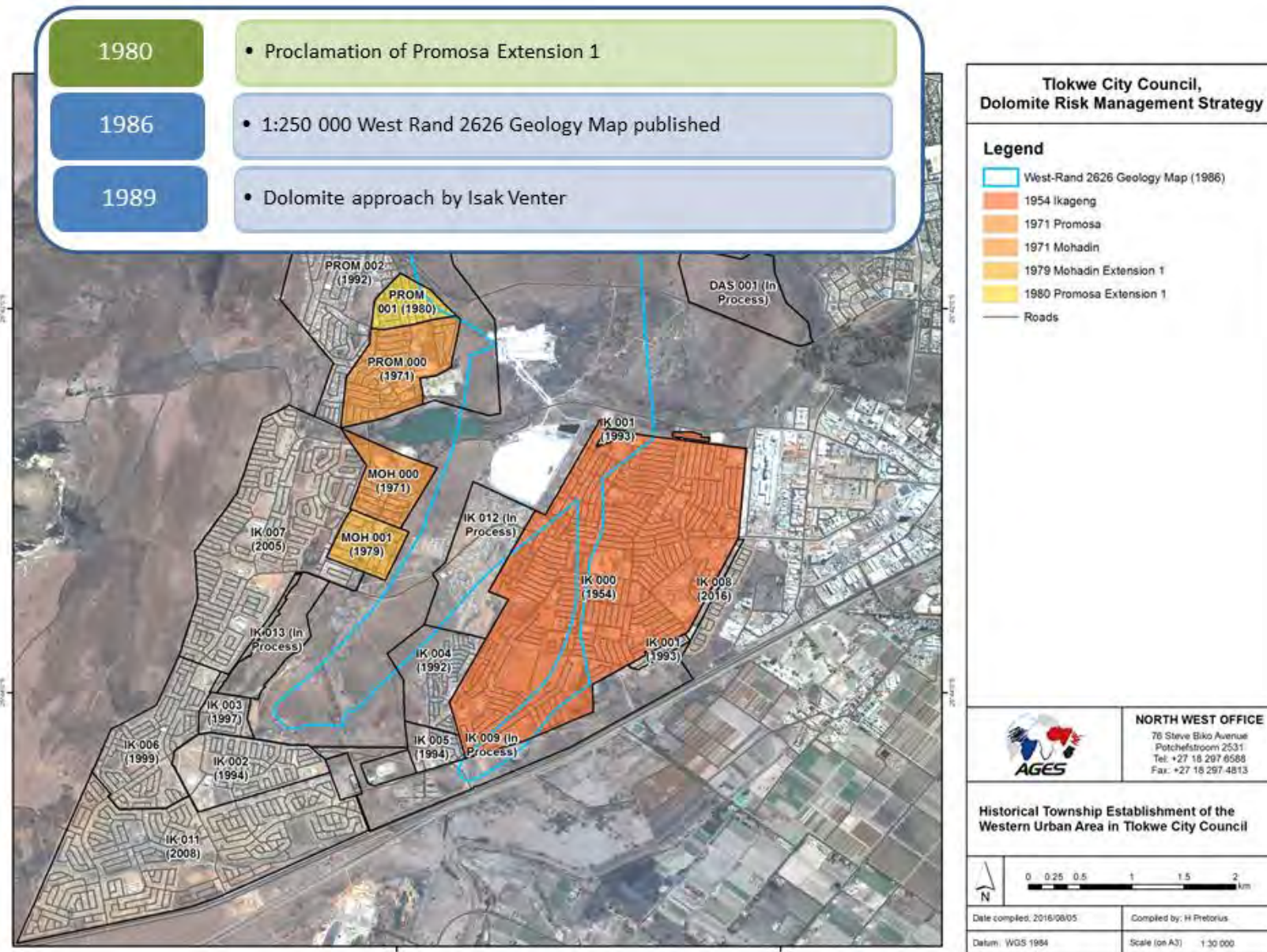


Figure 3-6: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

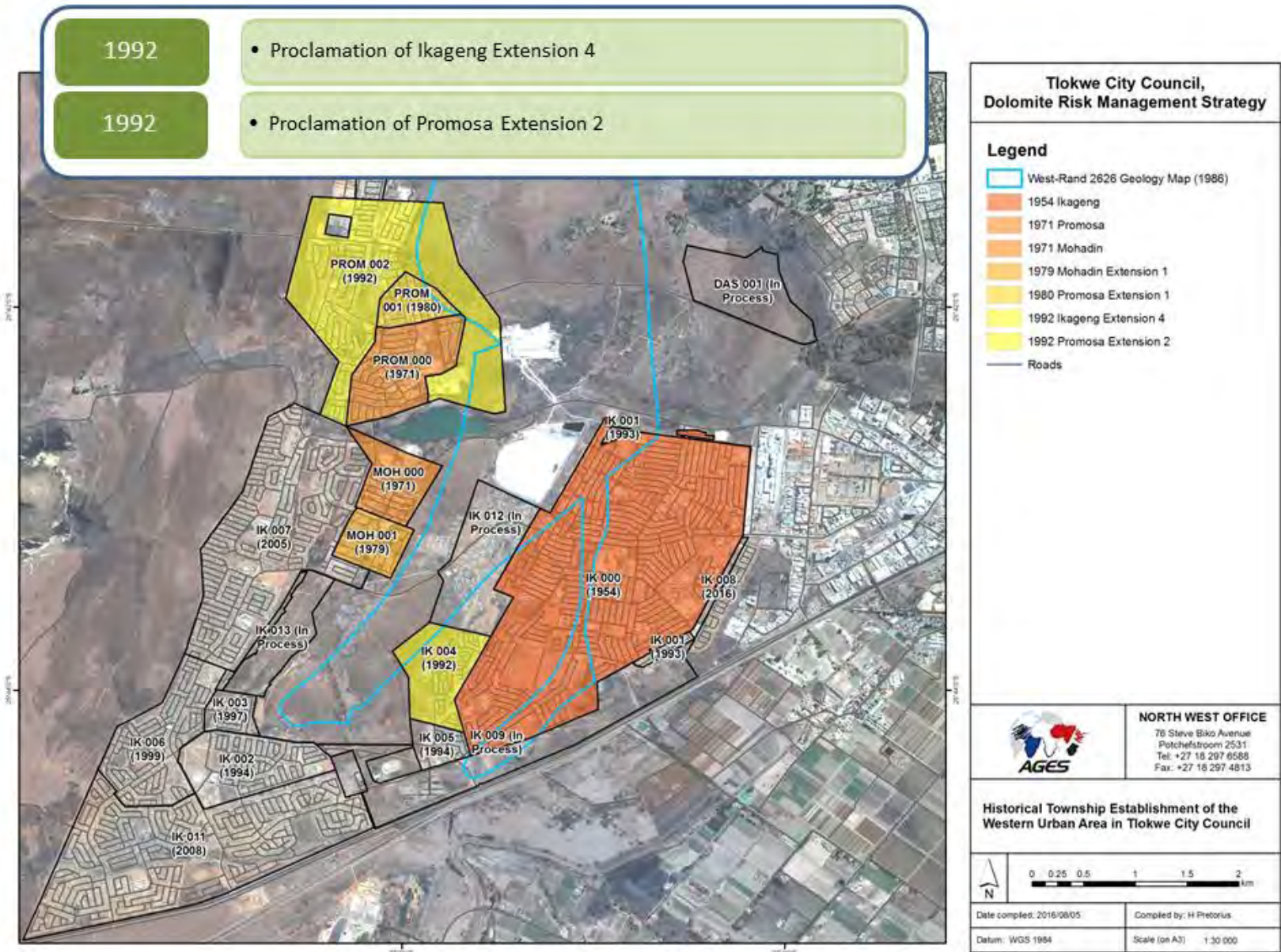


Figure 3-7: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

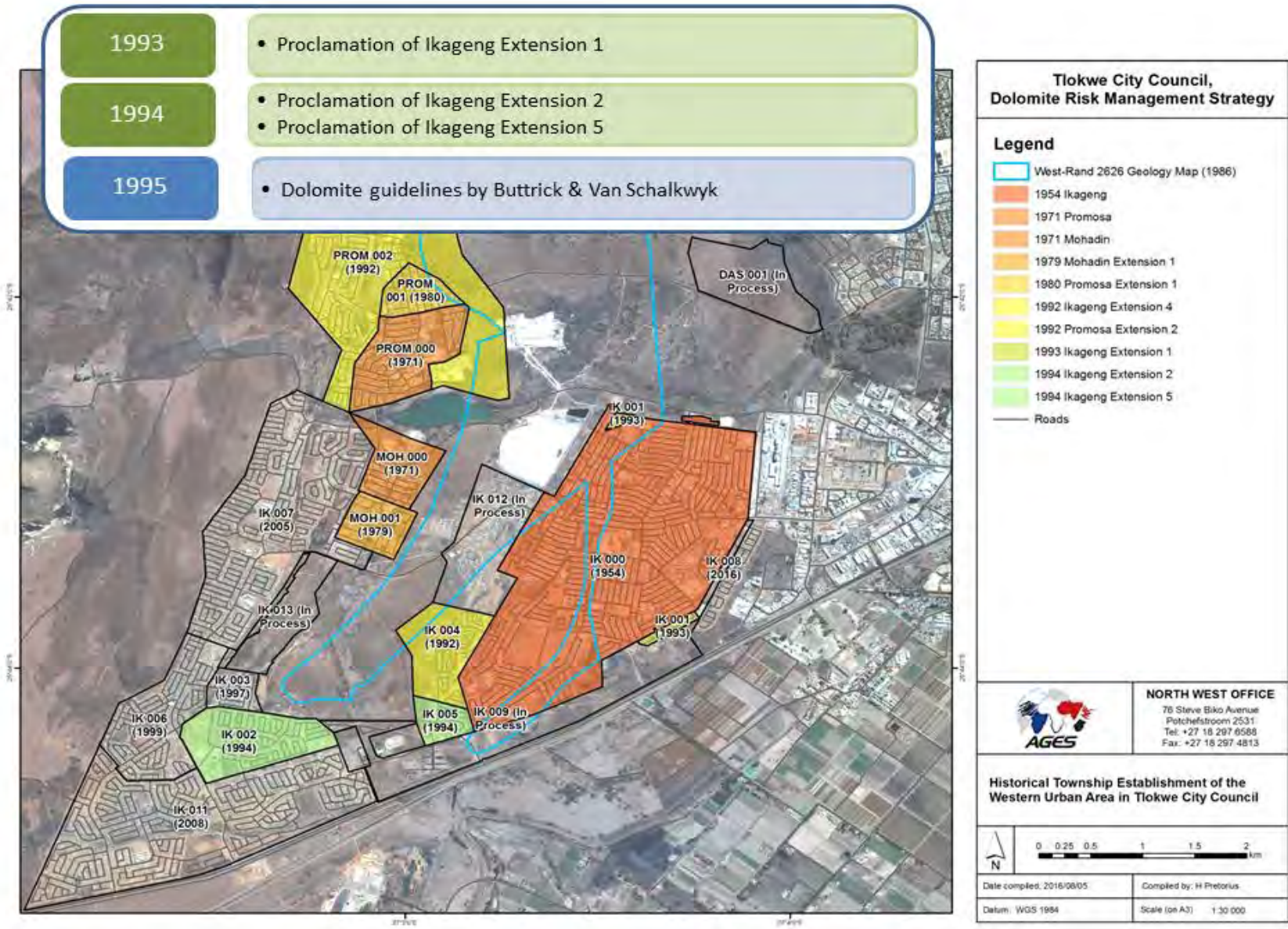


Figure 3-8: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

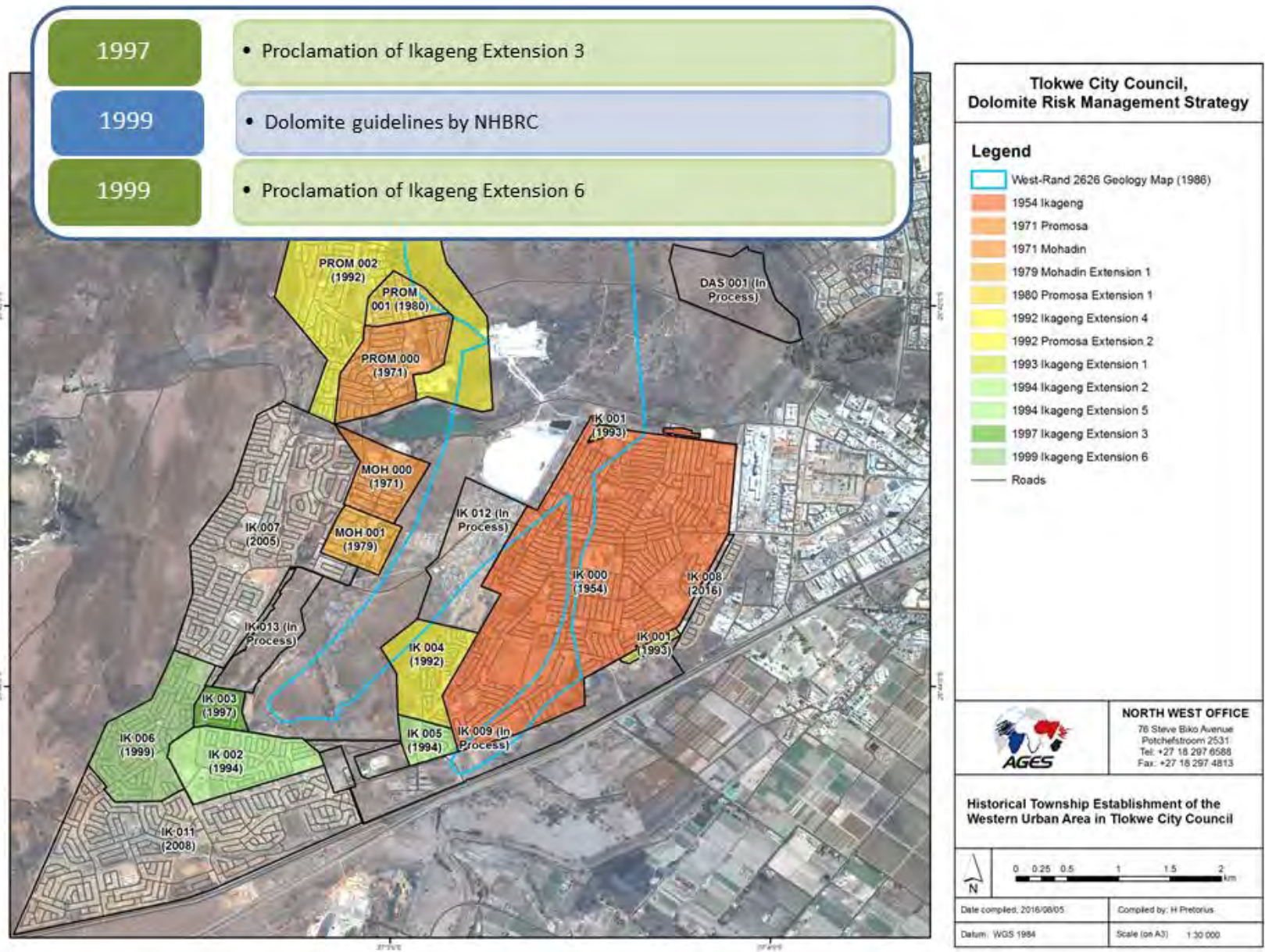


Figure 3-9: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

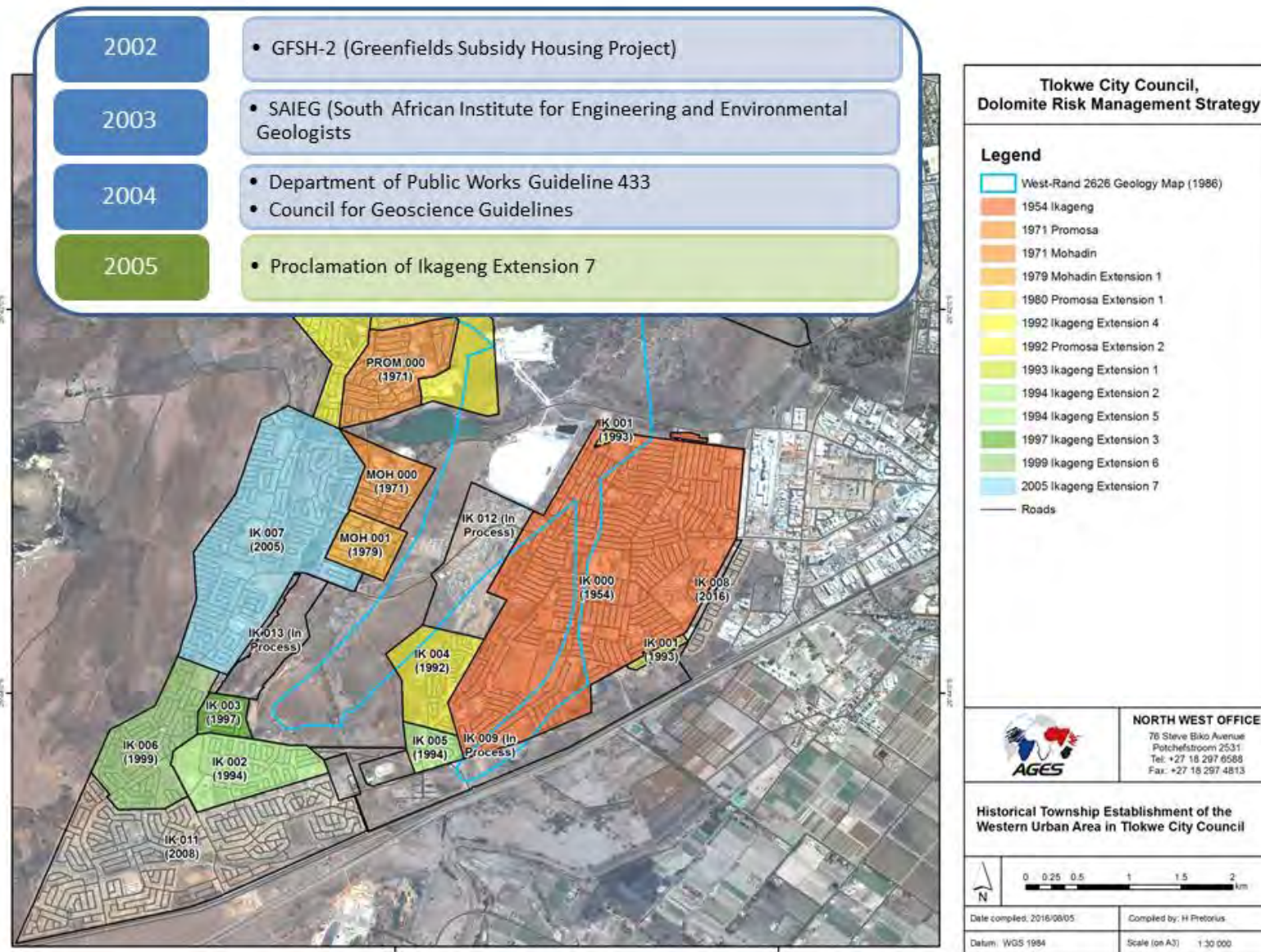


Figure 3-10: Timeline of settlement development in context of dolomite information and guidelines for development (Pretorius, 2016)

### **3.2.4 The Tlokwe Dolomite Risk Management Strategy as response to the occurrence of dolomite in TCC built areas**

The draft SANS 1936 (2009) as well as SANS 1936 (2012) regulating development on dolomitic land requires that local authorities that administrate land underlain by water soluble strata such as dolomite must develop and implement a DRMS prescribed to local authorities underlain by dolomite and that a DRMPr should be established and implemented. Geological studies in the jurisdiction of TCC indicated the presence of dolomite. Township establishment on dolomite as well as encroaching of settlements on dolomitic areas were a reality in the TCC jurisdiction. The process to establish a DRMPr was triggered by this regulation.

The most effective way of mitigation is naturally avoiding the subsidence areas and areas with high inherent susceptibility (Gutiérrez *et al.*, 2007:1018). As this is not always possible and in the case of TCC has not been adhered to in the past, preventative measures and regulations have to be introduced to regulate and limit development on hazardous dolomitic land. Dolomitic areas that have already been developed, have to be managed in order to reduce the effect of possible sinkhole or subsidence events (hazard) that can have catastrophic effects on vulnerable communities.

The TCC had to develop a DRMPr to mitigate the risk (AGES, 2010b; AGES, 2011; AGES, 2013e; AGES, 2013a; AGES, 2013b). Paukštys *et al.* (1999:1) argue that the most effective way to manage and implement these plans is when they are developed by the local administration. The TCC was not only required to manage and mitigate the dolomite risk in their jurisdiction but also the ideal agent to do so.

During 2009, the TCC introduced a phased DRMPr containing four processes within the framework of a 5 year three-phased implementation. During the first phase (Phase A) the hazard was identified and status determined, during Phase B the risk was quantified and evaluated and Phase C focuses on mitigation and management of the risk (Potgieter *et al.*, 2016:1018,1019). The respective phases will be explained in more detail in Chapter 4 of the study at hand. Figure 3-13 illustrates this process.

The DRMPr quantifies the hazard and determines the inherent and anthropogenic factors that increase the risk to residents and TCC (Potgieter, 2016:69). The DRMP guides the TCC on how to implement the strategy proposed for the management of dolomite risk with detailed recommendations on how to monitor, manage and mitigate the TCC dolomite risk (Potgieter *et al.*, 2016). The DRMS is the short, medium and long term framework and enforcing mechanism to put the DRMP into effect (Potgieter *et al.*, 2016). This allows the DRMPr to be implemented in

a systemised way.



Figure 3-11: TCC Strategic Planning for DRMPr adapted from AGES (2014)

In introducing the phased DRMPr, the TCC also initiated a process of engaging stakeholders affected by the dolomite hazard in different ways and with a variety of roles to fulfil in this process.

### **3.3 Engagement of stakeholders as part of the Tlokwe DRMS**

#### **3.3.1 Imperative to provide dolomite risk awareness to affected communities in TCC**

The affected community has the right to know which risks they are exposed to and public participation will contribute towards reducing the probability of events occurring, making it critical to educate the community on monitoring and vigilance (Buttrick & Roux, 1993; Buskirk *et al.*, 1999; Gutiérrez *et al.*, 2007). Morgan *et al.* (2002:7) postulate that during and following research, technical specialists and scientists are often not communicative about the hazards and associated risk to affected stakeholders, which leads to loss of credibility of the scientific process and purveyors thereof.

Walker *et al.* (2008:648) defines stakeholders as individuals or groupings who have an interest or proprietorship of the project, can be impacted by it or contribute toward it. Stakeholders can also be described as any group or person that may exert influence on a project or be influenced by it (Freeman, 1983; Freeman, 2010). For this study the definition will be as broad and encompassing as possible. Throughout the respective phases of the implementation of the DRMS, the stakeholder definitions will be consolidated into focused and prioritised interest and influence groupings.

The communication of risk to stakeholders requires time and resources (Sen, 2000; Lundgren & McMakin, 2013), which are limited commodities in most governmental projects. Walaski (2011:8,9) supports the notion that communicating risk to stakeholders is an ongoing process and therefore time consuming. Walaski (2011:9) also accentuates the complex process of convincing the decision makers of the necessity of stakeholder engagement and the allocation of resources toward this goal. Morgan *et al.* (2002:2) indicate that the diffusion of information regarding the risks will assist stakeholders in deciding which risks warrant their limited time, attention and resources. The awareness plan will inform them as to the nature of the hazard, how the risk can be managed and how to be vigilant.

Walaski (2011:36) refers to relationship development, information sharing and reaching consensus as key approaches to engaging stakeholders. These approaches also served as the foundation for the engagement of stakeholders within the DRMS.

Internal and external stakeholders have to be identified and analysed (Walaski, 2011:71), in order to establish whether all possible affected and tangential stakeholders have been included. This compilation of stakeholders was mapped according to interest in the project and levels of involvement (Murray-Webster & Simon, 2006; AGES, 2016a). These groups were mapped into 6 tiers which were used to map out the awareness and risk communication actions needed to

accomplish the stakeholder engagement and risk communication objectives established in the DRAP.

### **3.3.2 Legal framework for engaging dolomite affected stakeholders**

Public participation and the involvement of affected stakeholders are governed by fundamental source legislation of which the key legislation is summarised in chapter 1.4.1. The guidelines, acts and standards that apply to communities and local governance underlain by dolomite are the following:

- Constitution of South Africa (Act 108 of 1996),
- Geoscience Amendment Act, 2010 (Act 16 of 2010).
- Department of Mineral Resources and Geoscience Amendment Act Regulations, Act no. 16 of 2010.
- Department of Mineral Resources. Governmental Notice. 7 September 2011;
- South African National Standard SANS 1936 Parts 1 – 4;
- Consultants guide for the approach to sites on dolomite land by the TCC for Geoscience (2007);
- Council for Geoscience/South African Institute of Engineering and Environmental Geologists (2003) Guideline for engineering-geological characterisation and development of dolomitic land. Council for Geoscience Publication;
- Department of Public Works, 2010. Appropriate development of infrastructure on dolomite: Manual for Consultants;
- Building Regulations and Building Standards Act 1977 (Act No. 103 of 1977)
- South African National Standard SANS 633: 2009 – Edition 1 (in Draft);
- GFSH-2 Guidelines of the National Department of Housing (2002);
- National Home Builders Registration Council. 1999. Home Building Manual Part 1 & 2. Revision No: 1. February 1999;
- Housing Consumers Protection Measures Act (Section 12 of Act 95 of 1998)
- South African National Standard SANS 10400-B and H, as indicated in the Building Regulations and Building Standards Act, 103 of 1977
- National Building Regulations and its amendments from 2008 (Act 103 of 1977)
- Disaster Management Act (Act 57 of 2002)
- Occupational Health and Safety Act (Act 85 of 1993)
- National Environmental Management Act (Act 107 of 1998)
- National Water Act (Act 36 of 1998)
- National Environmental Management Waste Act (Act 9 of 2008)
- Spatial Planning and Land Use Management Act (Act 16 of 2013)

- The Right of the Public to be Informed about the risk of dolomite according to the Promotion of Access to Information (Act 2 of 2000)
- Various municipal By-Laws (AGES, 2013e)

The legislative, policy and constitutional requirements in the following key sources regarding development on dolomitic land and public participation were considered for the study at hand and are summarised as follows:

The idea or concept of public participation in government is established in the South African Constitution (South Africa, 1996). Chapter 2 of the Constitution contains the Bill of Rights, which includes equality, human dignity, freedom, environment, as well as the right to housing, health care, food, water, social security, education and access to information.

The White Paper on Local Government 1998 (South Africa, 1998b) recommends that municipalities ought to develop mechanisms to ensure citizen participation in policy initiation and formulation, and the monitoring and evaluation of decision-making and implementation. The following approaches can assist to achieve this:

- forums to allow organised formations to initiate policies and/or influence policy formulation, as well as participate in monitoring and evaluation;
- structured stakeholder involvement in certain Council committees, in particular if these are issue-oriented committees with a limited lifespan rather than permanent structures;
- participatory budgeting initiatives aimed at linking community priorities to capital investment programmes; and
- focus group participatory action research conducted in partnership with NGOs and CBOs can generate detailed information about a wide range of specific needs and values.

The Municipal Structures Act 117 of 1998 (South Africa, 1998a) as amended, allows for a Category A municipality with a sub-council or ward participatory system, or a Category B municipality with a ward participatory system, and executive committees or executive Mayor to annually report on the involvement of communities and community organisations in the affairs of the municipality. Section 72 states that the objective of a ward committee is to augment participatory democracy in local government and in Section 74 on functions and powers of ward committees.

The Municipal Systems Act 2000 (South Africa, 2000) defines “the legal nature of a municipality as including the local community within the municipal area, working in partnerships with the municipality’s political and administrative structures...to provide for community participation”.

According to the Municipal Systems Act of 2000 Section 4 (c) (e) (South Africa, 2000), the

council has the duty to:

- (c) encourage the involvement of the local community;
- (e) consult the community about the level quality, range and impact of municipal services provided by the municipality, either directly or through another service provider.

The Municipal Systems Act of 2000 Section 16 (1):

- (a) Encourage and create conditions for the community to participate in the affairs of the municipality, including in the IDP, performance management system, monitoring and review of performance...preparation of the budget, strategic decisions regarding municipal services
- (b) Contribute to building the capacity of the local community to participate in the affairs of the municipality and councillors and staff to foster community participation.

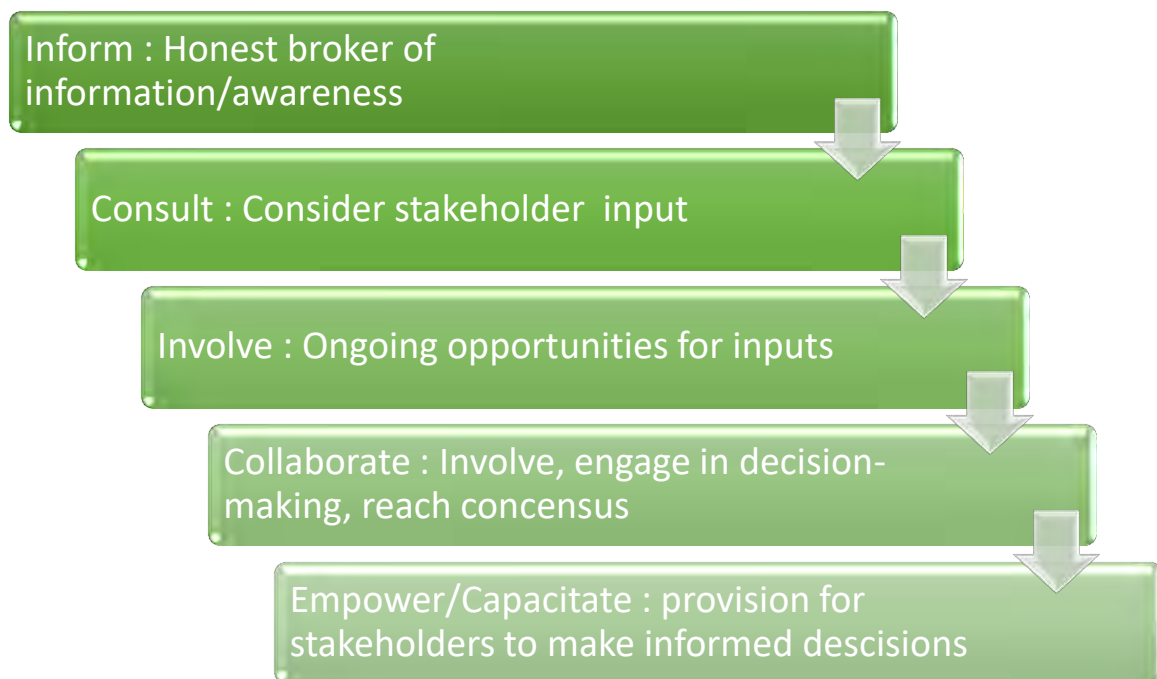
The Tlokwe Bylaw pertaining to public participation will be discussed as part of the preamble to the dolomite risk awareness action planning in Chapter 4, section 4.4.2.

SANS 1936 (2012) regulates the development and implementation of a DRMP. The TCC has complied with this requirement and subsequently re-affirmed their commitment toward affected communities to act pro-actively by issuing council resolutions to legitimise the DRMS, hereby making all actions recommended in the DRMS enforceable (Tlokwe City Council, 2009; Tlokwe City Council, 2010; Tlokwe City Council, 2011a; Tlokwe City Council, 2011b; Tlokwe City Council, 2012; Tlokwe City Council, 2013; Tlokwe City Council, 2014a; Tlokwe City Council, 2014b). The awareness actions and engagement of all stakeholders, formed part of these recommendations.

### **3.3.3 Levels of engagement of stakeholders**

The levels of engagement applied in the TCC case study refer to the guidelines of the International Association for Public Participation (2000). The levels of engagement are presented as a spectrum of participation starting from the lowest levels of engagement and progressing to the ideal state of participation. These levels are summarised in Figure 3-15. In the South African context, the most highly functioning level, namely empowerment, cannot be realised as not all stakeholders will be granted autonomous decision-making powers within our legal framework (Du Toit & Pollard, 2008:709).

Some of the levels of engagement such as providing information are associated with one-way communication, but when implemented within a participatory framework as the objective is with the DRAP, even the provision of information is implemented within a context of sharing, listening and responding to questions.



**Figure 3-12: Levels of stakeholder engagement based on IAP2 (International Association for Public Participation, 2000)**

When stakeholders are manipulated or placated to accept the actions associated with a project, stakeholder engagement serves as non-participation.

### **3.3.4 Objectives of communicating the risk to stakeholders**

Considering the urgency of communicating the risk associated with dolomite in TCC to affected residents, the objectives of the TCC Risk Awareness Plan were the following:

- communicating the risk directly to affected residents and establishing communication channels;
- communicating roles and responsibilities of consultants and the TCC in the DRMPr;
- establishment of regular transparent communication to residents affected by dolomite.
- stakeholder ownership of dolomite risk in order to mitigate the risk in a sustainable way;
- proactive approach to consultation with stakeholders;
- capacitating key stakeholders within the affected communities in order to capacitate others; and
- establishing trust in the TCC and service providers to the TCC to manage the risk (AGES, 2016a).

The chosen actions had to effectively disclose and share information concerning the dolomite

hazard and the outcomes of research conducted. As is often the case, some stakeholders such as politicians felt excluded and that information was lacking. Addressing these issues was critical in maintaining stakeholder engagement and transparency, therefore grievances were addressed through the media, political, governmental and other channels proposed in the Risk Awareness Plan (AGES, 2016a).

Figure 3-16 represents a summary of the different components of the stakeholder engagement process necessary for effective risk awareness and public participation (AGES, 2016a). These components function iteratively within no particular order.



Figure 3-13: Components of TCC stakeholder engagement components

**3.3.5 Stakeholder identification and mapping**

Glicken (2000:307) argues that “stakeholders” can be considered a relative term as communities, the public and groupings only become stakeholders in reference to a specific issue or risk affecting them directly or indirectly.

The mapping of stakeholders into tiers not only aligned awareness methods but also appropriate levels of engagement with the nature and register of stakeholder groupings. Deciding on the positions and priorities of stakeholder groupings or individual stakeholders is only of limited value if they are not actively engaged in practice (Murray-Webster & Simon, 2006:2). Murray-Webster and Simon (2006:2) suppose that only communication plans that are informed by accurate and complete stakeholder mapping and analysis can be effective.

The process of identifying and mapping stakeholders does not constitute stakeholder analysis as yet. Murray-Webster and Simon (2006:3) are of the opinion that when stakeholders are engaged and motives and positions concerning the project are established, the process of stakeholder analysis has begun. Provisional analysis could be done on the basis of what was known publically about the viewpoints, intentions and motives of affected stakeholders, but this could only be authenticated after the initial engagement actions, and evolved throughout the life cycle of the DRMS. This tendency of motives evolving, and the propensity of stakeholders to change stances and re-group to associate with alternative groups will be discussed in Chapter 4 of this research.

Reed (2008:2421) proposes that the toolkit approach, which is based on the premise of selecting the most suitable stakeholder tool, traditionally utilised in stakeholder mapping and analysis should be substituted by a process approach. The identification of stakeholders should be regarded as an iterative process (Reed, 2008:2421; Reed *et al.*, 2009:1937) where stakeholders are added as the project progresses.

In deciding who the stakeholders were this research commenced with the requirements of the SANS 1936 (2012), which specifies that dolomite risk management shall be implemented at four levels, as illustrated in figure 3-3.



Figure 3-14: SANS 1936 (2012) dolomite risk management levels (own representation)

In order to implement the management of dolomite risk on each level, the stakeholders would have to be engaged so that the risk can be understood, and they comprehend the motivation behind requirements for developing and living in dolomitic areas (SANS, 2012; AGES, 2016a). These levels have been taken as broad guidelines as to who the stakeholders for this complex issue were. From this point of departure, the following questions were formulated:

- Considering the relevant legislation who should be engaged?
- After the risk has been quantified who is most at risk?

- Who needs to be engaged as partners in managing the risk?

The focus should not merely be on compliance to legislation and guidelines, but also on learning, equity, trust creation and capacitating stakeholders (Reed, 2008:2422). In South Africa there is an added dimension of redressing the wrongs of the past. There are stakeholder groupings such as displaced communities that are more vulnerable due to Apartheid atrocities and inequality. They were specifically prioritised and capacitated in order to create resilience through the process of engagement.

### **3.3.5.1 Local authorities: District and local Municipalities**

The inclusion of all municipal departments, officials, council members and decision-making structures, formed the basis of all other actions concerning dolomite (Morgan *et al.*, 2002:35; Walaski, 2011:46). There had to be a seamless link between all stakeholders involved in order to manage the risk to council and residents. The starting point of the creation of awareness was the percipience of what dolomite is, the dissemination of research findings, and the recognition of the risks associated with living on dolomite. Mutual understanding and trust when managing dolomite and implementing the DRMS depended on informed and engaged stakeholders.

### **3.3.5.2 Government Departments and organs of state**

The same motivation as mentioned in 3.3.5.1. underpinned the inclusion of government departments, as these are the source of support for the management of dolomite, thus enhancing the regional and national management of dolomite.

### **3.3.5.3 Directly affected Communities**

The communities affected by dolomite exhibited extreme variations in risk awareness levels, ranging from having no knowledge of dolomite or the potential associated risk, while others were well informed about dolomite and the effects it may have on them. There were residents who had already witnessed sinkholes. Inaccurate narratives concerning dolomite already existed, and were in many instances politically motivated (AGES, 2012). The levels of awareness, as well as narratives concerning dolomite and sinkholes, were taken into consideration on a strategic level, when considering the affected community as stakeholders.

It was of critical importance to include all representatives of the community, as well as the community at large. Plans were devised to include all interested stakeholders, affected stakeholders, decision-making partners in business and government as well as the general public in order to voice and hear each other's fears and concerns and become part of acceptable risk management decisions (Morgan *et al.*, 2002:9). The exclusion of stakeholders at this early stage may have led to difficulties in communicating and mitigating the risk as part of

the implementation of the DRMS throughout the project life cycle. Including as many stakeholders as possible not only assists in the successful implementation of a DRMS, but empowers the affected community, and gives a voice to their fears concerning their future.

As stakeholder engagement levels may not correspond to the capacity or resilience of the stakeholders, Sen (2000:90) recommends that proxy organisations such as non-governmental organisations (NGO's) and community forums, that represent communities, are involved. Stakeholder groupings from the affected communities included leaders from various forums and structures representing the community formally and informally:

- ward councillors;
- ward committees;
- church leaders;
- local media;
- non-governmental organisations;
- labour movements;
- local business structures;
- political structures; and
- educational institutions.

#### **3.3.5.4 Service Providers**

Service providers that deliver services to municipal departments that are directly affected by the risk associated with dolomite had to be included, as it was critical that they receive accurate technical information on how to mitigate the risk associated with dolomite in their fields of expertise.

Planners, architects and draughtsmen needed to be aware of the design and building requirements for the different dolomite zones. Engineers, infrastructure and building contractors and other service providers needed to be aware of the technical requirements for development on dolomite. The omission of any of these stakeholders increases the risk to residents, the municipality, and service providers as such.

#### **3.3.5.5 External Stakeholders**

The politicizing of the dolomite issue elevated the focus on communication of the occurrence and associated risk of dolomite with external stakeholders. The narratives employed by proponents of opposing political views or activists can be neutralised when stakeholders are empowered with an understanding of dolomite and its associated risk. This also aided the acceptance and understanding of the motivation behind the preferential resettling of households

underlain by dolomite on new erven<sup>4</sup>, while others had been on waiting lists for many years.

### **3.3.6 Stakeholder Maps**

The preliminary stakeholder maps were compiled by means of various work sessions in which the inter-disciplinary team contributed from their fields of experience and identified role players interacting with their various disciplines. These work sessions were conducted keeping in mind that participatory processes lead to sustainable and high quality involvement of stakeholders (Gariépy, 1991; Chess & Purcell, 1999; Reed, 2008). Considering the commitment of the project to sustainable and high quality outcomes, the participatory approach was employed throughout the different DRMS phases.

Stakeholders identified through the initial work sessions were invited to participate in a stakeholder workshop (AGES, 2013f), in which they were provided with the relevant background to the project. They could then contribute suggestions on which stakeholders they felt should be consulted and recommendations were also made as to the levels of participation for each stakeholder definition. Figure 3-18 represents the initial conclusions to the mapping process and Figure 3-19 represents the stakeholder groupings by means of tiers progressing in priority from tier 1 being the highest priority and tier 6 the lowest priority. This prioritisation schedule is essential but can be deceptive as it may create the illusion that one grouping is superior to the other. The objective was only to provide a point of departure from where the awareness could be planned and implemented in a meaningful way.

The levels of engagement and associated actions with each level fluctuated and were adapted as the phases of the DRMS were implemented. The awareness plan was adjusted and moulded around the technical research and stakeholder response and input, constituting an iterative process.

---

<sup>4</sup> Erven is a South African term that refers to a plot of land demarcated for building purposes.

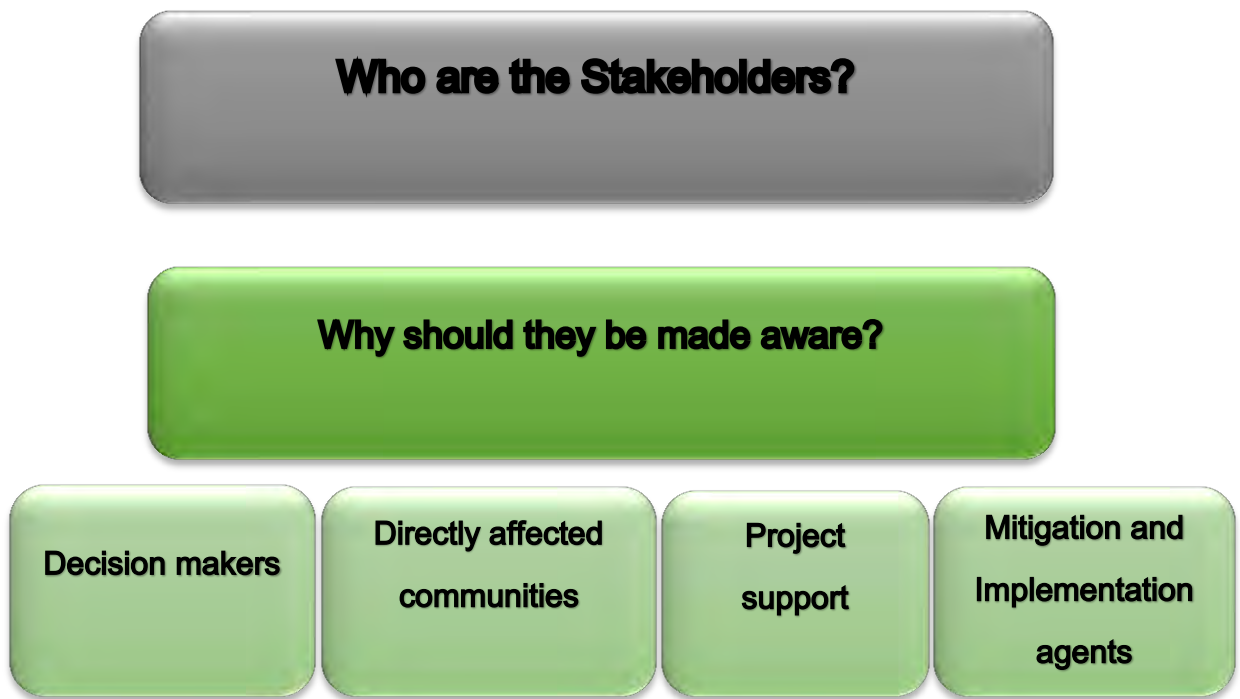


Figure 3-15: Stakeholder Mapping Framework (own depiction)

Tier 1: Institutional	Tier 2: Directly Affected	Tier 3: Affected	Tier 4: Government	Tier 5: Business	Tier 6: Tangential
<b>Decision Makers, Project Support, Mitigation and Implementation</b>	<b>Directly affected, Mitigation and Implementation, Project Support</b>	<b>Project Support, Implementation and Mitigation</b>	<b>Decision Makers, Project Support, Implementation and Mitigation</b>	<b>Project Support, Implementation and Mitigation</b>	<b>Project Support, Implementation and Mitigation</b>
Executive programme leadership	Residents affected by DRMA 1-4 dolomite hazard	TCC Officials	District Municipality	Affected businesses	General public
Program management	Affected industries	Government agencies affected by dolomite: SANRAL, ESKOM etc.	Provincial Government	Adjacent businesses	Environmental forums
TCC departments	Schools	Government departments affected by dolomite	National Government	Organized business	Academic institutions
Tlokwe City Council members	NGO's	Residents adjacent to dolomitic areas	Adjacent affected municipalities	Taxi Associations	Supporting consultants
Mayoral Committee	Churches	Service providers to TCC		Contractors and service providers to council	
Council for Geoscience	Political movements	Media		Service providers to affected residents	

**Figure 3-16: Stakeholder Tier Mapping (own depiction)**

The identification and mapping of stakeholders enabled the planning of specific awareness actions that were focused and structured to suit the roles and responsibilities for each stakeholder grouping. Chapter 4 will describe the awareness planning, processes and actions that matched the technical processes as it was implemented.

## CHAPTER 4

### DOLOMITE RISK AWARENESS IN BUILT AREAS

#### 4.1 Introduction

Chapter 2 of the study at hand described the hazard of dolomite and sinkholes and the associated risks of living on dolomitic land. Chapter 3 characterised the communities in TCC underlain by dolomite as well as the TCC response to dolomite hazard in the built environment. The process of identifying and mapping stakeholders into tiers was explained. Chapter 4 will provide an account of the DRMS risk awareness actions, in response to the research questions as to what planned awareness actions should be implemented during the research, reporting and mitigation phases of the DRMS as well as what the gaps in dolomite risk awareness are that occur in the respective phases, and how they should be addressed.

#### 4.2 Lessons not learnt from the past

This study was introduced by a tableau describing the terrible night in which a family in Blyvooruitzicht disappeared in a sinkhole. A resident at the time, Berend Schuitema (2012) described the feelings of the community as follows: “For the mine bosses appeasing miners about their safety in their dwellings, as well as the neighbouring farming communities and informal settlements was not just a communal concern, but one that also impacted on the mining methods being used if not the viability of mining in the Far West Rand in general. Getting to know and understand the scale and the nature of the underground water problem was a priority. It was well known that pumping millions of gallons per hour from the new mines were at the root of the sinkhole problem. But what was not very well understood was the true extent and location of the water aquifers that had formed in the dolomite rock. Mining in the area was very much a question of serendipity and a hasty solving of engineering problems as they arose, giving little attention to long term implications” (Schuitema, 2012).

On the 12<sup>th</sup> of December 1962, a sinkhole fell in the West Driefontein mine, the richest gold mine in South Africa, and took the lives of 34 mine workers (Anon, 1962a). Reverberating from this incident were reports of many sinkholes in the area surrounding the mine. Huge cracks in houses made them uninhabitable and residents had to be relocated. The subsidences in the area received much publicity, but authorities did not heed the warning. The residents wondered whether one of their homes would be next in line. A local newspaper speculated that Carletonville might become a ghost town or disappear in a crater (Anon, 1962b). The complaints from residents were resounding in these words. They had voiced their concerns in the past, but this only angered the City Council and Chamber of Commerce. Even after this incident, the City Council maintained that there was no cause for concern but that they would convene a meeting. The Department of Water Affairs appointed a committee to investigate subsurface water in the

area.

At the time of this event the newly built primary school had already shown huge cracks, but no measures were taken to address this situation. In January 1963 a part of the newly built school subsided and cracks widened. Some of the classroom doors could not close. The response from the Department of Education was to temporarily close the seven affected classrooms while drilling was done on site to investigate the subsidence, and school activities proceeded as normal. Homes across the school subsided to such an extent that the residents were relocated (Anon, 1963).

The writing was on the wall yet everyone was in denial. From this brief history preceding the Blyvooruitzicht (Carletonville) sinkhole, lessons can be learnt regarding risk awareness but not all municipalities seem to have taken cognisance.

The media voiced the concerns of residents, and cognisance should have been taken of the warnings from this source. Although tell-tale signs of pending disaster were evident, a lack of awareness of the risk of dolomite and sinkholes led to negligence. The area described as the most surveyed piece of earth in the world, was researched by different geologists who did not adequately convey awareness of the risks to their clients or consider it their responsibility to do more than surveying.

The concerns of residents were not heard and acknowledged. Affected residents did not receive risk awareness to monitor their own homes and know which warning signs should be reacted to. The approach to the management of dolomite and sinkholes was reactionary and not precautionary.

#### **4.3 Mitigating the risk of dolomite and sinkholes**

The mitigation of the risk associated with hazardous dolomite usually centres around the management of land use, engineering practises and building control. Educational programs are essential in any effort to mitigate the risk to all affected parties (Buskirk *et al.*, 1999; Gutiérrez *et al.*, 2007). In South Africa the development of a DRMS still does not automatically include a separate risk awareness focus which is specified in the DRMS. In a study conducted within the Merafong Local municipality (MLM) by Moshodi (2014:84), it was found that 66,6% of councillors indicated that they had not received dolomite risk awareness information and 83,3 % indicated that there had been no awareness campaigns. Twenty-nine out of thirty affected residents indicated that to their knowledge no awareness campaigns were conducted. The interpretation of these results could be problematic, as was apparent throughout the Tlokwe DRAP study, since the consulting firm responsible for the MLM DRMS, has indicated that awareness actions have been conducted. Stakeholders from all the stakeholder groupings at times indicated that they had not received awareness, while there was ample proof that they

had received awareness on various occasions.

Evaluating the management of dolomite in Merafong Local Municipality (MLM), Van Eeden and Nealer (2011:133) concluded that over multi-decades the following trends were noticeable:

- ignorance by Government and local government concerning dolomite;
- avoidance of dolomite issues by goldmining authorities;
- limited access to research findings for affected stakeholder;
- knowledge gaps created by consultants and government structures when they are succeeded by others; and
- deficits in co-operation between the institutional and affected stakeholders.

The only other local municipalities that have conducted awareness on the risks of dolomite and sinkholes are the City of Tshwane Metropolitan Municipality and Ekurhuleni Metropolitan Municipality (EMM). EMM distributed awareness leaflets designed for this purpose and awareness billboards have been erected. There exists a gap for a comprehensive risk awareness strategy or risk awareness plan with robust community consultation, as part of the DRMS.

The TCC has made the decision to take a pro-active approach to dolomite risk management and awareness by including awareness actions in all the respective phases and to specify the DRAP in detail as part of the DRMS. In each of the phases of the TCC DRMS the risk was mitigated by creating awareness and acknowledging the lessons of the past. The following phases form part of the TCC DRMS:

- Phase A  
The Initial Geo-Environmental Assessment of Dolomitic Land (2009 to 2010) was completed in 2010 and resulted in developing a knowledge base, GIS database, and technical report from which a framework was developed to implement a long-term DRMPr.
- Phase B  
Implementation of the initial DRMP (2010 to 2013) comprising of a combination of detail research, risk analysis and evaluation actions in order to quantify the risk of dolomite, the management of risks, small scale mitigation of known risks, as well as establishing a comprehensive risk monitoring programme.
- Phase C  
The long-term risk management, mitigation, monitoring and review phase (ongoing on an interim basis from 2011) focuses on the implementation of mitigation measures on a long-term basis, as well as managing and monitoring the risk as defined by the

updated DRMP. Phase C was sub-divided into Phase C1 with a focus on integration and

#### **4.4 DRMS Phase A**

The Preliminary Geo-Environmental Assessment of Dolomite Land in Potchefstroom (AGES, 2010a), assigned priority risk ratings to areas, based on the risk levels and status of infrastructure in this area. These risk ratings referred to the probability that dolomite and sinkholes might occur on failed wet infrastructure and was organised into focus areas in which research and mitigation were to be focused (AGES, 2010a; Pretorius, 2012a:21). During the Regional Dolomite Assessment (AGES, 2010b; Pretorius, 2012a:25) existing information was collated from sources such as regional mapping as well as regional risk determination.

##### **4.4.1 DRMS Phase A: DSI research processes**

During Phase A of the DRMS a DSI is conducted as part of the research. The following actions form part of the Phase A DSI preliminary Geo-Environmental assessment:

- Existing information and data collated;
- regional mapping;
- regional risk determination;
- Indicated risk map; and
- DRMS Framework and DSI Framework.

##### **4.4.2 The foundation for a Risk Awareness Plan**

The TCC approved the DRMS and DRMP in July 2010 (C120/2010-06-09), but a year long delay due to political instability, halted the implementation of these reports. The occurrence of subsurface events and hazardous activities on high risk dolomite necessitated the rendering of a Strategic Planner (AGES, 2011) defining the risks to the TCC and residents.

One of the four key recommendations made, focused on a DRAP (AGES, 2011; Tlokwe City Council, 2011b). The most significant recommendation resulting from this report was the establishment of a Dolomite Steering Committee (DSC), tasked to assist the TCC with all technical implementations and legal issues, as well as the implementation of dolomite risk awareness actions (MM Resolution 163/2011-11-22).

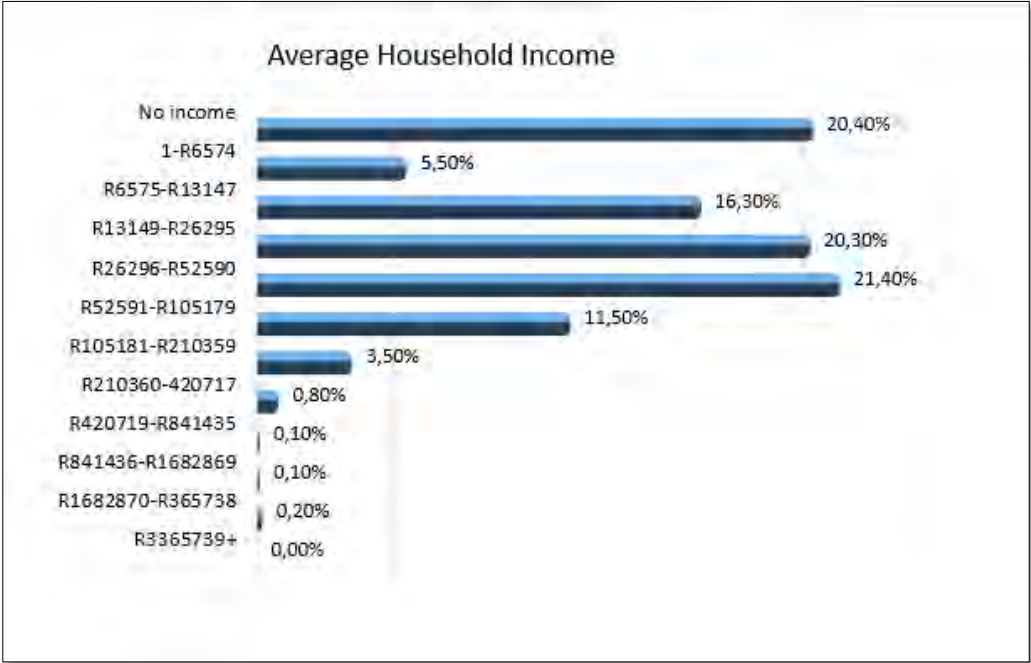
A preliminary stakeholder analysis was compiled (Pretorius, 2012b) and the focus fixed firmly on capacitating the TCC as decision makers (Tier 1 stakeholders), with an essential understanding of dolomite and sinkhole formation, as well as the legal implication thereof, through various presentations to council. The trademark approach of all AGES projects was the focus on the community as end-user of geotechnical, engineering and environmental interventions. This

stance contributed greatly to inform the TCC council resolution, which has a firm focus on the establishment of dolomite risk awareness plans. During this period of the first focus groups were facilitated with institutional and community leaders from the affected dolomite affected area.

Fischhoff (1995:138) declares that risk communication begins before a word is spoken on the subject. The fact that the risk is not communicated sets the tone for the trust relationship to follow. Even the perception that there is an unwillingness to share information creates mistrust. The TCC therefore had made the decision to create awareness from the inception of the research process.

**4.4.3 Vulnerable Stakeholders**

Together with the TCC, the residents directly affected by dolomite in the TCC jurisdiction were the main stakeholders who had to be engaged in dolomite risk awareness actions. The vulnerability of a community impacts the methods and levels of engagement in risk awareness actions; therefore a study was done to ascertain the levels of vulnerability by assessing existing data. The historic vulnerability of these communities has been discussed in section 3.2 of this study. The Economic Area Analysis of the Tlokwe Neighbourhood Development Partnership Grant (NDPG)<sup>5</sup> (DEMACON, 2013:18), illustrates the vulnerability of this community through three basic indicators: average household income (figure 4-2), levels of education (figure 4-3) and unemployment levels (figure 4-4).



**Figure 4-1: Ikageng Average Household Income (DEMACON, 2013)**

<sup>5</sup> The purpose of the grant is to fund, support and facilitate the planning and development of neighbourhood development programmes and projects that will be catalysts for further development in these areas. It is managed by the National Treasury.

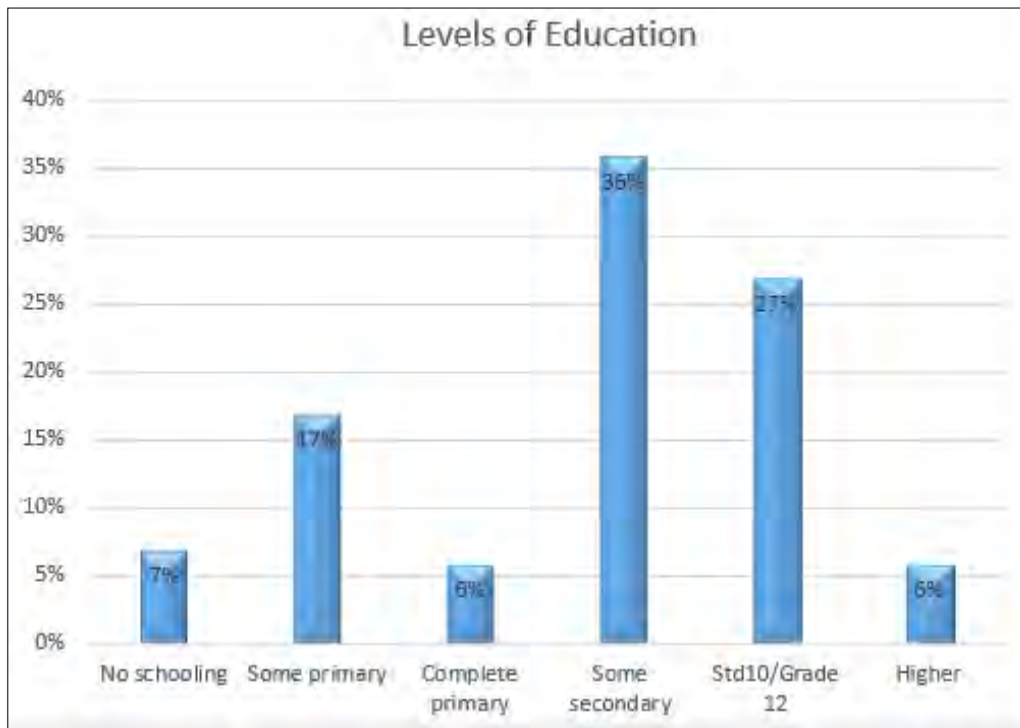


Figure 4-2: Ikageng Levels of Education (DEMACON, 2013)



Figure 4-3: Ikageng Unemployment Levels (DEMACON, 2013)

The average household income in Ikageng in the TCC area of jurisdiction, according to

DEMACON (2013), indicates that 42,2 % of households earn less than R13 147,00 per annum. The low levels of education in figure 4-2 contribute to the low levels of income but also to the vulnerability status of the Ikageng community. The final conclusion as to the effects of the vulnerability of the affected communities on the planning of awareness actions, have been rendered in section 5.1.9. of this study.

The preliminary findings on the vulnerability of the TCC communities on dolomite indicate one or more of the following consequences:

- inability to replace or repair damage resulting from sinkholes and subsidences to property, due to financial constraints;
- inaccessibility of alternative erven for resettling due to extensive waiting lists.
- constraints in interpreting and understanding research results and awareness material.
- obstruction of access to information due to political interference.
- focus on survival rather than on issues perceived as being on the periphery of basic needs.
- impairment of informed decision-making due to educational disadvantages; and
- unwillingness to resettle due to lack of trust in government garnered from previous experience.

The extent of the impact of dolomite on vulnerable communities in Ikageng, Promosa and Mohadin were analysed by means of the indices of settlement categories and residents affected in the respective DRMA's.

Table 4-1 indicates the categories of housing and approximated number of residents affected in the respective DRMA's. The total affected residents residing on dolomite are 23933, which provided an indication of the extensive scope of the DRAP. It was the residents residing on DRMA 1 that provided the greatest challenge.

**Table 4-1: Residents affected by dolomite**

Dolomite Risk Management Area	Existing Stands	Stand Population	Residents affected				Total Residents Affected
			Backyard Dwellers on stand	Backyard Population	Illegal Informal Structures not on stand	Illegal Squatters Population	
DRMA 1	1890	6549	368	810	593	2016	<b>9375</b>
DRMA 2	275	1069	72	142	108	367	<b>1578</b>
DRMA 3a	1707	6490	192	390	53	180	<b>8515</b>
DRMA 3b	392	1301	69	154			
DRMA 4	1011	3746	150	314	5	17	<b>4077</b>
DRMA 5	418	87	1	1	88	299	<b>387</b>
<b>Totals</b>	<b>5693</b>	<b>19242</b>	<b>852</b>	<b>1811</b>	<b>847</b>	<b>2880</b>	<b>23933</b>

Source: (AGES, 2013e).

The community related activities and land uses on dolomite are summarised in Table 4.2. The community related activities on dolomite was cause for concern. Especially schools needed to be monitored and capacitated to monitor their own buildings and infrastructure. The risk may be reduced by creating awareness within the communities surrounding these amenities.

**Table 4-2: Community related activities and land use on dolomite**

Community related activities and land use on Dolomite							
No	Facility Type	Name	Town	No	Facility Type	Name	Town
1	Educational	Creche	Ikageng	23	Religious	Church	Ikageng
2	Educational	Pudulogo Primary School	Ikageng	24	Religious	Church	Ikageng
3	Educational	Bolitirelo Primary School	Ikageng	25	Religious	Church	Ikageng
4	Educational	Tshepo Primary School	Ikageng	26	Religious	Church	Ikageng
5	Educational	Resolofetse Secondary School	Ikageng	27	Religious	Church	Ikageng
6	Educational	Boitshoko Secondary School	Ikageng	28	Religious	Church	Ikageng
7	Educational	Promosa Secondary School	Promosa	29	Religious	Church	Ikageng
8	Sport and Recreation	Municipal Swimming Pool	Mohadin	30	Religious	Church	Ikageng
9	Sport and Recreation	Clubhouse and Tennis Courts	Mohadin	31	Religious	Church	Ikageng
10	Community Facility	Mohadin Community Centre	Mohadin	32	Religious	Church	Ikageng
11	Community Facility	Mohadin Library	Mohadin	33	Religious	Church	Ikageng
12	Clinic	Ikageng Clinic Ext 4	Ikageng	34	Religious	Church	Ikageng
13	Clinic	Mamerotse Clinic	Mohadin	35	Religious	Church	Ikageng
14	Cemetery	Lusaka Cemetery	Ikageng	36	Religious	Church	Ikageng
15	Cemetery	Ikageng Cemetery	Ikageng	37	Religious	Church	Ikageng
16	Taxi Rank	Sarafina Rank (Informal)	Ikageng	38	Religious	Church	Ikageng
17	Taxi Rank	Lusaka/Kanana Rank (Informal)	Ikageng	39	Religious	Church	Ikageng
18	Taxi Rank	Ikageng Rank (Informal)	Ikageng	40	Religious	Church	Ikageng
19	Taxi Rank	Mohadin Rank (Informal)	Ikageng	41	Religious	Mosque	Mohadin
20	Religious	Church	Ikageng	42	Religious	Church	Promosa
21	Religious	Church	Ikageng	43	Religious	Church	Promosa
22	Religious	Church	Ikageng	44	Religious	Church	Promosa

Source: (AGES, 2013e).

#### 4.4.4 The DRMA's

As a result of the research done in the Phase A DSI, Hazard Zones were classified. In the respective Inherent Hazard Class Zones and the DRMA's that formed part of the indicated risk maps in figure 4-4 and 4-5, the land uses were determined concomitant to each zone. This data informed the DRAP as it indicated how many stands and residents were affected and to what extent they were affected, as well as how many amenities and community services were at risk. Affected parties are usually provided with columns of numbers which are similar to those found in reports and data bases (Fischhoff, 1995:139). Translating these numbers into maps made data more accessible to stakeholders. The premise is always that stakeholders on all levels have to be guided on how to interpret a map before the content of the map can be explained. Implementing risk awareness in such a way capacitates stakeholders profoundly as they have gained a skill in addition to visualising research results.

Inherent Hazard Class	Characterization of area
Class 1 Areas	Areas characterized as reflecting a low inherent susceptibility of sinkhole and subsidence formation (all sizes).
Class 2 Areas	Areas characterized as reflecting a medium inherent susceptibility of small-size sinkhole and subsidence formation
Class 3 Areas	Areas characterized as reflecting a medium inherent susceptibility of medium-size sinkhole and subsidence formation
Class 4 Areas	Areas characterized as reflecting a medium inherent susceptibility of large-size sinkhole and subsidence formation.
Class 5 Areas	Areas characterized as reflecting a high inherent susceptibility of small- size sinkhole and subsidence formation.
Class 6 Areas	Areas characterized as reflecting a high inherent susceptibility of medium-size sinkhole and subsidence formation.
Class 7 Areas	Areas characterized as reflecting a high inherent susceptibility of large- size sinkhole and subsidence formation.
Class 8 Areas	Areas characterized as reflecting a high inherent susceptibility of very large-size sinkhole and subsidence formation.



Figure 4-4: Inherent Hazard Class Zones

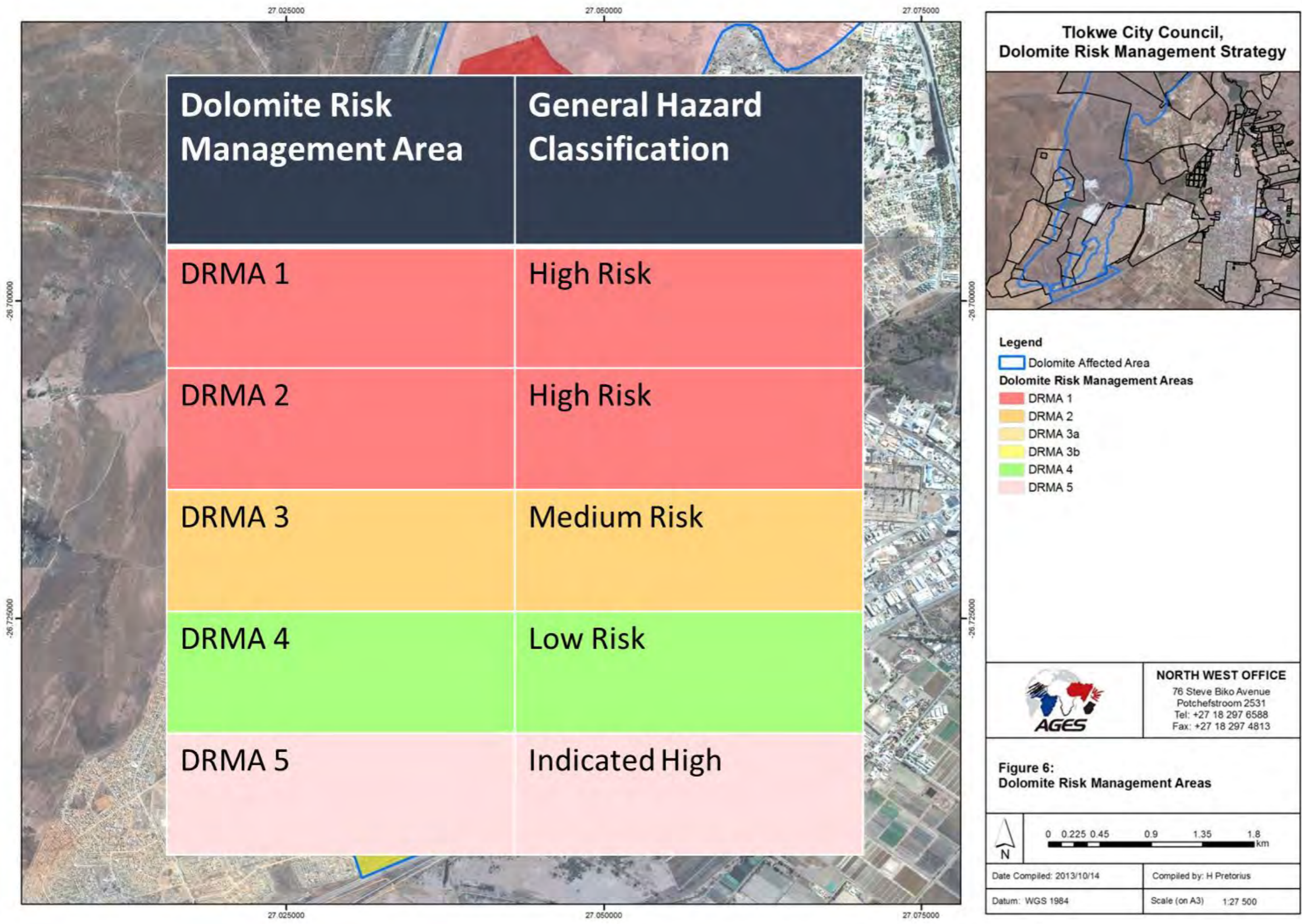


Figure 4-5: Dolomite Risk Management Areas (AGES, 2014)

#### **4.4.5 Sarafina subsidence event**

On the 16<sup>th</sup> of May 2011, the first sinkhole within a built area of Potchefstroom was reported and this area prioritised. The Sarafina subsidence event triggered a DSI for this focus area in Ikageng, in order to determine the risk to residents and council infrastructure (Pretorius, 2012a:31). The incident created stirrings in a community who had up to now been oblivious to the pending risk and felt relatively safe. This necessitated that the risk awareness actions were prioritised.

#### **4.4.6 Institutional awareness**

The primary actions as part of creating awareness, other than with the council members, was the Dolomite Risk Management workshop that included pivotal officials from all departments in TCC (Tier 1 and 3 stakeholders). A presentation was given and awareness material distributed to officials. During the preparation for workshops, the significance of relevant and communicative knowledge material became apparent. The need existed to visually represent sub-surface karst. The only available pamphlet on dolomite and sinkholes was not considered relevant for any of the stakeholder groupings. During Phase B awareness leaflets were developed to fill this gap.

#### **4.5 DRMS Phase B**

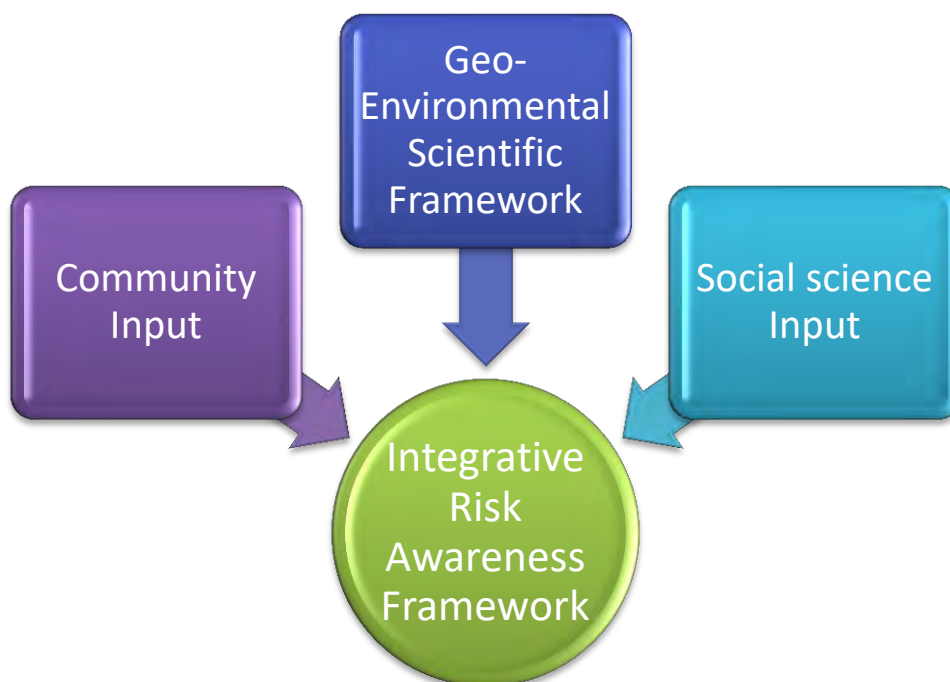
One of the objectives of the engagement of stakeholders and awareness actions, as reasoned in Chapter 3.3.4, is taking ownership of the reality and mitigation of dolomite risk (AGES, 2016a). This entailed that stakeholders either had direct personal control over the risks or indirect control by means of influence such as enforcing policies and legislation or the management of hazards (Morgan *et al.*, 2002:2). To elaborate on this Morgan *et al.* (2002:22) indicate that emotional and cognitive skills are needed to receive and understand the risk information supplied, but that the affected communities will still be vulnerable if the information contained in the risk communication is not accurate and inclusive. This conclusion supports the concept of aggregating a scientific information and data framework as foundation for awareness actions. There has been criticism on the exclusive use of a scientific model (Morgan *et al.*, 2002:4; Reynolds & W. Seeger, 2005:48; Reynolds, 2011). Reynolds (2011) promotes the idea of an integrative model, and Morgan *et al.* (2002:4) proposes a mental model approach. The mental model approach complements the scientific framework with the beliefs and concerns of the affected stakeholders (Fischhoff, 1995:9). The risk communication actions are then designed to address the tenets of this framework.

Walker *et al.* (2008:648) reasons that what we perceive as facts are merely our interpretation of

intricate ideas and are constructed perspectives within our own social framework. We choose these facts to represent the reality of the risk but to other stakeholders our representation may seem biased, misrepresented or vague. Knowing what the affected communities should know is just one dimension of risk communication (Cone *et al.*, 2013:351). Their perceptions, narratives and indigenous knowledge concerning dolomite and sinkholes completed the picture.

During Phase A, the scientific information and data framework was developed by the interdisciplinary team. This framework was then collated to match the responses to the most pressing concerns from the side of the community. These concerns were isolated by means of the first focus group workshop held during DRMS Phase A (Tier 1 and 2 stakeholders), where the stakeholders were identified, and community leaders could provide input as to the most crucial issues surrounding the concerns and uncertainties regarding the management of the dolomite and sinkhole risk (AGES, 2012).

The issues isolated in conjunction with the essential scientific information and social practice were consolidated to form the Integrative Risk Awareness Framework (figure 4-6) that form the knowledge base for all risk awareness tools and awareness processes in the DRAP.



**Figure 4-6: Integrative Risk Awareness Framework**

Morgan *et al.* (2002:21) assert that risk communication should begin by stating the myths concerning a specific disaster risk and then correcting it. In this study, it has been found that

openly stating the incorrect narratives create confusion. Feedback from focus groups indicated that especially vulnerable groups incorporate the incorrect narratives as factual elements.

Since the technical specialists were not trained to engage stakeholders and found it frustrating (Morgan *et al.*, 2002:7), the technical team decided from the start of the research in Phase A to assign the principal responsibility of engaging stakeholders to social scientists functioning within an interdisciplinary team consisting of technical specialists and representatives from the TCC.

#### **4.5.1 Phase B: DSI research processes and outcomes**

Following another delay of seven months due to political instability, the Phase B study was approved by the TCC (Council Resolution C145/2013-07-02). The research processes required for Phase B DSI, acts as “building blocks and not stepping stones” (direct communication Pretorius, 2016). Each action provides data for the following actions, with the DRMP and DRMS as the cumulative result of these actions. The DSI Phase B research actions entailed the following:

- collation of previous available data;
- Geo-environmental desktop study: Regional and geological setting;
- geological mapping: verification of desktop study, site visit to existing instability features, survey data;
- geophysical surveys: e.g. gravimetric and electromagnetic surveys;
- siting for drilling, rotary percussion and logging;
- on site characterisation;
- Geo-hydrological study and modelling;
- Status of infrastructure and developments on dolomite;
- Interpretation and evaluation of the above data;
- DRMA zoning;
- DRMP with technical specifications and recommendations; and
- Compilation of DRMS.

#### **4.5.2 Initial steps in risk awareness**

During Phase A of the DRMS the TCC Council Resolution drafted resolution (C145/2013-07-02) which stated

*“That a community awareness and information strategy be implemented with immediate effect”*

This TCC resolution not only triggered the initial awareness planning and interventions but also the compilation of a Social Awareness Framework (SAF) in phase B of the DRMS. The urgency of the situation resulting from the Sarafina incident necessitated the immediate launch of key

actions while developing the SAF.

The approach was to match the awareness actions and stakeholder groupings with the technical research actions. The principle of a phased approach originated from research conducted by Aucamp (2003). This alignment of social actions within the project life cycle inspired the idea of matching social awareness actions with the technical phases in the DRMS life cycle.

The residents living on dolomite represented an overburden of vulnerable people. It was therefore essential to adhere to all legislation regarding the spread of information in order to capacitate vulnerable communities for their maximum benefit. When the minimum requirements of public participation and awareness requirements as stated in the Tlokwe bylaws had been met, the rest of the framework could be addressed with creative and innovative approaches to creating risk awareness. The very specific Tlokwe Public Participation bylaw was helpful as a foundation for the awareness framework.

The Tlokwe Public Participation Bylaws focus on Public Participation processes when lodging complaints concerning governance and the IDP, but can be applied to all communication emanating from the TCC. For this purpose, bylaw 5.7: *Notification and 8. Communications to local communities* needed to be perused (Tlokwe City Council, 2004).

#### *Bylaw 5.7: Notification*

##### *5.7.1 Whenever the Council -*

*5.7.1.1 holds a public meeting as provided for under this by-law;*

*5.7.1.2 holds a session about any matter contemplated in subsection 5.3; or*

*5.7.1.3 holds a public meeting on any other matter decided by the Council that warrants notification to the community; the aforesaid matters must be advertised once in two of the daily newspapers as well as community newspapers circulating in the municipal area according to the Council's language policy for a period of at least fourteen (14) days before the event.*

##### *5.7.2 Copies of all notices contemplated in subsection 5.7.1 must be posted at -*

*5.7.2.1 the notice-board at the Council's offices;*

*5.7.2.2 all libraries in the municipal area; and*

*5.7.2.3 other places as may be available.*

#### **Bylaw 8: Communication to local Community**

8.1 When anything needs to be communicated to the inhabitants of the Municipality, Council will make use of one or more of the following means of communication:

8.1.1 Notices in the local newspaper or newspapers of its area and in the appropriate language for its area;

8.1.2 notices in a newspaper or newspaper circulating in its area and decided by the Council as a newspaper of record;

8.1.3 radio broadcasts covering the area of the Municipality;

8.1.4 distribution of flyers, pamphlets and/or posters;

8.1.5 loud-hailing in the area concerned;

8.1.6 announcements at church services and schools; or via communications through its ward committees.

In collaboration with the above bylaws, the principles for community participation as set out in the National Policy Framework for Public Participation (South Africa, 2007) were considered. Table 4-3 summarises the principles of the act.

**Table 4-3: Principles of Community Participation**

<b>Principle</b>	<b>Examples of applying these principles</b>
Inclusivity	Identifying and recognising existing social networks, structures, organisations, social clubs and institutions and use them as a vehicle for communication.
Diversity	Ensure that different interest groups including women, the disabled and youth groups are part of governance structures.
Building community capacity	Solicit funding from external sources to train ward committees and IDP forums on their role in development and service delivery.  Embarking on citizen education on all aspects of local governance.
Transparency	Engendering trust in the community by opening council meetings and processes to the public and encouraging attendance.
Flexibility	Being flexible in terms of time, language and approaches to public meetings and processes.

Accessibility	Conducting public meetings and processes in the local languages.
Accountability	Ensuring report backs to the community forums or ward committees at least on a quarterly basis.
Trust, Commitment and Respect	Ensuring that the purpose of the process is explained adequately, as well as how it will develop.

(South Africa, 2007)

The three factors that create a framework of trust and credibility and which act as enablers for all of the abovementioned principles and regulations as stated by Walaski (2011:22) are:

- Perceptions of knowledge and expertise
- Perceptions of openness and honesty
- Perceptions of concern and care

With these guiding principles the dolomite risk awareness actions were approached and implemented. Peters *et al.* (1997) found that especially for government an increase in the public perception of commitment will increase trust and credibility. This commitment alongside the perceptions of expertise, openness and concern are key factors in gaining the trust of the affected stakeholders.

#### **4.5.3 There's a new drill in town (Drilling Phase 1)**

When initiating a process such as dolomite risk awareness the starting point was the scientists, technicians and officials who would have the initial encounter with the dolomite research process, but also those who had the first contact with the community. These stakeholders were the technical team working within the community doing research, as well as the officials facilitating the management and technical implementation of this process (Tier 1 and 3 stakeholders).

The geotechnical team would have the dolomite expertise, but other technical specialists involved in this process may not have been as updated to the risks of working on dolomite. Two aspects deserved attention in these initial research actions: the first was the general dolomite awareness, and the second was equipping technical stakeholders with the social impact and social awareness component of the project. They would have to answer challenging questions on site, and also facilitate emotions and reactions to interventions. It would have been a very simplistic viewpoint to believe that just presenting the scientific facts concerning the risk would

be sufficient to change the perceptions of a community (Cone *et al.*, 2013:348).

Because of this critical and sensitive first community encounter, a DRMS workshop, Engineering workshop, Ad hoc Legal workshop and Social Awareness workshop were held, not only for the sake of project management, but also to create awareness with all officials and technical personnel on the risks of dolomite and sinkholes. The aim was also to guide technical personnel on how to explain the DSI actions to affected communities, so that the possible reactions and impact on the community could be facilitated correctly and proactively.

The information contained in the message that was decided on by multiple inputs had factual meaning, but symbolic and cultural meanings were also attached to the message conveyed (Kasperson *et al.*, 1988:177; Reynolds & W. Seeger, 2005:45). This social context frames the message and the impact and value of the message may have been altered by politics and cultural factors. In planning the message and the way in which it was communicated, socio-cultural moderators were considered in order to create the greatest potential for creating awareness.

The measures taken into consideration to moderate for this phenomenon in the compilation of risk awareness material were:

- multi-cultural input in message construction and framing;
- input from different levels of socio-economic realities;
- input from vulnerable groupings; and
- backdrop for message from their own familiar surroundings, culture and language.

These principles were implemented with all chosen methods of risk communication, especially concerning the design and scripting of the dolomite risk awareness leaflets.

A drilling rig entering an affluent neighbourhood would not warrant a second glance, but in vulnerable communities, people stop their activities and observe from the moment it enters town. The news of a drilling rig entering town spread quickly throughout the community (Tier 2, 5 and 6 stakeholders).

The first action was to train Drilling Liaison Officers (DLO's). They were sourced from a local community training project and trained on the technical aspects of dolomite as well as the research actions taking place (AGES, 2013f). In order to train the liaison team, knowledge products had to be developed based on the IRAF. The training was done at the hand of a few burning questions they would most probably be asked concerning dolomite, sinkholes and the DSI. The DLO's were also made aware that their only interest should be in creating awareness, and not to have a vested interest in how their audience reacts to their message (Morgan *et al.*, 2002:5). The only goal of the dolomite risk awareness actions were to help affected residents

toward their best interest (Morgan *et al.*, 2002:7).

#### **4.5.4 The Social Map**

At this stage, affected residents (Tier 2 stakeholders) were already enquiring through the Dolomite Management Desk (DMD) that was established at the beginning of Phase B of the DRMS to manage building plan enquiries as well as general enquiries, to access the Indicated Risk map that resulted from the Phase A research. The Indicated Risk map could not be disseminated, as the risk was not quantified and could create confusion and unnecessary panic. The decision was made to compile a social awareness map (AGES, 2013f). It would follow the broad outlines of the indicated risk area but the DRMA's would not be visible and the outlines would be less harsh than the Indicated Risk map (AGES, 2013f). It would facilitate the social boundaries that exist such as wards, streets and neighbourhoods within the indicated risk areas.

The social awareness map (figure 4-7) became a useful tool for the Town Planners and Building Inspectors. A moratorium was placed on all new developments, housing or extension to residences until the research was completed and the DRMA's finalised. In order for stakeholders to understand why a moratorium had been placed on extensions or new developments in their area, this map was utilised.

This map was enlarged to A1 size and used by the DMD and liaison officers on a daily basis to educate, inform, consult and involve stakeholders. It has been used for press releases, press conferences and information sessions with ward councillors.

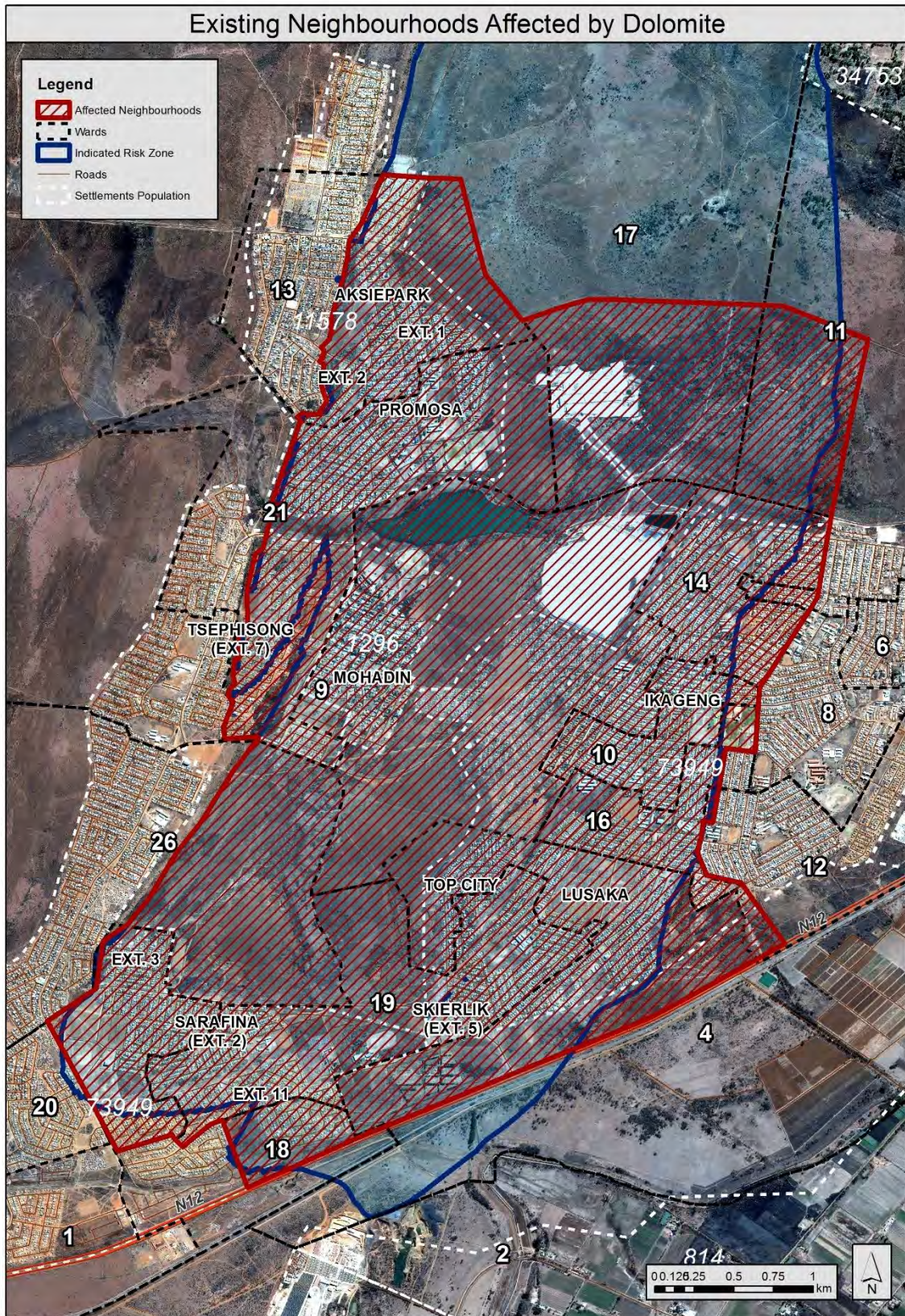


Figure 4-7: Social Awareness map (AGES, 2012).

The DLO's were deployed on site alongside the drilling rig. Included in their job description was the task to keep the perimeters safe as part of the Health and Safety procedures, as especially children wanted to approach the drilling rig. While this protocol kept interested residents at a distance, it provided the opportunity to explain to them what was happening on a technical level.

Where boreholes were sited, the ward councillor of that particular ward was contacted and invited to be on site. Concurrently with this invitation, the ward councillor and committee members were invited for a focused awareness session. They were also shown maps of how the indicated risk impacted on their ward (AGES, 2013f).

Before the drilling operations started in the mornings, the DLO's visited each home along the street where the drilling would take place. They explained the drilling process, as well as the fact that there would be dust and noise for a while. The ensuing rehabilitation of the borehole and drilling waste was also explained. When a school was adjacent to the site, the Principal was visited and also invited on site. Both the onlookers and residents living in the street signed a register to acknowledge that they were made aware of the risks associated with dolomite and sinkholes (AGES, 2013f). The DLO's kept a register and incident report of every concern or comment from the community including contact details. Concerns were followed up by either the technical team or liaison team. The incident report not only served as a reflection of concerns but also of positive attitudes and interest.

Holes or cracks in the ground were also reported to the team by residents and officials and promptly followed up by the technical team accompanied by a liaison officer. The findings were reported through the DMD to the SC. In certain cases, the technical team would revisit the erven in order to monitor the status of holes or cracks.

At this early stage, it was already clear by means of the social monitoring conducted by the DLO's that many damaging narratives were circulating within the community. Many residents did not even want to provide their signature to confirm that awareness was done at their homes, as they were afraid that they might be signing their homes away (see section 3.2. on forced removals). The known untrue narratives were the following:

- dynamite was planted underneath Ikageng, Mohadin and Promosa during the Apartheid era so that they could be blown up should it be called for;
- the TCC has established that gold deposits were found underneath these areas and used dolomite as an excuse to resettle them in order to gain access to the gold. The same narrative was also repeated with oil and diamonds being the motive;
- the TCC wants to build a shopping centre and other developments on the so-called dolomitic areas as soon as they have removed the residents;

- there is no such thing as dolomite. It is a snake under the ground that creates tunnels; and
- during the Apartheid era people were moved stating dolomite falsely as a motivation, and now TCC are doing the same.

In order to mitigate these narratives, the liaison team started redressing it with accurate information. References to the narratives were incorporated in the script of the drilling liaison and door-to-door risk awareness.

#### **4.5.5 The Media**

The SC decided that a press release should be drafted and a media conference should be held to explain the status of the project, since affected residents as well as ward councillors were voicing concerns on the financial implications of additional DSI studies. They expected a response as to why previous studies such as the pre-Phase A studies were not sufficient. The immediate risk communication needs of a community are always to reduce uncertainty through a basic awareness of the facts of the case (Reynolds & W. Seeger, 2005:50). Subsequently the decision was made to draft a press release in response to the concerns raised.

The press release was adequate in addressing concerns from the average affected resident but had little effect on politicians, as no answer would be satisfactory and fit into the rhetoric they were supporting. At this stage, political factions were developing, and the issue of the amount of funds allocated to DSI, led to accusations of misappropriation of funds rather than dolomite research. During the preceding elections, certain politicians used the argument that no phenomenon such as dolomite existed, as one of the pillars of their election manifesto. The dolomite investigation posed a serious threat to their power base. The community welcomed this new narrative as its implication was that they did not have to fear anything and would not be resettled.

On the 28<sup>th</sup> of February 2013, the Human Settlements Portfolio Committee in Parliament released a statement that pronounced that the presence of dolomite was no longer an excuse for the state to refuse to build houses for the poor (City Press, 2013). This confirmed the framing of dolomite as a political issue. As housing is one of the most basic needs of human beings, it came as no surprise that the shortage in housing provision needed a scapegoat.

The matter was further complicated by non-compliance to the moratorium on building. Residents found it difficult to comprehend that some affected residents were building while others were not permitted to build. Within this setting, awareness became complicated and the campaign had to be intensified to waylay the ever-mounting list of narratives that were emerging.

#### **4.5.6 The Dolomite Management Desk**

During the first rotary percussion drilling the DMD was established and managed by the dolomite research consultancy. By calling the dedicated mobile phone, information regarding dolomite or the research process could be obtained. Details on the moratorium placed on building plans could be accessed through this avenue (AGES, 2013f).

A statement was compiled together with the SC to elucidate the moratorium placed on building and building extensions on indicated risk areas. This statement was provided to all residents submitting new applications. The building plans were still submitted to the TCC building office, but the DMD then provided input to the TCC regarding the status of dolomite on the erf. An additional notice was drafted to explain the current process and expected progress. This notice was distributed to all building and building extension applicants, together with a copy of the press release and a map of the indicated risk area (AGES, 2013f).

#### **4.5.7 We are not alone: Karst Worldwide**

In the process of conducting workshops, focus sessions with ward councillors, as well as sessions with affected residents, a concern raised by residents was that it seemed that previously disadvantaged residents were affected and not the affluent parts of Potchefstroom. They needed perspective in judging their own situation in terms of the rest of the world. The issue was acknowledged by including maps of the world karst terrains as well as information on which other regions of South Africa were underlain by dolomite.

Williams and Fong (2008) assembled data for a map of the karst regions of the world. In table 4-4 the occurrence of karst by region and country is summarised. This information accompanied by the World Karst Map (Williams & Fong, 2008) represented in figure 4-8, supported the fact that dolomite is a worldwide phenomenon, and not an occurrence affecting them exclusively. The provision of a summary of the occurrence of dolomite within South Africa as in table 4-9 solidified the solidarity with affected residents countrywide. Residents indicated during awareness focus groups that this fact reassured them and reduced the anxious feelings of being exposed to dolomite.

**Table 4-4: Countries with karst (Williams & Fong, 2008)**

Region	Countries Included
World	Exclude Antarctica, Greenland and Iceland
Russia Federation plus	Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia, Turkmenistan, Uzbekistan
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Falkland Islands (Malvinas), French Guiana, Guyana, Paraguay, Peru, South Georgia and the South Sandwich Island, Surinam Uruguay, Venezuela
Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, Zimbabwe
North America (exclude Greenland)	Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Canada, Cayman Islands, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Turks and Caicos Islands, US, Virgin Islands, Virgin Islands (US)
East and South East Asia	Brunei Darussalam, Cambodia, China, East Timor, Indonesia (excluding Papua), Japan, Korea (north and south), Lao, Malaysia, Mongolia, Myanmar, Philippines, Singapore, Taiwan, Thailand, Vietnam
Middle East and Central Asia	Afghanistan, Bangladesh, Bhutan, Cyprus, India, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Maldives, Nepal, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Sri Lanka, Syria, Tajikistan, Turkey, United Arab Emirates, Uzbekistan, Yemen
Europe (exclude Iceland and Russia)	Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Monaco, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, UK, Vatican City, Yugoslavia
Australasia	American Samoa, Australia, Baker-Howland-Jarvis, Christmas Island, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Islands, Palau, New Guinea (Papua New Guinea plus Papua), Solomon Islands, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands, West Iran, Western Samoa.

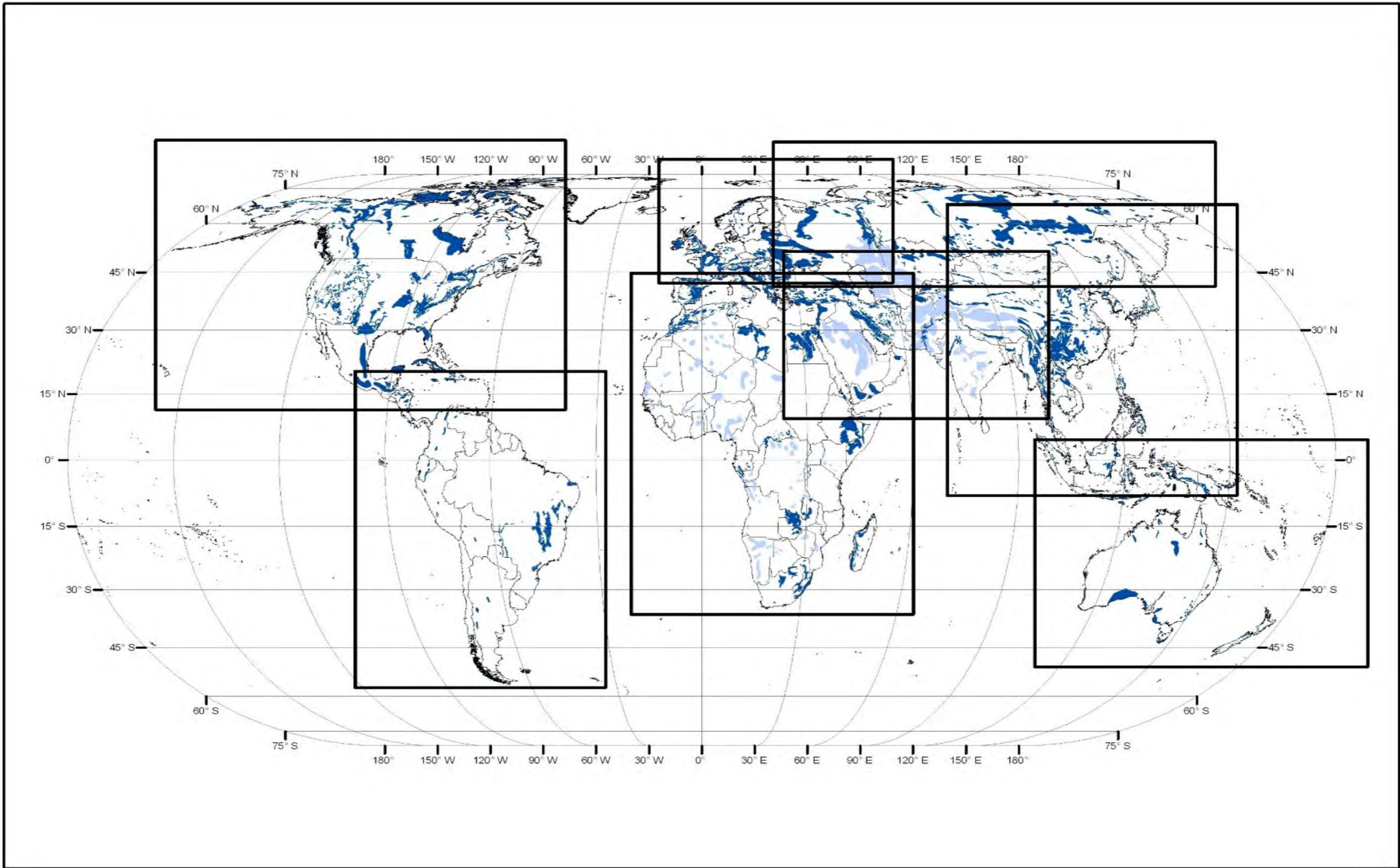


Figure 4-8: World Karst Map (Williams & Fong, 2008)

To zoom into the South African context, the affected areas in South Africa is summarised in Table 4-7.

**Table 4-5: Karst areas in South Africa (National Home Builders Registration Council (NHBC), 2014)**

Common name	New name	Common name	New name
Barberton	Umjindi	Lebowakgomo	Lepelle-Nkumpi
Barkley West	Thusanang Municipality	Lichtenburg	Lichtenburg Local Municipality
Belfast	Highlands	Mafikeng	Mafikeng Local Municipality
Benede	Benede	Marble Hall	Greater Marble Hall Municipality
Bo Karoo	Bo Karoo	Meyerton	Midvaal Local Municipality
Brits	NW372 Local Council	Mogwase	Mankwe-Madikwe Local Municipality
Bronkhorstspuit	Kungwini Local Municipality	Nelspruit	Mbombela
Burgersfort/ Ohrigstad/Eastern Tubatse	Greater Tubatse Municipality	Nylstroom	Modimole
Bushbuckridge	Bushbuckridge Municipality	Parys	Ngwathe Local Municipality
Carletonville	Merafong City Local Municipality	Pietersburg	Polokwane
Daniëlskuil	Dan-Lime Municipality	Pomfret	Molopo Local Municipality
Delmas	Delmas	Postmasburg	Re a Ipela Municipality
Diamondfields	Diamondfields	Potchefstroom	Potchefstroom Local Municipality (TCC)
DMA Lowveld	DMA Lowveld	Potgietersrus	Mogalakwena
East Rand	Ekurhuleni Metropolitan Municipality	Pretoria	Tshwane Metropolitan Municipality
Ellisras	Lephalale	Prieska	Priemaday Municipality

Elukwatini/Carolina	Albert Luthuli	Randfontein	Randfontein Local Municipality
Ganyesa	Kagisano Local Municipality	Reivilo	Greater Taung Local Municipality
Griekwastad	Siyancuma Municipality	Rustenburg	Rustenburg Local Municipality
Groblersdal	Greater Groblersdal Municipality	Sabie	Thaba Chweu
Heidelberg	Lesedi Local Municipality	Sasolburg	Metsimaholo Local Municipality
Hoedspruit	Drakensberg Municipality	Schuinsdraai Nature Reserve	Schuinsdraai Nature Reserve
Hopetown	Oranje-Karoo Municipality	Sterkfontein	Sterkfontein
Johannesburg	City of Johannesburg	Thabazimbi	Thabazimbi
Kalahari CBDC	Kalahari CBDC	Tzaneen	Greater Tzaneen Municipality

Morgan *et al.* (2002:24) argues that risk communication should not “talk down” to stakeholders but should assume that the stakeholders are interested in the awareness material and capable of mastering it. This statement cannot be universally applied, especially not in developing countries such as South Africa, but could represent a communication approach to certain stakeholder groupings such as technical and research partners. The examples of risk awareness material that could be accessed worldwide were clearly aimed at educated audiences and comprised lengthy booklets or pamphlets in fine print filled with technical detail and warnings. This approach would clearly not meet awareness goals for a vulnerable community with low levels of literacy.

The primary objective was therefore to acquire an illustration that could be used to explain the subsurface incidence of dolomite and the role ingress of acidic water and water abstraction had on karst. A very elementary illustration would suffice. The illustration in figure 4-9 published by [watermatters.org](http://watermatters.org), proved to be ideal and is still used daily in awareness interventions.

#### **4.5.8 Phase B research awareness leaflet**

The second objective was to develop a leaflet that would illustrate dolomite related risks

informally and in images residents could relate to. It should explain dolomite and the presence of the drilling rig. A conversation script was developed and photographs taken at recognisable venues within the affected areas with local residents as the characters. It is pictured in figures 4-11 and 4-12.

The leaflet was made available in English, Afrikaans and Setswana. It was reviewed by community members and technical personnel to ensure that the message was effectively and clearly stated. Morgan *et al.* (2002:4) compare random and unproven communication to distributing untested medication. The awareness team supported this argument and continued the review process until the feedback proved that it complied with cultural and language requirements.

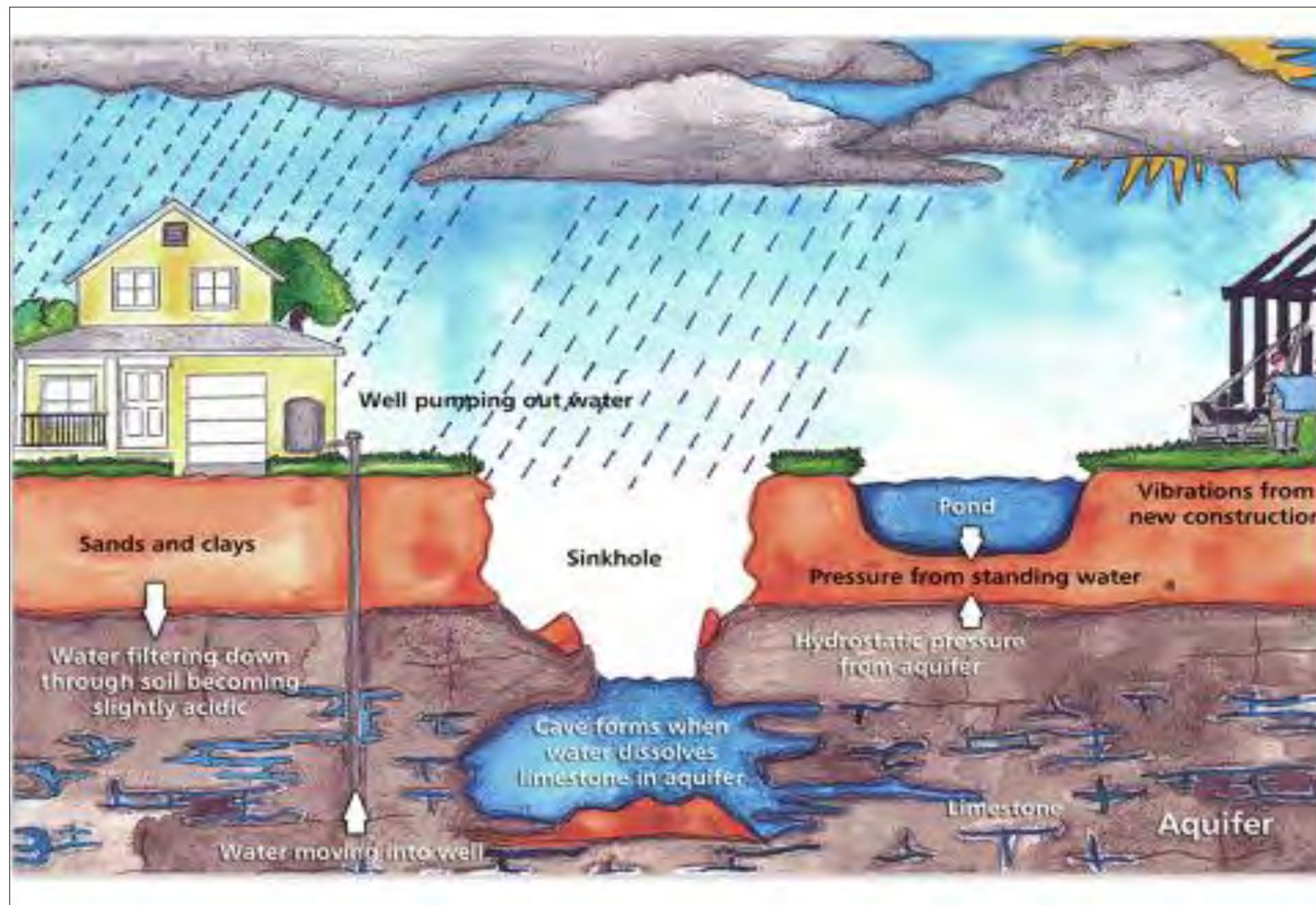


Figure 4-9: Sinkhole formation (Source: watermatters.org)

**be informed!**   
Take a ride with us and learn more about Dolomite!

**1** Welcome to Ikageng....  


**2** We are on our way to town...  


**3** Approaching the drilling machine...  


**4** Look!! What is that big Machine doing in our area?  


**5** I hear they are searching for diamonds!  


**6** I have seen it is another street  


**7** No Man! They are drilling for Oil  


**8** Isn't the taxi going to town? Am I going to be safe near the drill, what about my make-up?  


**9** The Geologists are drilling boreholes so that they can see where the dolomite is, how deep it is, and if it is good or bad  


**10** Dolomite is a type of rock that is made up of minerals that slowly dissolve in water over many years  


**11** When it dissolves in water cavities are made in the rocks, when these cavities become large enough to ground that is above the cavity may fall into the cavity, including anything that is above it  


**12** What is dolomite ses?  


**13** At every drilling site there will be drilling liaison officers who will answer the questions of the residents  


**14** Ivan, the drilling liaison officer  


**15** Ivan, What can this Dolomite do?  


**16** Sinkholes can form in dolomite when water from leaking pipes flow into the ground, when water is ponding on the ground surface and when too much water is taken out of the ground  


**17** Let's go I will explain further  


**DOLOMITE HELP DESK**  
**HELPLINE**  
**086 789 9876**

**Call us to report Dolomite damage OR if you need more information regarding the subject**

Figure 4-10: Dolomite risk awareness leaflet 1 (AGES, 2013c)

The poster features a dark blue header with the text "Be informed!" in white. Below this is a circular logo containing a stylized blue figure with arms raised, standing on a green field. The main body of the poster is light blue and contains the text "DOLOMITE HELP DESK" in large, bold, dark blue letters. A photograph of a white truck with a tall crane-like structure on its bed is shown. In the bottom right corner, there is a smaller, tilted inset poster that also says "Be informed!" and includes a speech bubble with the text "We are on our way to solve...".

**Be informed!**

**DOLOMITE  
HELP DESK**

On the back - Cartoon

**HELPLINE**  
**086 789 9876**

**Be informed!** Take a ride with us and learn

**Ikageno**

We are on our way to solve...

Figure 4-11: Poster on reverse of leaflet 1 (AGES, 2013c)

#### **4.5.9 Drilling Phase 2**

During the second phase of drilling, liaison officers were used on site again to prepare the community for the drilling and to conduct general awareness surrounding the site. They used the opportunity to disseminate information on infrastructure care and on how and where to report leakages and other infrastructure problems.

A focused awareness was conducted for three weeks that targeted taxis and taxi ranks as high volumes of affected community members passes through this point daily. Liaison officers visiting the taxi rank and travelling in the taxis did the awareness as an informal narrative.

#### **4.5.10 Radio**

Radio as medium with wide availability and flexibility is an ideal way to create awareness on an issue (Reynolds & W. Seeger, 2005:49). A senior geologist and team member from the risk awareness team received a slot in a breakfast show on the local radio station, Aganang FM to explain some of the burning issues concerning dolomite. The listeners called in afterwards with questions of their own. Their questions were translated to the team and they could respond. Only after the show, one of the social monitors informed the team that a listener asked a politically sensitive question. However, the DJ did not translate it but asked a different question. This was damaging because it seemed as if the team did not want to answer such questions, and it contributed toward mistrust.

#### **4.5.11 Campaign Tihalefa**

A campaign called Tihalefa (to know more) was initiated to target focus areas that have already been identified as being at high risk. Promosa, Sonderwater (Ikageng) and Sarafina (Ikageng) were included in the first stage of this campaign. As part of this campaign, door-to-door awareness was done by a team of well-trained social technicians. They commenced each visit with three questions to establish a baseline for the levels of awareness in the community. Most residents knew about dolomite but could not explain what it was or did not know how sinkholes were formed. The technicians then explained dolomite and sinkholes using the leaflet and illustration. They combined dolomite awareness with infrastructure awareness and explained the correct channels to follow for reporting infrastructure failure. They were provided with contact numbers for the TCC Department of Infrastructure as well as for Disaster Management line. The community was also encouraged to report infrastructure failure in dolomitic areas to their ward councillors. Out of this awareness campaign queries regarding building plans were brought to the attention of the social team. These queries were reported to the DMD where it was either addressed by contacting the residents telephonically or by visiting their homes.

Community members indicated to the awareness team that due to criminals entering their yards and politicians campaigning, they experienced uncertainty as to whether visits from the team were legitimate visits. The community indicated that the liaison team would be welcomed if they were identified as such. Coinciding with the development of a dolomite logo for the website and helpdesk, clothing worn by the social team working in Ikageng, Mohadin and Promosa were branded with this logo. They were also issued with branded caps.

A new social map was compiled for Ikageng, Mohadin and Promosa to indicate priority focus areas for intensive awareness interventions for the following six-month period (figure 4-13). These priority focus maps were not for public viewing but were used as a planning tool.

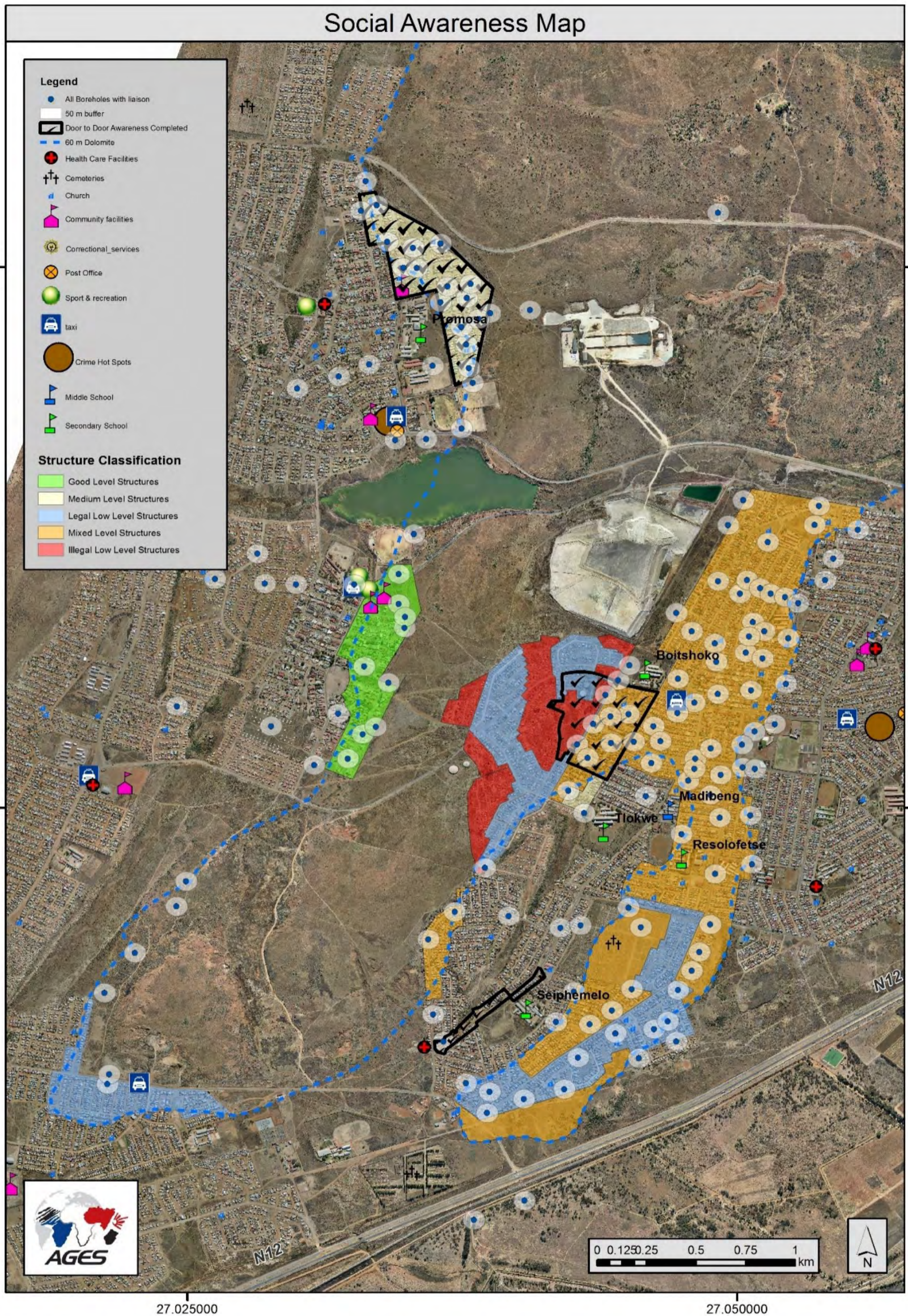


Figure 4-12: TCC Social Awareness Map

#### **4.5.12 The Ikageng Reservoir resettlement**

The risk as defined by the technical report on the Ikageng West Reservoirs indicated that the reservoirs and associated infrastructure were non-compliant according to any minimum current standards and practice. The Ikageng West Reservoirs are underlain by highly weathered chert and dolomite residuum.

Based on the results of previous research done in the area of the Ikageng West reservoirs, the new drilling data and the status and geo-environmental conditions of the site, the area was classified as DRMA 4 with an inherent hazard class 8/8. These conditions indicated a high risk for the loss of life and infrastructure. The area surrounding the reservoirs was inhabited by 164 illegal and informal structures that were at risk. Four rounds of awareness were conducted to ensure that all the affected residents understood that they were at risk and would have to be resettled.

A Resettlement Action Plan (RAP) was compiled and the first of three phases of resettlement have successfully been implemented. This incident required comprehensive awareness and consultation and placed the risk awareness team in perilous situations. The theme running through most conflict situations could be connected to the housing dilemma. In Ikageng alone 50, 3 % of residents are awaiting housing. As part of this resettlement, people who have settled illegally would receive a serviced erf ahead of residents who had been on waiting lists for many years. One of the greatest challenges was to create awareness within communities adjacent to the reservoirs as well as the community at large pertaining to the risk and necessity to resettle these residents without delay.

#### **4.5.13 The subsurface model**

Feedback from the door-to-door awareness pointed towards residents experiencing frustration understanding the subsurface conditions, as it was not visible to the eye. Residents had difficulty in understanding that on the surface they observed no problem, yet they were being told that their lives and homes were in danger. In response to this, a model as depicted in figure 4-15, was built using the data from the Sarafina subsidence investigation. The model has since become the most effective tool for awareness. When closed it resembles a quiet normal street and opening it up reveals the subsurface conditions. The houses built to scale, can be lifted and inserted into the dolomite cavities, illustrating the magnitude of the cavities.



Figure 4-13: Sarafina Subsurface model

#### **4.5.14 Workshops**

When conducting workshops, the first priority was to create awareness of the hazard of dolomite and the risks associated with this hazard. The affected communities were always the centre of these concerns. As the anthropogenic factors that impact this hazard had to be addressed in order to reduce the risk, the technical officials and consultants that mitigate anthropogenic hazard, should also be equipped to understand the risks of dolomite and to work safely on dolomite utilizing compliant materials and methods.

In order to reach this objective, the following workshops were conducted and stakeholders provided with awareness material and guidelines for developments on dolomite:

- engineering workshop;
- social awareness workshop;
- legal workshop;
- Ikageng Tailings dam workshop;
- Disaster Management workshop;
- DRMS alignment workshop: Public safety
- DRMS alignment workshop: Housing and Planning; and
- DRMS alignment workshop: Financial and Corporate services.
- Strategy Alignment Workshop: Regional
- Strategy Alignment Workshop: Service Providers
- Mitigation Workshop

#### **4.5.15 General awareness**

The medical clinics adjacent to dolomite affected areas were visited by prior arrangement. At some clinics the awareness team joined efforts with TCC Disaster Management to make community members aware of the risk they face. Fieldworkers used the subsurface model to illustrate the formation of a sinkhole and handed out dolomite awareness leaflets. This created an opportunity for questions and concerns to be raised. During this campaign, small focus groups of affected residents were formed and the perceptions and concerns of the residents were documented.

Most concerns centred on the fear of having to be removed from their homes and the possibility

of not being able to receive RDP<sup>6</sup> housing because of dolomite. These concerns were considered and mitigated for by being sensitive to their fears, as these stakeholders represented the most vulnerable of affected residents.

The response of the risk awareness team was to recommend that the door-to-door campaigns, which provide for more time to explain issues to individual households and an opportunity to ask questions and raise concerns which can be addressed on the spot, be intensified.

#### **4.5.16 Alignment with Infrastructure survey**

As the technical team became aware of more reports of cracking and suspected holes, it was decided that another round of focused awareness should be done to facilitate more practical information on how to react when encountering cracks and subsidences (AGES, 2013f). This also served the very specific purpose of doing an infrastructure survey in order to inform technical team members as to the possibility of increased risk to the community.

During the initial door-to-door awareness campaign as well as the infrastructure survey, the DMD was immediately informed of a concern or possible incident. Imagery of the crack, structural damage or hole was sent electronically to the DMD.

The DMD consequently dispatched a geologist to conduct a site inspection. A report was then rendered to the DMD to either submit to council or recommended for further investigation. The process was facilitated by an awareness team member with the home-owner in mind. The liaison officer explained the process as well as the monitoring actions to the home-owner. The infrastructure survey therefore opened up the opportunity for follow-up with infrastructure specialists to monitor cracks, which in turn informed the dolomite scenario as a whole.

The awareness team ensured that the concerns of the home-owners were addressed throughout. Additional awareness sessions with geologists in combination with the use of the dolomite model were arranged.

The dolomite risk awareness at the homes surrounding the Sarafina subsidence event was prioritized and relied not only on the owners reporting infrastructure failure by means of the survey, but also on physical inspection by the fieldwork team. The application of an integrated awareness approach, which the team employed in Sarafina was an effective way to monitor changes in sinkhole activity but also to monitor concerns, levels of community awareness, emotions and narratives concerning progress and outcomes of the research process.

The perception of the community as expressed through the media and door-to-door awareness

---

<sup>6</sup> Reconstruction and Development Programme providing Low Income housing to previously disadvantaged beneficiaries

existed that the technical process had been prolonged more than expected and that its results were not disclosed and disseminated adequately. This implied that their tolerance levels were already reduced and therefore a careful strategy on disclosing information and introducing mitigation was essential.

#### **4.5.17 The Kanana subsidence event**

During September 2013 while the TCC Department of Infrastructure was digging a trench in Kanana, Ikageng, a sinkhole opened up in the midst of seven homes, and created pandemonium in the surrounding community. The research commenced immediately with the drilling of five rotary percussion boreholes, a detailed gravity survey and a 3-D resistivity tomography survey. Based on the outcome of this research it was determined that the bedrock was overlain by highly weathered chert rubble material in a silty clay matrix with traces of wad and dolomite residuum (AGES, 2013d; AGES, 2016b).

The bedrock represented cavernous conditions typical of extreme karst conditions. The overburden material was characterised by highly weathered material, with extensive cavity formation. The entire profile surrounding the dolomite related feature represented active subsurface erosion and a very late stage of incipient sinkhole formation represented by progressive collapse of the roof of the void (AGES, 2013d; AGES, 2016b).

Based on the geophysical analysis, a correlation was made between the subsurface profile of the areas where the drilling had taken place and the areas where no drilling had taken place yet. Based on this, the affected erven had been identified and classified into 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> order erven for immediate resettlement (AGES, 2013f; AGES, 2016b). A RAP (AGES, 2016b) was compiled for this incident and four rounds of door-to-door awareness was performed to communicate the risk associated with this hazard, and the resulting resettlement process to residents. Reynolds and W. Seeger (2005:44) found that risks such as dolomite and sinkholes that are perceived as being unnatural and curious create great uncertainty. This was confirmed in the Kanana incident. The most obvious route for vulnerable residents were to be guided by either scientists, government or politicians. As fear played a pivotal role in this vulnerable community, most heeded to politicians who advised them that any sinkhole can merely be filled with soil and the community would not have to be resettled. This was said to ensure that their political base remained for upcoming elections as resettlement could place them a different ward. Although it was difficult to understand this perspective, the view of Eiser (2004:6) that this subjective representation of their reality should be seen as a legitimate alternative reality that may take time to mitigate, was taken as guideline to approach the fear and uncertainty of the community.

Since then many meetings and awareness sessions had been conducted within this community,

but due to logistical constraints such as the availability of erven and political resistance to resettlement, also associated with housing issues, the resettlement has not yet been implemented (as at the end of 2016). Figure 4-14 shows the Kanana subsidence event and the precarious situation of surrounding residences.



Figure 4-14: Kanana Subsidence

**4.5.18 Political climate**

The stakeholder that gains or has the most power to influence opinion and process will have the greatest impact on the community’s attitude towards this project. It was therefore extremely important to acknowledge and involve these stakeholders. These stakeholders included the geotechnical team, social scientists, ward councillors, ward committees, churches, schools and the media. Approaching the 2014 Elections, the politicians representing all parties would function in pivotal roles regarding the perception of dolomite risk and the general attitude

towards mitigation of the risk.

The raised levels of irritation concerning the transparency of results transposed on the general feelings of uncertainty and political turmoil, created a potential flammable situation that needed to be mitigated for the DRMS to be implemented (AGES, 2013f). The perception of lack of transparency arose because the TCC acted within their primary obligation to ensure that only the most critical information needed is made public (Fischhoff, 1995:140). To create a secure climate for implementation, the narratives, social awareness levels and potential barriers had to be identified timeously and addressed while still on a manageable level. If levels of mistrust and frustration escalate the mandate of the TCC to implement the DRMS and the mitigation of the dolomite risk would be seriously impaired.

The social monitoring included the liaison and follow-up of queries addressed to the DMD. These queries and concerns had the potential to create conflict and uncertainty. The perception of impact appeared to be more dependent on the perception of how adequately authorities managed the risk, than the possible impact of the risk itself (Kasperson *et al.*, 1988:178). The mistrust and politicising the DRMS generated, confirms the focus on the perception of successful risk management in contrast with the actual risk posed by dolomite instability. There was also disagreement on how risk is defined. Both the TCC and affected residents believed that the risk exists but the residents felt it was only necessary to move if a catastrophe was imminent, while the TCC interpreted research and decided that the risk was significant enough to resettle residents in order to pre-empt disaster.

#### **4.5.19 The Media revisited**

During the Risk Communication workshop, it was proposed that quarterly media conferences be held to update all stakeholders on the progress and implementation of the DRMS. According to Walaski (2011:2), our current culture relies constantly on verbal and written messages to inform us of the risks we face. These messages do much more than inform us. They wield power to mobilise large groups of people and alter their behaviour and perceptions (Walaski, 2011:2). The media should therefore always be considered as one of the most powerful mechanisms in risk communication, and should be managed wisely.

A media event which was hosted in November 2014 received wide coverage in the media. This event afforded the TCC an opportunity for an interview on National Television, which created awareness on the necessity of a DRMS.

The media received transparent information on the status quo of the DRMS implementation, yet chose to focus headlines on the wave of negativity from individual community members (figure 4-17). The moratorium on new developments was still an issue, as housing developments were

also halted in the process. The conclusion reached was that the media should receive additional awareness as to the implications of fear mongering and sensationalism on the mitigation of the dolomite risk.

During the aftermath of the Kanana subsidence event the media reported on the frustrations of the affected residents on having to leave their neighbourhood and homes behind (figure 4-18). In the process of different role players releasing information, a map was provided to the media which was at that stage classified as confidential and would be provided to the affected residents at a later stage during consultation (Herald, 31 October 2014). Although this was an honest oversight, it did flag the situation that confidential information may be inadvertently divulged. Fear of leakages must not drive the TCC towards over protectiveness and secrecy (Gould, 2012:4), but should highlight the sensitivity of access to information.

The publication of this map, lead to a very close co-operation between the TCC and dolomite risk awareness role players, to agree to the levels of disclosure of documentation and information. The TCC spokesperson and communications department now confirm all statements and awareness material with other team members before its release to the media.

# Dolomite places residents between a rock and a hard place

**Victor Boqe**

More than 80 residents staying in Boskhuiso Street in Itageng are to be relocated to Moadin.

This comes after Tlokwe City Council appointed Ages to drill and test the ground for dolomite in September last year.

According to the municipal spokesperson, Mr Willie Maphosa, council has accepted the Dolomite Risk Management Strategy that was presented to

it following intensive studies on the prevalence of the dolomite in local residential areas.

The measured dolomite risk management investigation has indicated that people residing in the Kanana area, next to the old Itageng cemetery, are at inherent risk and should therefore be relocated as a matter of urgency. According to the report, there is no level of mitigation that can salvage the situation.

However, Maphosa said it had been

agreed that resettlement would be embarked upon only as a last option, and that resettlement would not be undertaken on a large scale.

The relocation programme has been divided into three phases in order for the process to go ahead in a seamless manner.

The first phase consists of relocating ten households with immediate effect. Alternative stands have been identified in the Moadin area.

The second phase comprises twenty one households whilst the third and final phase will involve 51 households.

"This is the first time that the municipality has embarked on such a task and many lessons will obviously be learned in the process. The co-operation of the households concerned, and the community in general, will be critical to ensure that lives are spared from potential danger. The area from which the residents are being removed will be cordoned off so as to avoid future intrusions.

It is expected that the relocation process will be completed before the end of the year due to the urgency of the matter. Discussions with individual home owners for re-imbursment or compensation will take place immediately," says Maphosa.

According to Ages, a pre-risk assessment was conducted in the direct vicinity of the Kanana's dolomite-related instability feature. It was ascertained that at least the following houses may be adversely affected by instability caused by the sewer pipe. Based on the assessment, the coloured erven as shown in the photo have been prioritised.

The red stands are the most at risk and highest priority, followed by the orange and yellow as second and third order stands respectively.

But dolomite risk or not, the residents are up in arms and are firmly opposed to being relocated. Ms Baeng Molefe is adamant that she is there to stay.

"We have being staying here for the past ten years now. How can they expect us to give up our homes just like that? Who is going to pay for school fees and transport once we have been moved to Moadin?" she asked angrily.



The Ages report shows the 82 houses - red, orange and yellow - that have been affected by dolomite and have to be relocated.

Steek jou neus in besigheid.

'n MBA van NWU Potchefstroom Besigheidsskool, waarborg studente besigheidsonderig in lyn met die hoogste internasionale standaarde. Ons MBA is dinamies en fokus op strategiese denke. Dit is ontwerp om jou 'n mededingende voorsprong te gee.

018 298 1419  
 pbsinfo@nwu.ac.za  
 http://pbs.nwu.ac.za  
 NWU Potchefstroom Business School

NWU POTCHEFSTROOM Besigheidsskool

Figure 4-15: Potchefstroom Herald 31 October 2014

# Council spends R4 million on dolomite studies but affected communities are 'gatvol'

Victor Boqo

Tlokweng City Council had set aside and spent R4 million to manage the risk posed by development on dolomite but, despite this massive spending, the R2 households affected in Kanana section next to the graveyard are 'gatvol.'

After the studies were done and a report handed over to council by Ages, it emerged that the affected households are at serious risk from dolomite instability and must be relocated as a matter of urgency. But the community is adamant that it is not going anywhere.

The studies consisted of two initial phases that focused primarily on the assessment of the risk, including geotechnical, geohydrological, land use, infrastructure and social investigations. The results of these risk assessments were incorporated in a report adopted by council in January.

On Monday, during site inspections, the MMC (member of the mayoral committee) of housing, Hodge Molegethi, the housing manager, Laws Mchloni, ward 4 councillor, Matlhomola Seobi and Stephan Potgieter of Ages, accompanied by a media contingent, were booed by some of the residents.

The community accuses the city council of withholding information on the dolomite findings and are questioning the reasons for relocation.

The municipality will soon be embarking on a door-to-door awareness campaign, and workshops.

During the media briefing, the MMC said Tlokweng Municipality has been proven to be one of a few municipalities in South Africa that already has a comprehensive dolomite risk management strategy (DRMS) in place, as required by law. The document has to be updated every five years.

The MMC insisted that the resettlement of households is regarded as a very last resort, and is only considered when all other mitigation options have been proven to be insufficient to effectively reduce the risk within tolerable limits. The municipal manager has already started the implementation process and the resolutions adopted in council.

The municipality is continually engaging with the affected homeowners to achieve the best alternative housing solutions possible.

"The community will be kept informed through an intensive social awareness, vigilance and risk communica-

tion programme over the following months and years," Molegethi said.

This includes both general and focused awareness, media statements, posters and cartoon pamphlets, liaison through community leaders and ward councillors, school programmes, workshops and door-to-door awareness campaigns.

"But the programme does not replace the responsibility of each affected community member to inform themselves about the risks at hand with regards to their specific development."

A workshop has been scheduled for 27 November, where ward councillors and their respective committees will be empowered to address enquiries from the community in more detail.

"Although there is no guarantee that sinkholes will never occur, as long as the risks are adequately and timeously

managed, there is no need for panic."

The role and responsibilities of the typical homeowner or occupant include immediately reporting or fixing any leaking taps, water pipes, or sewer pipes on the occupied stand. No building or upgrading is permitted without authorisation or approved building plans. All new buildings or extensions to existing buildings should be reported to the Dolomite Help Desk at (071) 268 9508 for evaluation by the dolomite specialist and approval by the Tlokweng City Council Building Department before construction may take place," Molegethi added.

"Council would like to assure the community that it is doing everything in its power to manage the dolomite risk to the benefit of all, and urges those affected to co-operate with the municipality and the specialist consultants."



These are the officials who addressed the media on the status of dolomite in the city: Matlhomola Seobi (ward 4 councillor); Hodge Molegethi (MMC housing); Laws Mchloni (housing manager); Dr Emily Bana Molegethi (municipal manager) with Stephan Potgieter from Ages. Photo: Victor Boqo.

## Was Ventersdorp Police Station robber(s) perhaps looking for this smashed laptop?

Victor Boqo

A burglary at Ventersdorp Police Station over the past weekend has raised eyebrows and questions.

son, Brig. Thulani Ngubane, confirmed that there had been a burglary at the Ventersdorp Police Station.

But Ngubane denies that the laptop came from the municipality.

Figure 4-16: Potchefstroom Herald 14 November 2014

#### **4.5.20 Phase B leaflet 2: Dolomite risk awareness and the way forward**

The mounting irritation with delayed dissemination of reporting led to the development of the second dolomite risk awareness leaflet (figure 4-17). This communique presented an opportunity to address the roles and responsibilities of the homeowners residing on dolomite.

The drafting of another leaflet with similar content provided the opportunity to repeat the intended message together with all the avenues employed to convey the risk message, amplifying the message by repetition from varied sources, as suggested by Kasperson *et al.* (1988:181).

# Be informed!

Take a ride with us and learn more about Dolomite!

**1** On our way to the Tuck shop

**2** Arriving at our destination

**3** Dolomite stories doing the rounds...

**4** Tell me Sessi, what is this Dolomite?

**5** Dolomite is a type of rock that is made up of minerals that slowly dissolve in water over many years.

**6** When it dissolves, cavities are made in the rocks.

**7** When these cavities become large enough, the ground that is above the cavity may fall into the cavity, including anything that is above it.

**8** Council is acting pro-actively by conducting research.

**9** The research results will be used to address the risk towards residents.

**10** My child, listen to the social technician, she is explaining.

**11** You must care for the environment and...

**12** ...report leaking pipes and suspicious holes and cracks in the ground.

**13** close taps properly and don't use cheap plastic taps.

**14** Avoid ponding of water and make sure rainwater drains quickly from your property.

**15** don't throw objects into the sewerage system and storm water drains

**16** Report all your queries and incidents to the Dolomite Help Desk

**DOLOMITE HELP DESK HELPLINE 071 268 9508**

Call us to report Dolomite damage OR if you need more information regarding the subject

Figure 4-17: Dolomite Risk Awareness leaflet

#### 4.5.21 Dolomite Management Desk processes

During Phase B it became increasingly apparent that the building application process was at the core of most complaints about dolomite research, feedback or deficits in awareness. The door-to-door campaign, visits by residents to the AGES office and feedback from TCC officials collectively indicated uncertainty and frustration as to the perceived proliferation of the process.

The DMD increasingly narrowed its task to focus on adhering to strict timeframes and developed a flowchart to utilise as awareness support (figure 4-20). This flow chart was used with all building applications on dolomite to clarify the process and expected timeframes. During

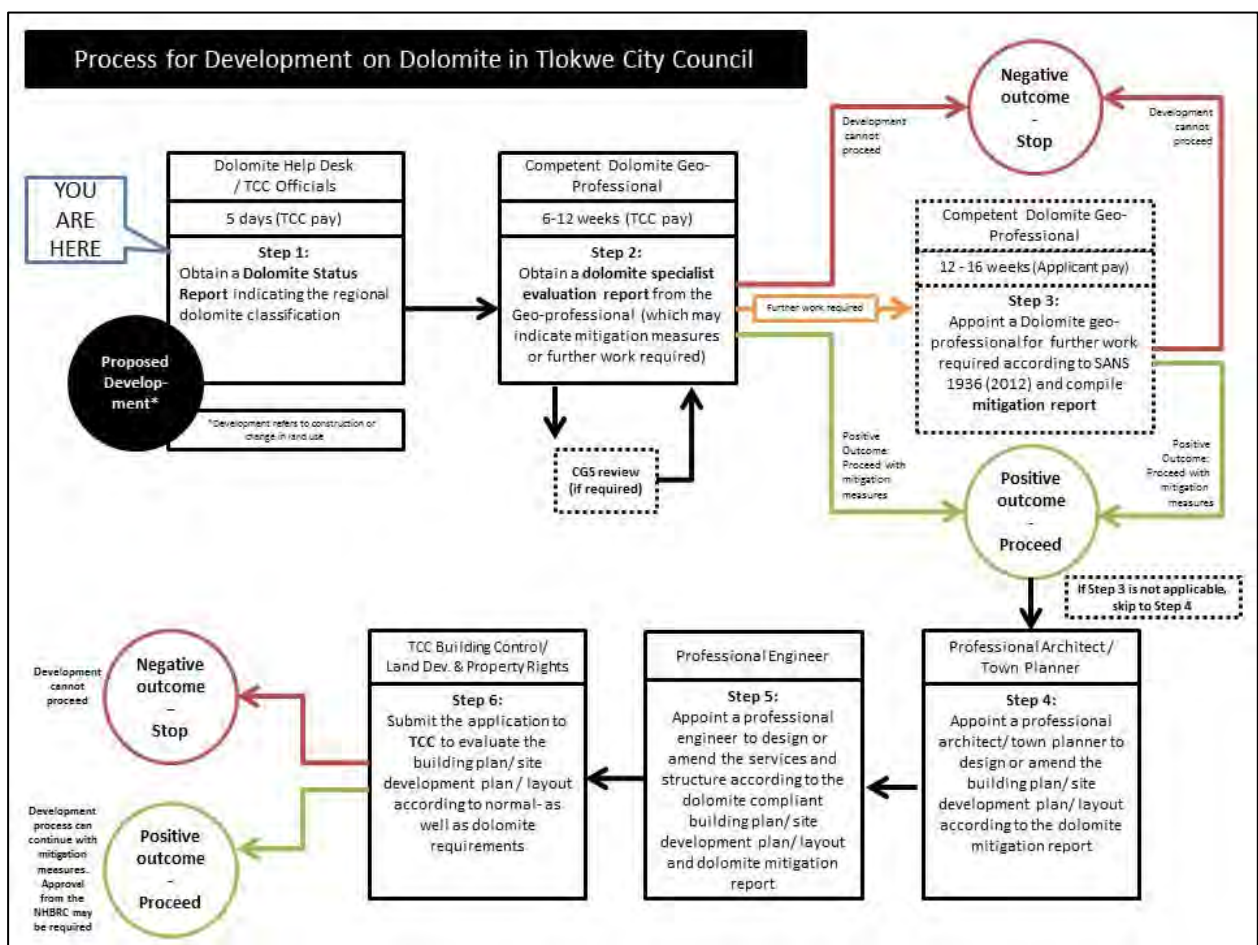


Figure 4-18: DMD Building application flowchart

all risk communication actions, it became a useful tool to create awareness and transparency.

#### 4.6 DRMS Phase C1

The DRMS was officially adopted in 2014 which in effect introduced the third phase of the DRMP (Potgieter *et al.*, 2016:1045). For this phase an implementation plan was developed based on the approved DRMS, council resolutions, DSC decisions and annual internal review

processes (Potgieter *et al.*, 2016:1045). During this phase, it was proposed that the nomenclature be adapted to define the objectives and actions of the Social Awareness Plan more clearly. The liaison team started to refer to the plan as a Dolomite Risk Awareness Plan (DRAP) and the actions as risk communication or risk awareness actions.

During this phase the social processes involved to amplify the risk message according to the guidelines proposed by Kaspersen *et al.* (1988:180), was recognizable:

- the risk message was processed through filtering and decoding of the signals;
- the message was shared and interpreted by means of interaction with the affected residents' cultural and peer groups; and
- these groups contributed to the validation and decision-making as response to the message.

It became apparent through the negation of the existence of dolomite or any problematic issues connected to it, that the political leaders and community leaders framed the message interpretation and validation with their own agendas.

#### **4.6.1 DRMS implementation and mitigation processes**

The following processes were included in Phase C1:

- reporting continued;
- dissemination of reporting;
- implementation of recommendation; and
- mitigation measures.

#### **4.6.2 Risk Communication Workshop**

As part of Phase C1 of the DRMS, a Risk Communication workshop was planned. The objective of the workshop was to revisit the risk communication actions up to date, contribute innovative inputs and receive feedback from the TCC and community members. A risk communication specialist was also invited to present an overview of what risk communication entails.

The input received from this workshop was pivotal in assessing the actions implemented and possible future actions that should be included in the DRAP.

### 4.6.3 Media Partners

After the first media conference the article showed in figure 4-21 appeared in a regional newspaper (Platinum Kosh, 14 November 2014). It featured dolomite the mineral instead of dolomite rock. This had the potential to create confusion with a community already beleaguered by conflicting messages concerning dolomite. A closer association with the media as well as a more informed media could prevent these misrepresentations occurring.



The panel whom addressed the media regarding the Status of the Dolomite Risk Management Programme in areas under the jurisdiction of the Tlokwe City Council.  
Fltr: Cllr. Matlhomola Seobi (Ward Councillor- Highly affected ward), Alderman Hodge Mokgethi (Member of the Mayoral Committee for Human Settlement & Planning), Mr Laws Mohlomi (Manager for Human Settlement & Planning), Dr Nomathemba Emily Blaai-Mokgethi (Municipal Manager) and Mr Stephan Potgieter (Senior Engineering & Environmental Geologist) from AGES North West (Pty) Ltd.



**Dolomite Rock.**

**Figure 4-19: Dolomite risk managed in Tlokwe**

A key outcome of the Risk Communication workshop and the DRAP, was that the media should be made partners in addressing the risk associated with dolomite. This process was initiated by employing the following actions:

- individual journalists from local publications were invited to join the liaison team in a comprehensive dolomite risk awareness session;
- they received awareness material and an invitation was extended to visit at any time or contact the team for the verification of information;
- media statements were drafted quarterly as well as with each subsidence event as it occurs; and
- the TCC initiated contact with the media when a subsidence event occurs. The media has also been invited on site with the technical specialists and the risk awareness team to acquire relevant and accurate information.

- The media provided the TCC and dolomite risk awareness team with draft copies to proofread for technical accuracy.

#### **4.6.4 Ward Councillor Workshop**

At the beginning of 2015, a ward councillor workshop was held. Ward councillors were given an awareness presentation followed by an update on the progress of the programme. Ward councillors from dolomite affected wards received a file incorporating data and maps pertaining to their wards. They had an opportunity to voice their concerns and address questions to the team.

#### **4.6.5 Door-to-door resumes**

After a tumultuous time preceding the local elections and subsequent political instability, the door-to-door campaign was resumed. The door-to-door campaign could only be continued after the ward councillor workshop had taken place. The climate was still very tense. Within the affected areas residents felt disenfranchised and perceived the municipality as not acting with integrity. The narratives employed for political gain preceding the 2014 elections were damaging and would not easily be mitigated.

As previously illustrated, an awareness plan can be discredited very easily by a few politicians or affected residents, indicating that they have not received awareness. Within a legal framework, this could also have major implications for the municipality to show their commitment and due diligence concerning awareness. In planning the new door-to-door campaign the logistical planning of the campaign was conducted with diligence as not to miss a single residence and gather as much proof as possible.

In order to capacitate the TCC to continue implementation of the DRMS the door-to-door campaign was planned by AGES but executed by the Disaster Management Volunteers (DMV's). They were briefed every morning and at the end of the day returned the data, which was subsequently captured by AGES technicians and represented on GIS and spreadsheets. Congruent to other campaigns the volunteers reported flagged incidents at the end of each day. High-risk scenarios were immediately reported from the field into the DMD and promptly followed up by the DMO's. Figure 4-22 shows the map that indicates the proposed area demarcation for the awareness actions. In Figure 4-23, the specific street demarcation for a TCC Disaster Management Volunteer fieldwork team can be seen. When the team had visited a residence, it was highlighted on the map. Figure 4-24 constitutes a summary of all the door-to-door awareness done in focus areas up to the 2015 moratorium on risk awareness campaigning.

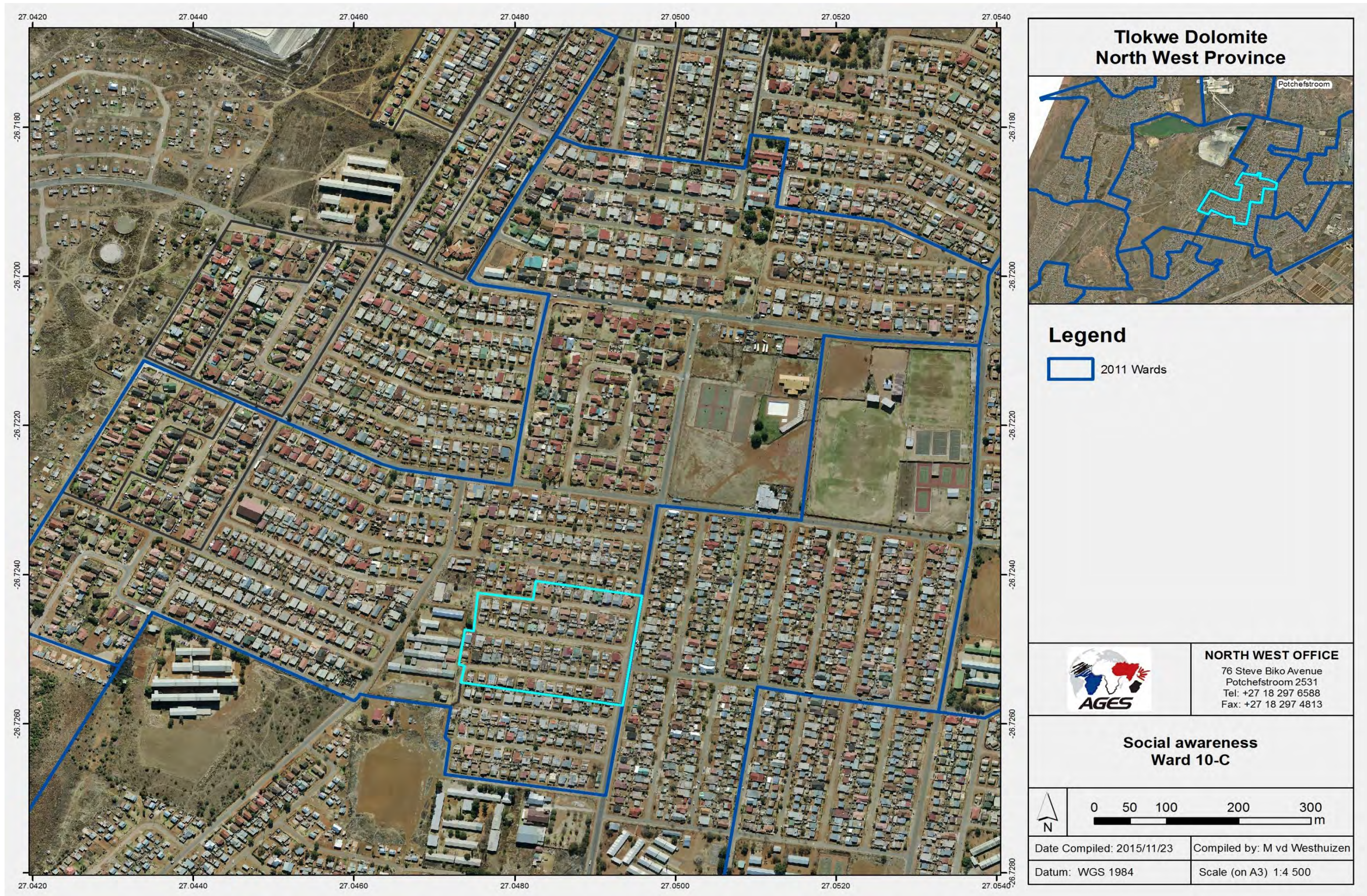


Figure 4-20: Door-to-door Campaign Ward planning

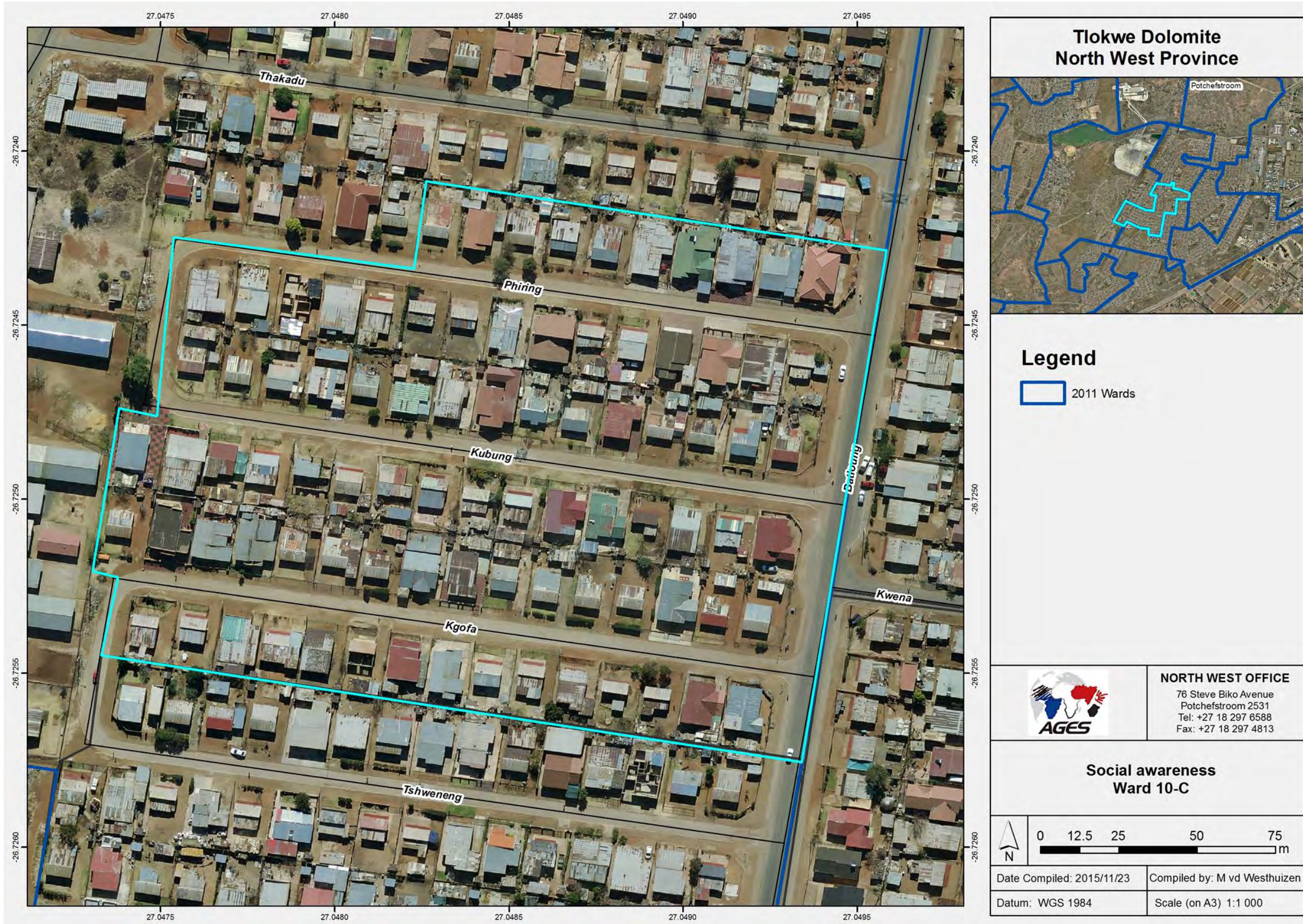


Figure 4-21: Door-to-door Campaign Verification Map

# Dolomite Social Awareness: May 2015

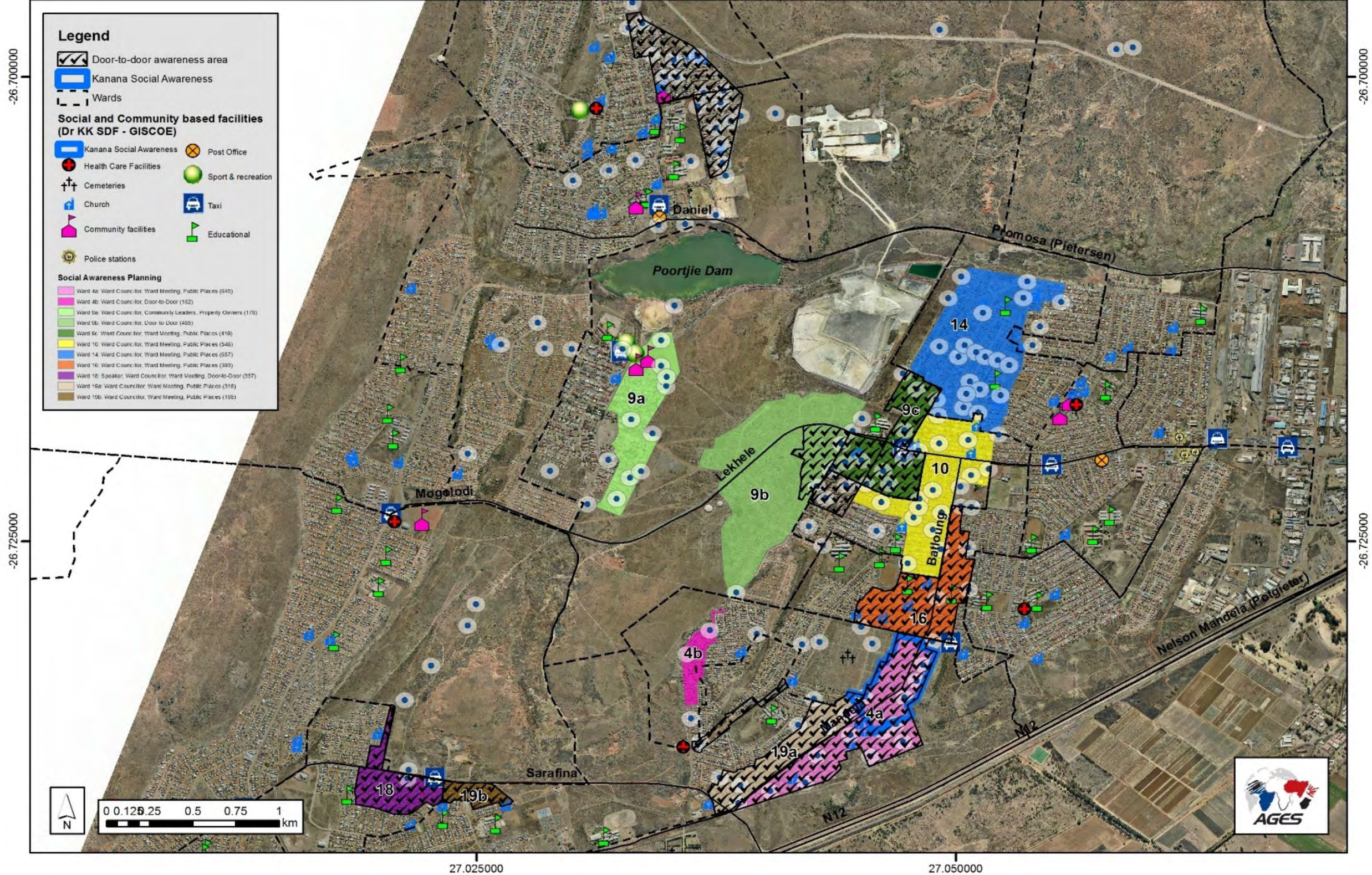


Figure 4-22: Dolomite Risk Awareness 2015 summary

#### **4.6.6 Political Impasse**

During the February 2016 period, by-elections were held in a few wards. This political context delayed the door-to-door campaign as well as all other actions planned for schools. The field had to be cleared for politicians to campaign and not even the DMV's could proceed with awareness campaigns. With the completion of the by-elections, the National Election was in view and the door-to-door and schools program was postponed until after the elections.

#### **4.6.7 Schools Program**

The importance of school programs to channel information to households is evident. Due to the political climate and context, the interventions planned for this specific period could not proceed. This leaves the schools program as the biggest gap in dolomite risk awareness.

In Phase C2, which is not discussed as part of this study as it has not yet commenced, the schools program will entail a roadshow with an industrial theatre production visiting affected schools. A script with humorous scenes and live music, which learners can relate to, has been drafted from within the community. As part of the new academic year (2017) at the North-West University (NWU) Potchefstroom campus, students as well as local NGO's will take part in rehearsing the production and performing it at affected schools.

However, the worst affected school has been visited frequently and a meeting was convened between the Department of Education, TCC and school management in order to address critical issues such as the cessation of borehole abstraction activities and monitoring of leaks and cracks.

Risk messages in general tries to change behaviour by describing the threat presented when behaviour is not modified (Reynolds & W. Seeger, 2005:45). With the schools program the focus should not be in creating panic but rather capacitate to them to be vigilant and take an interest in the science of dolomite, as well as the mitigation measures associated with dolomite and sinkholes.

As part of the Phase C2 actions schools will be provided with the Living on Dolomite documentary film, which can be shown at any stage as part of assembly or in Geography or Science classes. Appointments have been made to address SGB's and educators at affected schools in order to create awareness and make them partners in monitoring and vigilance.

#### **4.6.8 Dolomite ambassadors**

In an interview with Wiggill (2016:50), the TCC Human Settlements and Planning Manager indicated his preference for ward councillors to be capacitated so that they can in turn serve as a source for risk information for their ward members. This premise has become somewhat

problematic as ward councillors represent a diverse range of political views and represent opposing political factions and alliances, as well as personal and ward agendas linked to housing provision and support base.

Through the workshops and SC meetings, the dolomite ambassadors were defined as students within the community who have been studying Environmental Sciences and who will be trained to function as information sources for the affected wards. A number of challenges arose from this endeavour:

- students were identified as potential candidates with the assistance of the NWU-Potchefstroom School for Environmental Management, however, only two students fit into this category;
- sustainable remuneration was not available; and
- students were only available for the remainder of their studies.

Due to above mentioned constraints, the TCC decided to rather request councillors to identify candidates within their wards to be ambassadors. Guidelines for the identification of suitable candidates were provided, as well as agreements concerning the roles and responsibilities of chosen candidates. This process was postponed due to the lack of remuneration incentives for ambassadors, added to time constraints for Ward Councillors to implement guidelines concerning the appointment of ambassadors.

#### **4.6.9 Research outcomes on Dolomite Management Desk**

In a study conducted to investigate the effectiveness of the DMD (Wiggill, 2016:53), the affected residents responded concerning the overall perception of the communication of risk to residents:

- although affected residents were visited by monitoring teams they were not capacitated to manage the risk and do monitoring;
- there is uncertainty regarding the respective roles and responsibilities of AGES and TCC. This confusion leads to expectations that AGES should repair infrastructure;
- TCC does not follow up on calls to report cracks and leaking infrastructure;
- respondents were not certain about the nature and extent of the risk;
- respondents felt unsafe because of the lack of information from TCC and ward councillors;
- TCC does not care about their safety;
- the AGES awareness campaign is effective and the risk is explained well;
- AGES was perceived as informed, friendly and helpful;

- AGES does not keep residents with building plan applications up to date with progress
- the ward councillor was asked to get AGES to inform the ward, but the ward councillor refused;
- the TCC does not communicate openly about the dolomite risk;
- the TCC does not want to promulgate the findings of the AGES DSI;
- the TCC is not to be trusted to manage the dolomite risk;
- you have to be insistent and badger the TCC to obtain information;
- ward councillors do not want the risk to be revealed as it would damage their power base; and
- residents are frustrated with extended delays and lack of communication.

Wiggill (2016:54) concluded that two-way communication should be established so that affected residents may be heard and participate in decision-making and roles and responsibilities should be defined and communicated. Wiggill (2016:54) also proposes that feedback by the DMD should be provided without delay to affected residents and the TCC should communicate the dolomite risk clearly and openly and should not allow politics to influence the communication of risk. Wiggill (2016:54) concludes that dolomite risk communication in the TCC should not focus on technical issues only and not be one-way in nature but should focus on establishing trust relationships and capacitating the community to participate in decision-making. The conclusions of the study by Wiggill (2016), as well as the mitigation measures to address these issues highlighted by the research are summarised in table 4-5.

**Table 4-6: Risk Awareness Mitigation**

Action/ Uncertainty/Concern	Risk Communication Method	Mitigation
<b>TCC and AGES</b>		
There is uncertainty regarding the respective roles and responsibilities of AGES and TCC. This confusion leads to expectations that AGES should repair infrastructure	Media, Door to door, Ward Councillor	Media statement explaining status and way forward
<b>TCC</b>		
TCC does not follow up on calls to report cracks and leaking infrastructure	Workshops for Officials, door to door, leaflets	Workshop Infrastructure held, leaflets with roles and responsibilities and contact channels provided with door to door and all awareness actions
Respondents felt unsafe because of the lack of information from TCC and ward councillors	Media, Door to door, Ward Councillor	Individual sessions with ward councillors
TCC does not care about their safety	Media, Door to door, Ward Councillor	Media statement, article in Tlokwe news, Ward Councillor sessions, door to door focus on proactive stance of TCC and progress
The TCC does not communicate openly about the dolomite risk	Media, Door to door, Ward Councillor	Media statement, article in Tlokwe news, Ward Councillor sessions, door to door focus on proactive stance of TCC and progress
The TCC does not want to promulgate the findings of the AGES DSI.	Media, Door to door, Ward Councillor	Ward Councillor sessions, Planning for Ward Councillor workshop 2
The TCC is not to be trusted to manage the dolomite risk	Media, Door to door, Ward Councillor	Media statement, article in Tlokwe news, Ward Councillor sessions, door to door focus on proactive stance of TCC and progress
Ward Councillors do not want the risk to be revealed as it would damage their power base	Ward Councillor	Individual sessions with ward councillors
The ward councillor was asked to get AGES to inform the ward, but the ward councillor refused	Ward Councillor	Individual sessions with ward councillors
Residents are frustrated with extended delays and lack of communication	Media, Door to door, Ward Councillor	Media statement, article in Tlokwe news, Ward Councillor sessions, door to door focus on proactive stance of TCC and progress
<b>AGES</b>		
AGES does not keep residents with building plan applications up to date with progress	Dolomite Desk, Media, Door to door	Dolomite desk process revisions
AGES was perceived as informed, friendly and helpful	Dolomite Desk.	Affirmation of actions
The AGES awareness campaign is effective and the risk is explained well	Dolomite Desk, Media, Door to door	Affirmation of actions

#### **4.6.10 Dolomite desk revisited**

The level of sophistication of the DMD was developed and implemented to the extent that building plan turnover adheres strictly to the timeframes set. Acknowledging the input from stakeholders and considering the practical implementation of handling inquiries as to the progress of building plan applications, the DMD has developed a sms (text message) notification system to update applicants as their application proceeds through every stage. This is a powerful way to create awareness of dolomite processes and relieve the uncertainty experienced by affected residents. As part of the awareness sessions, this feature is explained alongside the building plan process.

#### **4.6.11 Dolomite Documentary**

Since the inception of dolomite risk awareness actions, developing a documentary that would serve as an awareness tool at schools, but also appeal to a variety of stakeholders was planned. The benefit of a scripted documentary was that the pitfalls of personal communication such as non-verbal cues and nervousness, which can create mistrust can be avoided (Fischhoff, 1995:142). The first draft of the script was developed by geo-environmental specialists and re-scripted to form a storyline with simplified concepts. The script was subsequently submitted to community members to provide input as to the effectivity and clarity of terminology and concepts employed. This script was edited to become a frame-by-frame documentary script.

To create more accessible material, the live shots were interspersed with 2D and 3D animation. The first part of the dolomite documentary covered the basic questions about dolomite:

- What is dolomite?
- Where does it occur?
- How are sinkholes formed?
- What must I do?

The second part of the documentary was planned for external stakeholders such as service providers and affected municipalities. It contains interviews with an engineering geologist and a senior housing and planning official, providing recommendations pertaining to the DRMS and requirements for development on dolomitic land.

The dolomite animation character was based on the geologist acting in the live footage. The appeal this character had on pilot audiences as well as the real-life responses to the geologist presenter during fieldwork awareness interventions, served as motivation for using this character for continuity in the successive leaflets. The learners at schools could now not only identify with the character, but also with someone from their own community who has been

educated and in turn aims to capacitate them.

#### **4.6.12 External stakeholders**

Tier 4, 5 and 6 stakeholders were engaged on a management level. Presentations on the risk of dolomite and sinkholes were made on district and provincial levels with the focus on disaster management, human settlements planning and environmental departments. Presentations were also made to environmental forums and the NHBRC. The NWU was involved in the project providing inputs on all aspects of the DRMS. Seven post-graduate studies have been conducted on various aspects of the project, which lead to academic awareness of the risks associated with dolomite and sinkholes. The dolomite risk awareness team also has a seat and standing presentation on both the TCC Disaster Management Advisory Forum and the Dr Kenneth Kaunda District Municipality Disaster Management Advisory Forum.

#### **4.6.13 Monitoring**

Monitoring is either routine with the intention to measure fluctuation in subsurface water levels, to survey crack monitors installed in high risk residences or in response to the logging of an event or concern from the community. During the initial visit by a geologist to a residence that has been affected by dolomite, risk awareness was conducted and the homeowner provided with risk awareness leaflets.

#### **4.6.14 The Reverend Phethlu street sinkhole**

The Reverend Phethlu street sinkhole collapsed on 15 June 2016. The eyewitness observed a taxi with learners on their way to school pass along the street. Moments thereafter a sinkhole collapsed in the tarred road. This incident highlighted the urgency of dolomite risk awareness and mitigation. The dolomite liaison officers were informed and immediately went on site. The liaison team started door-to-door visits in the affected street and found most home owners to be informed. The directly affected home owners indicated that they were not informed about dolomite risks. The data base was consulted and it was ascertained that these homes were visited for door-to-door awareness. Proof in the form of signed registers and images could be provided. In follow-up visits learners from the affected homes retrieved leaflets from drawers and cupboards.

A community representative forum was established and invited to attend an awareness session. They were provided with awareness material and were kept updated with all progress on the investigation and rehabilitation of the sinkhole. They also assisted in creating general awareness in their neighbourhood.

#### **4.6.15 Dolomite roles and responsibilities**

Risk communication messages should include responsibilities that can provide affected stakeholders with a perception of control (Reynolds & W. Seeger, 2005:45). A fact sheet with the roles and responsibilities of home owners living in dolomitic areas was drafted and attached to all correspondence for home owners. The fact sheet was also printed on the reverse side of risk awareness leaflets. Due to the vulnerability of the community, it was decided to convert this information into a cartoon leaflet (Figure 4-25).

This leaflet was the final risk awareness action to be considered part of the DRMS C1 implementation.

The completion of the Phase A, B and C1 DRMS implementation and the risk awareness actions that supported these phases led to conclusions and some recommendations for scientists and decision-makers managing and mitigating the risk posed by dolomite and sinkholes that will be summarised in Chapter 5 of the study at hand.

# Be informed!

Take a ride with us and learn more about Dolomite!

**1**

**Yoh! Yoh! Yoh!!!**  
Eish, is that a sinkhole?

I have heard stories about sinkholes!

**2**

I wonder if there is anything we can do, I'm scared

Don't worry guys, there is a lot you can do. Look out for the following and report them immediately:

**3**

Look out for unfamiliar holes around the yard, as well as surface cracks.

**7**

Fix leaking taps and report leaking water or sewer pipes.

**8**

Check after every rainstorm that water drains away from your property. Avoid ponding of water in your yard.

**9**

Do not flush any foreign objects (such as nappies, rubbish, plastic etc) down the toilet as it can block the sewer pipes.

**4**

Look out for cracks in and around your house. A dolomite specialist will insert crack monitors to see if the cracks widen with time.

**6**

**5**

I heard that there was a leaking water pipe that formed a sinkhole.

Yes, that is why you must at all times:  
Make sure that all taps are closed properly.

**6**

**10**

Building and extension of houses cannot be done without permission or approved building plans.

**11**

All building plans should first be evaluated by a dolomite specialist and be approved by Tlokwe City Council.

**12**

Rea leboga. We now know what we can do to live safely on dolomite.

**For Emergencies:**  
**018 299 5347**

Call us if you need more information regarding Dolomite **071 268 9508**

Figure 4-23: Dolomite Risk Awareness leaflet 3

## CHAPTER 5

### CONCLUSION AND RECOMMENDATIONS

#### 5.1 Introduction

Chapter 1 of the study at hand introduced the research problem and the research questions that would meet the research objectives of the study. Chapter 2 responded to the first research question by describing the hazards posed by dolomite and sinkholes in built areas. Chapter 3 provided an overview of why TCC communities are underlain by dolomite and who the stakeholders are that have to be engaged in dolomite risk awareness actions. Chapter 4 described the dolomite risk awareness actions that were planned and executed to match the technical research phases of the TCC DRMS as well as the actions that were implemented in response to community feedback, perceived gaps and research findings. In Chapter 5 the conclusions made based on the TCC case study will be rendered as well as the recommendation made for future dolomite risk awareness interventions. The Chapter will be concluded with a proposed Dolomite Risk Awareness Framework which may serve as guideline for similar projects.

#### 5.2 Conclusions

##### 5.2.1 Considering the hazards and risks associated with karst in built environments

Surveying the reports, scientific articles and books on dolomite management the focus is predominantly reactive and underpinned by engineering and environmental outcomes. (Waltham *et al.*, 2007:271-350) presented sixteen case studies bridging the boundary between geology and engineering. Specialists worldwide contributed these case studies to demonstrate the remediation of karst incidents. The only case study in this volume alluding to mitigation of risk by creating risk awareness is Case study #12 by Fred Calitz from South Africa. Calitz (Waltham *et al.*, 2007:330) concludes the following in respect to the subsidence collapse of a warehouse in South Africa: “This failure indicates an insufficient knowledge on the part of the developer and land user regarding development on karst, especially those areas with a soil cover of unstable wad, and proves again that the education of engineers, town planners, developers and local authorities with regard to the geotechnical characteristics on dolomite terrain is essential.”

In section 2.2 of this study, the hazards of dolomite and the risk to communities living on dolomite have been described. The risk is attributed to the weathering of dolomite leading to dolomite instability, which in the presence of the ingress of acidic water and/or the abstraction of groundwater may result in the formation of sinkholes and subsidences.

This chapter also concluded in section 2.3 that anthropogenic factors such as leaking and failing infrastructure and illegal abstraction of water leading to fluctuation of piezometric levels, exacerbate the risk to communities underlain by dolomite. The risk to communities underlain by dolomite can be determined by quantifying the dolomite hazard and interpreting it in conjunction with the vulnerability levels of the affected community and the anthropogenic factors aggravating the hazard. Included in this equation is the lack of awareness, which increases the vulnerability and anthropogenic impact on the existing hazard. Building resilience and capacity by means of dolomite risk awareness can mitigate the risk to a great extent.

The successful implementation of a DRMS is incumbent upon the realisation of risk awareness objectives. The cognizance and comprehension of the risks associated with dolomite and sinkholes in built areas mediates and moderates the implementation of technical recommendations and mitigation measures by the stakeholders affected by or involved in the mitigation of the dolomite risk.

### **5.2.2 Stakeholders to be engaged in dolomite risk awareness**

In response to the research question as to who the stakeholders are that needed to be made aware in TCC, Chapter 3 summarized the history of how vulnerable communities came to reside on dolomite, creating the anthropogenic context for the gradual destabilization of dolomitic areas.

In compliance with legal and institutional requirements as summarised in section 3.3.2 affected communities should be informed of the risk they are facing and what their roles and responsibilities and that of government are in mitigating the risk.

These communities have to be the main focus of awareness actions. Dolomite risk awareness should be done to mitigate the risk and as well as create ownership of managing the risk to those affected by it. In order to support these communities and to mitigate the risk more effectively it is essential that government and business stakeholders be made aware of the risk in order to support informed decision-making.

Considering the requirements and proactive stance taken by the TCC, the stakeholders were identified, analysed and mapped into focused tiers as represented in figure 3-5, in order to address dolomite risk awareness systematically and comprehensively. Stakeholders should receive awareness at various levels of engagement, as proposed in section 3.2.2.

### **5.2.3 Dolomite risk awareness actions**

Chapter 4 provides an account of the dolomite risk awareness actions that were planned and implemented in accordance with public participation guidelines and bylaws, as well as the

ethical appeal to create awareness of risks endangering the community under the jurisdiction of the TCC. The actions were initiated either as part of a planned strategy and research, or in response to gaps experienced through academic contributions, narratives of community members, media reactions or inputs from institutional and technical stakeholders.

The cooperation between technical and risk awareness teams on all levels of the DSI and development and implementation of the DRMS was initially a conscious and strategically planned effort. Project meetings and DSC meetings were held to implement the social actions to match technical interventions. Commencing with DRMS Phase C2, the multi-disciplinary team acknowledged that the integration of technical and risk awareness actions was the only viable option for approaching the risk presented by dolomite in built areas.

For the various stakeholders involved in the executive management as well as day-to-day management of the project the risk awareness actions were ancillary to their technical and management actions. TCC officials attended workshops diligently and the implementation of technical actions were aided by the risk awareness actions. The comprehension of the risk by affected stakeholders, functioned as motivation for officials to reach technical objectives.

External stakeholders such as government departments and agencies welcomed the invitation to become involved with mitigating the dolomite risk and allocated time to meet the dolomite awareness team. The attendance of workshops by a range of disciplines contributed to the implementation of dolomite compliant designs, infrastructure and building practices. The list of new contractors, “fly-by-night” entrepreneurs and emerging businesses prompted the perpetuation of risk awareness in the form of workshops and guidelines for all contractors and consultants on dolomite.

#### **5.2.4 Measuring effectiveness of the dolomite risk awareness actions**

The effectivity of the DRAP in realising the risk posed by dolomite and sinkholes in built areas with affected stakeholders have not yet been quantified. Follow up of the baseline survey done during Phase B of the DRMS that was planned for Phase C1 could not be implemented due to political moratoriums on door-to-door activities. This will however be addressed during Phase C2 of the DRMS.

#### **5.2.5 Political context**

The TCC managed to address feedback on risk awareness, including gaps in risk awareness, which emerged throughout the research, implementation and mitigation of the DRMS adequately by reciprocating with ancillary interventions. The ontogenesis of additional actions in order to augment gaps and feedback from stakeholders complemented and enhanced the dolomite risk awareness actions. The dolomite risk awareness actions have been amended to

include the combined feedback from stakeholders and the affected community.

Because of the involvement of politicians and concomitant political agendas, it was, and still is extremely difficult to determine the perceptions of affected stakeholders regarding risk awareness. Affected stakeholders and specifically stakeholders such as politicians insist that no risk awareness has been done albeit evidence exists to the contrary.

It was concluded that it was not sufficient to implement risk awareness actions only once. Actions needed to be reiterated, evolved and augmented progressively in order to reach objectives, addressing the prevailing frame of mind, current stress levels and layers of distrust, hostility, political influence, vulnerability and fear that cloud the impact of the message to be conveyed.

It is imperative that processes to mitigate politics be established. Political agendas act as catalysts for non-compliance, negation and repudiation of risk awareness actions and subversion tactics towards the accomplishment of DRMS implementation objectives. Concurrently it strives to tarnish the reputations and credibility of agents of change aiming to act proactively to the benefit of affected stakeholders.

#### **5.2.6 Regional risk awareness**

The conclusions made by Van Eeden and Nealer (2011) confirming ignorance by local government and limited access to research findings as well as deficits in co-operation between stakeholders coupled with the findings of Moshodi (2014) concerning the deficits in engaging stakeholders in dolomite risk awareness actions in MLM, cautions other local authorities to engage internal as well as external stakeholders proactively.

As part of the initial consultation process, a meeting with MLM was organised. Since then various attempts have been made to involve MLM as stakeholder within the regional dolomite context. During the rendering of this study, a state of disaster has been declared in MLM. This contingency was triggered by the formation of catastrophic sinkholes causing damage to infrastructure that resulted in more than 40 000 residents with no access to water.

The involvement of the Dr Kenneth Kaunda district municipality in initiating DSI's within its area of jurisdiction is encouraging and paves the way to involving stakeholders in the implementation of a regional DRMS.

#### **5.2.7 Dolomite risk awareness team**

In interviews with technical specialists and stakeholders involved with the formulation and implementation of DRMS's, it became apparent that the prevalent perception is one of "feeding them with the facts" by erecting notice boards and distributing leaflets. No evidence could be

found of even a vague recognition of a two-way, consultative engagement of stakeholders. This attitude is perpetuated by local authorities appointing technical consultants who leave the most crucial component of the DRMS to geotechnical scientists, thereby inadvertently acknowledging that they are ignorant of the pivotal imperative for the engagement of stakeholders in risk awareness actions in order to successfully formulate and implement a DRMS.

### **5.2.8 Perceptions of risk awareness levels**

Within the TCC DRAP there has been extensive consultation with stakeholders representing all tiers. Nevertheless, the perception exists that not enough has been done and therefore, the consultation will have to be broadened and focused. The inclusion of focus groups and forums will aid in filling the gaps in consultative and participatory engagement of stakeholders. The DRAP is underpinned by the approach that every technical or risk awareness action or intervention is an opportunity for dialogue.

Fischhoff (1995:142) describe two possible outcomes of unrealised risk awareness communication very aptly when he identifies the two possible outcomes namely:

- “I don’t understand you”, and
- “I don’t believe you.”

Since the TCC and consultants involved in creating risk awareness are still encountering abovementioned responses, it can be deduced that gaps and deficits in the DRAP still exist and these gaps have to be mitigated. Whether or not risk awareness has been done consummately, becomes irrelevant if the perception that not enough has been done is perpetuated.

### **5.2.9 Vulnerability of dolomite affected communities**

In conclusion to Chapter 4, describing the dolomite risk awareness actions and responses to interventions, the vulnerability of the affected became evident to such an extent that a summary of the categories and dimensions of the main categories of vulnerability could be observed. These findings are summarised in Table 5-1 below.

**Table 5-1: Categories and dimensions of vulnerability within dolomite affected communities**

Vulnerability to the situation/Exposure	Vulnerability to understand	Vulnerability to control
Dolomite instability Sinkhole formation Infrastructure status Ingress of water Water abstraction Poor quality housing Compliance to building regulations	Lack of awareness Political intimidation Educational levels Narratives Literacy Socio-economic status Language of risk awareness Trust Access to technical information and decisions Transparency of authorities Trust in authorities Trust in consultants Perceptions of ability of authorities to manage dolomite Fear	Financial resources Socio-economic status Political interference or support Resilience Risk awareness levels Community support Access to technical information and decisions Monitoring awareness Awareness of roles and responsibilities Level of involvement into decision making Perceptions of ability of authorities to manage dolomite

The vulnerability to the situation points to the vulnerability of a community to the dolomitic hazard but also to the anthropogenic factors that influence the risk posed by dolomite. Some stakeholder groupings will be more vulnerable than others because of the poor structural quality of their homes or ignorance of the effects of non-compliance to building regulations. Dolomite risk awareness actions should consider this vulnerability by acting promptly and providing as much information as possible for them to reduce some of the vulnerability to anthropogenic factors.

When planning dolomite risk awareness actions the vulnerability of affected stakeholders can be reduced by considering current narratives, literacy levels, and educational levels. These actions must reflect the basic tenets of transparency and access to information in order to create trust and decrease fear.

The capacity to control the exposure to the dolomite risk will greatly reduce the vulnerability of the affected communities. This can be done by capacitating communities with technical knowledge and giving them responsibilities to monitor for signs of dolomite instability and sinkhole formation.

### **5.3 Recommendations**

With the completion of Phase A, B and C1, and on the brink of Phase C2, the following recommendations are presented for consideration by stakeholders involved in managing and mitigating dolomite and sinkhole risk.

#### **5.3.1 Participatory engagement**

- In many cases, the primary need for affected stakeholders is to have a place at the table to voice their concerns and be heard. Alternatively some stakeholders want to be involved and play an active and constructive role (Fischhoff, 1995:142). Both needs should be addressed by the DRAP.
- Affected stakeholders should be made partners in risk management and not only be passively made aware of the risks associated with dolomite and sinkholes. Creating risk awareness partnerships will assist in affected stakeholders becoming risk awareness advocates because they take ownership of the risk. These partners will in turn perpetuate the messages concerning risk awareness and facilitate dialogue. Decision-making stakeholders will make decisions that mitigate the risk of dolomite and implement the recommendations of the DRMS.
- The legitimacy of each other's participation should be protected (Reed, 2008:2420) through perseverance in dialogue and problem solving behaviour. Respectfully listening to each other and asking for the opinion of other stakeholders when conducting awareness redefines the stakeholder relationship (Fischhoff, 1995:142,143). As a result, it can be defined as a partnership rather than a linear communication action.
- Avoiding conflict is not a realistic objective for risk awareness communication. There are people who earn their living from creating controversies based on flawed narratives (Fischhoff, 1995:144). The timely and transparent creation of risk awareness is an effective buffer against untrue narratives.
- The influence of politics in the successful implementation of DRAP objectives have been described in this study. It must be agreed with Newcombe (2003:846) that in the mitigation of this additional risk, ethical consideration should be given to what role consultants should play in political activities functioning in projects. The high levels of risk awareness with politicians and government as well as affected community will contribute to mitigating the risk politics represent.

#### **5.3.2 Focus groups**

Focus groups should be prioritised in order to gain more specific input from the affected community, and create a platform for consultation with community leaders such as church

leaders, managers of NGO's and informal leaders pertaining to the mitigation of influences such as politics in general and narratives that evolved over time. The group should be monitored and varied as to moderate for political influence and fear to speak out.

### **5.3.3 TCC Institutional Memory**

- To manage the dolomite risk it is of key importance that future employees of the TCC remain vigilant when planning new developments, maintaining infrastructure and receive applications for mining ventures.
- Decisions made by TCC officials and management, if not taken within the secure knowledge of the risk posed by dolomite and the implications of dewatering, ingress of acidic water and anthropogenic susceptibility of the environment, or considering compliance of housing developments, may have a profound effect on communities underlain by dolomite.
- Stakeholder groupings are fluid, and stakeholders are replaced by others that have not been engaged. As punctuated by Glicken (2000:310), documentation is essential for new officials and makes the process less open to challenges.
- Dolomite risk awareness material should be included in the induction of newly elected ward councillors and ward committee members. SALGA (South African Local Government Association) should be considered a major stakeholder and role player in this regard. SALGA is responsible for the training and preparation of all ward councillors and ward committees in municipalities.
- Dolomite risk awareness material should be included in the induction of all appointed TCC officials as well as form part of their Key Performance Indicators. This will ensure that the implementation of the DRMS is realised and institutional memory regarding dolomite risks be preserved.

### **5.3.4 Approach to DRAP**

An interdisciplinary as opposed to a multi-disciplinary approach should be implemented. A multi-disciplinary approach requires that technical and social scientists work alongside each other, while an interdisciplinary approach challenges the scientists to function as a team (Bews, 2013:12). In order to align technical research actions with risk awareness actions the scientists should plan every action as a team, where recommendations can be made from the perspective of social scientists regarding technical interventions within the affected community.

### **5.3.5 Vulnerability of affected communities**

The vulnerability of the affected community needs to be clarified in greater detail so that the DRAP can be aligned with every aspect of vulnerability in order to reduce the anthropogenic risk as well as the risk to affected stakeholders. Table 5-1 illustrates the categories of vulnerability

with associated dimensions as concluded by this study.

### **5.3.6 Trusted and transparent risk awareness**

One of the recommendations of this study is made in agreement with Cone *et al.* (2013:347) when it is concluded that local authorities and DRMS consultants should not aim to be trusted brokers of risk communication but above all trusted brokers of risk communication dialogue. In connecting stakeholders with the municipality and with each other by means of risk awareness actions such as workshops the atmosphere of trust and transparency as well as shared responsibility for the dolomite risk can be established.

## **5.4 Framework for Dolomite Risk Awareness Plan**

In conclusion of the research conducted and as part of the recommendations resulting from this study, a conceptual framework is presented in figure 5-1. It can serve as guideline for compiling a DRAP to mitigate the risk of dolomite and sinkholes through dolomite risk awareness actions, including a wide spectrum of stakeholders and recognising the vulnerability, socio-economic and political context of the dolomite affected communities.

This framework recognises the three critical elements in the realisation of a DRAP namely the message content, the entity or person that conveys the message and the receiver of this message in the form of affected stakeholders. The framework establishes an iterative flow between message formulation, messenger entity and stakeholders within a socio-economic and political context which impacts the implementation of the phases of the DRMS and the chosen risk awareness actions that act as enablers for the mitigation of the risk associated with dolomite and sinkholes.

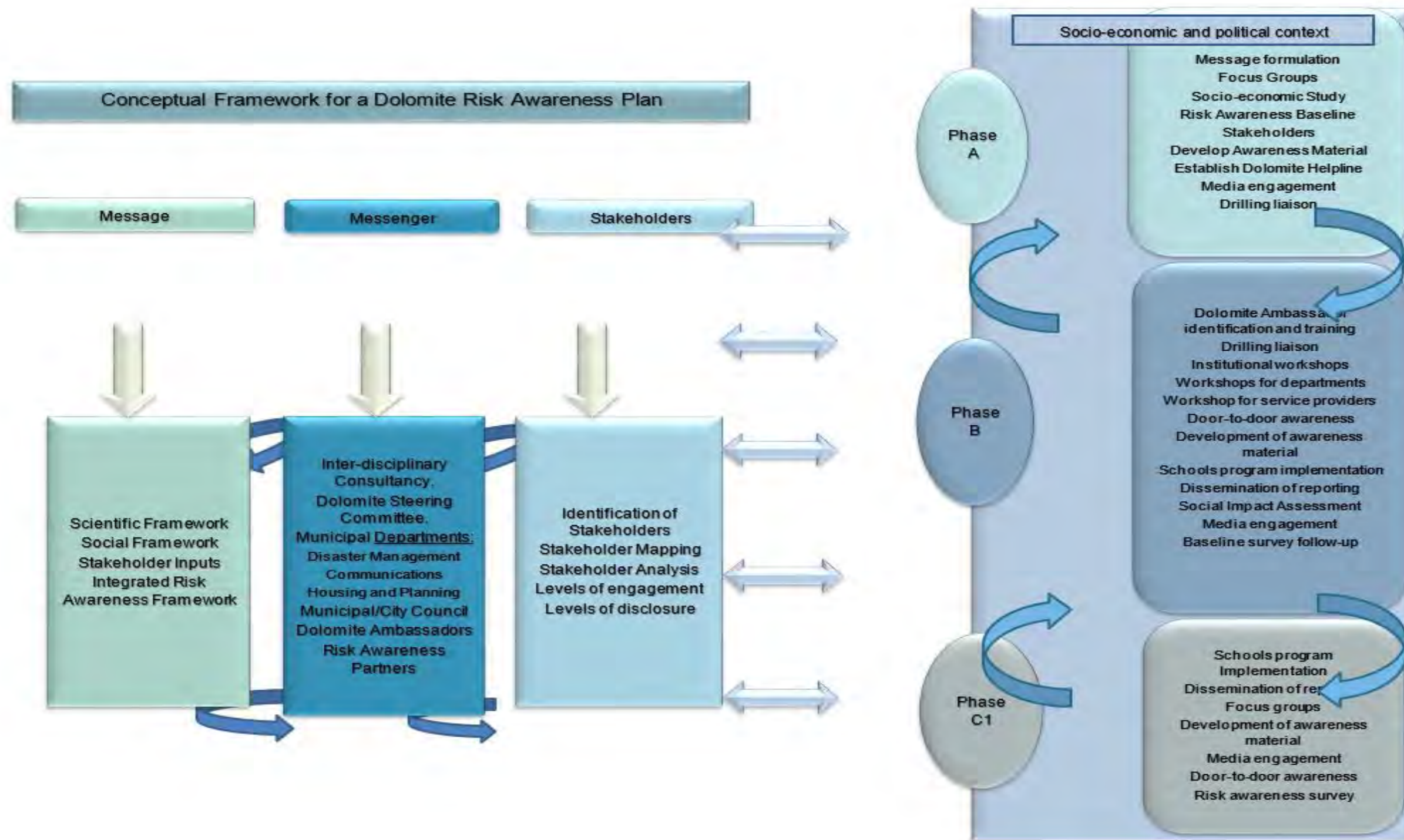


Figure 5-1: Proposed Conceptual Framework for DRAP

## REFERENCES

- AGES. 2010a. Dolomite Risk Management Programme: Report 4: Volume 1: Geo-Environmental Assessment of Dolomitic Land in Potchefstroom in preparation for the development of a Dolomite Risk Management Plan. Potchefstroom. (2010/05/03 DSA).
- AGES. 2010b. Dolomite Risk Management Programme: Report 5: Volume 2: Preliminary Regional Dolomite Risk Management Strategy and Plan for Potchefstroom: Framework for Implementation. Potchefstroom. (2010-05-03 DSA).
- AGES. 2011. Dolomite Risk Management Strategy: Strategic Planner 2011. Potchefstroom. (2011-10-08 DRMS).
- AGES. 2012. Tlokwe Dolomite: Ikageng Reservoir Social Impact report. Potchefstroom.
- AGES. 2013a. Dolomite Risk Management Programme: Report 8: Regional groundwater model on the Dolomite Aquifer. Potchefstroom. (2013/10/15 IWMS).
- AGES. 2013b. Dolomite Risk Management Programme: Report 10: Integrated Dolomite Stability Investigation. Potchefstroom. (2013/06/17 DSI).
- AGES. 2013c. Dolomite Risk Management Programme: Report 14: Dolomite Assessment and Mitigation at Ikageng-West Reservoirs. Potchefstroom. (2012 / 11 / 19 DRA).
- AGES. 2013d. Tlokwe City Council Dolomite: Pre-risk assessment of a dolomite related instability feature at Erf 5835, Kanana, Ikageng. Potchefstroom. (2013/09/09 DRA).
- AGES. 2013e. Tlokwe Dolomite Risk Management Programme 2013: Report 1. Potchefstroom. (2013/ 09 / 03 DRMS).
- AGES. 2013f. Tlokwe Dolomite Risk Management Programme: Report 24: Social Awareness Status and Impact report. Potchefstroom.
- AGES. 2014. Dolomite Risk Management Programme: Report 2: Draft Dolomite Risk Management Plan 2013/2014. Potchefstroom. (2013/10/01 DRMP).
- AGES. 2016a. Tlokwe Dolomite Risk Management Programme Phase C 2015/2016: On-going Social Awareness. Potchefstroom. (2016 / 03 / 01 / SS).
- AGES. 2016b. Kanana, Resettlement Action Plan (RAP). Potchefstroom. (2014-09-

05 RAP).

Anon. 1962a. Aarde verswelg 43 werkers. *Die Vaderland* 13 December 1962.

Anon. 1962b. Carletonville: Spookdorp of Yslike Krater. *Die Dagbreek* 16 Desember 1962.

Anon. 1963. Insinking van grond bedreig laerskool. *Die Transvaler* 19 January 1963.

Aucamp, I.C. 2003. The role and the place of social impact assessment in the project life cycle. Unpublished Dissertation: North-West University.

Babbie, E. & Mouton, J. 2002. Social research. *Belmont, CA: Wadsworth Group*.

Baxter, P. & Jack, S. 2008. Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, 13(4):544-559.

Bell, A. 2003a. A narrative approach to research. *Canadian Journal of Environmental Education (CJEE)*, 8(1):95-110.

Bell, F.G. 2003b. Geological hazards: their assessment, avoidance and mitigation: CRC Press.

Bews, N. 2013. Social Impact Assessments, theory and practice juxtaposed— Experience from a South African rapid rail project. *n.a.*

Buskirk, E., Pavelk, M. & Strasz, R. 1999. Education about and management of sinkholes in karst areas: initial efforts in Lebanon. (*In. Hydrogeology and engineering geology of sinkholes and karst. Proceedings of the 7th multidisciplinary conference on sinkholes and the engineering and environmental impacts of Karst. organised by Harrisburg/Hershey, Pennsylvania. p. 263-266*).

Buttrick, D. & Roux, P. 1993. The safety of high density informal settlements on the dolomites of South Africa. *Applied karst geology proceedings. Balkema, Rotterdam*.

Buttrick, D., Trollip, N., Watermeyer, R., Pieterse, N. & Gerber, A. 2011. A performance based approach to dolomite risk management. *Environmental Earth Sciences*, 64(4):1127-1138.

Buttrick, D.B. 1986. Wad and ferroan soil developed in the dolomitic area south of Pretoria: publisher not identified.

Buttrick, D.B., Trollip, N., Gerber, A. & Pieterse, N. 2014. Susceptability, hazard zonation and risk management: Quo vadis. (*In. Dolomite Conference organised by University of Pretoria.*)

Buttrick, D.B., Van Schalkwyk, A., Kleywegt, R.J., Watermeyer, R.B. & Trollip, N. 2001.

Proposed method for dolomite land hazard and risk assessment in South Africa : technical paper. *Journal of the South African Institution of Civil Engineering / Joernaal van die Suid-Afrikaanse Instituut van Siviele Ingenieurswese*(2).

Chess, C. & Purcell, K. 1999. Public participation and the environment: Do we know what works? *Environmental Science & Technology*, 33(16):2685-2692.

City Press. 2013. Dolomite not an excuse for housing. *City Press*, 28 February 2013.

Cone, J., Rowe, S., Borberg, J., Stancioff, E., Doore, B. & Grant, K. 2013. Reframing Engagement Methods for Climate Change Adaptation. *Coastal Management*, 41(4):345-360.

DEMACON. 2013. Tlokwe NDPG Economic Area Analysis. Pretoria.

Department of Public Works. 2010. Appropriate development of infrastructure on dolomite: Manual for consultants.

Department of Water Affairs. 2009. Dolomite guideline: A short guide to available documents on procedures for developing dolomitic land. South Africa: Department of Public Works, Department of Water Affairs. Council for Geoscience, University of Pretoria, Water Geosciences Consulting.

Department of Water Affairs and Forestry. 2006. A guideline for the assessment, planning and management of groundwater resources within dolomitic areas in South Africa. Pretoria.

Du Pisani, K. 2013. Development and history of Potchefstroom for the Tlokwe DRMS. Potchefstroom.

Du Toit, D. & Pollard, S. 2008. Updating public participation in IWRM: a proposal for a focused and structured engagement with catchment management strategies. *Water SA*, 34(6):707-713.

Dwyer, A., Zoppou, C., Nielsen, O., Day, S. & Roberts, S. 2004. Quantifying social vulnerability: a methodology for identifying those at risk to natural hazards: Citeseer.

Eiser, J.R. 2004. Public perception of risk. *Report prepared for Foresight Office of Science and Technology (July, 2004)*:b10.

Fischhoff, B. 1995. Risk Perception and Communication Unplugged: Twenty Years of Process. *Risk Analysis: An International Journal*, 15(2):137-145.

Flyvbjerg, B. 2006. Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2):219-245.

- Freeman, R.E. 1983. Strategic management: A stakeholder approach. *Advances in strategic management*, 1(1):31-60.
- Freeman, R.E. 2010. Strategic management : a stakeholder approach: Cambridge : Cambridge University Press, 2010.
- Gariépy, M. 1991. Toward a dual-influence system: assessing the effects of public participation in environmental impact assessment for Hydro-Quebec projects. *Environmental Impact Assessment Review*, 11(4):353-374.
- Glicken, J. 2000. Getting stakeholder participation 'right': a discussion of participatory processes and possible pitfalls. *Environmental Science & Policy*, 3(6):305-310.
- Glynn, P.D. 2015. Integrated Environmental Modelling: human decisions, human challenges. *Geological Society, London, Special Publications*, 408:SP408. 409.
- Gould, W.R. 2012. Open innovation and stakeholder engagement. *Journal of technology management & innovation*, 7(3):1-11.
- Green, J., Camilli, G. & Elmore, P. 2006. Handbook of Complementary Methods in Education Research: American Educational Research Association by Lawrence Erlbaum Associates: Inc.
- GSSA. 2011. South African history online. <http://www.sahistory.org.za/dated-event/oosthuizen-family-disappears-down-massive-sinkhole-carletonville> Date of access: 5 May 2015.
- Gutiérrez, F., Cooper, A.H. & Johnson, K.S. 2007. Identification, prediction, and mitigation of sinkhole hazards in evaporite karst areas. *Environmental Geology*, 53(5):1007-1022.
- Hewitt, K. 2014. Regions of risk: a geographical introduction to disasters: Routledge.
- International Association for Public Participation. 2000. Planning for effective public participation Denver USA.
- Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X. & Ratick, S. 1988. The Social Amplification of Risk: A Conceptual Framework. *Risk Analysis*, 8(2):177-187.
- Klimchouk, A. & Aksem, S. 2005. Hydrochemistry and solution rates in gypsum karst: case study from the Western Ukraine. *Environmental Geology*, 48(3):307-319.
- Lundgren, R.E. & McMakin, A.H. 2013. Risk communication: A handbook for communicating environmental, safety, and health risks: John Wiley & Sons.

- Malhotra, N.K. 2008. Marketing research: An applied orientation, 5/e: Pearson Education India.
- Maree, K. 2007. First steps in research: Van Schaik Publishers.
- Meintjes, J.W.P. 2016. Assessing the regional structural geological setting as fundamental component of the dolomite risk management process. North-West University; Potchefstroom campus.
- Meintjes, J.W.P. & Muller, D. 2016. Living on dolomite Potchefstroom [Documentary script].
- Morgan, M.G., Fischhoff, B., Bostrom, A. & Altman, C.J. 2002. Risk communication: A mental models approach: Cambridge University Press.
- Moshodi, T.I. 2014. Towards a strategy for sinkhole risk reduction: the case of the Merafong Local Municipality. North-West University.
- Murray-Webster, R. & Simon, P. 2006. Making sense of stakeholder mapping. *PM World today*, 8(11):1-5.
- Newcombe, R. 2003. From client to project stakeholders: a stakeholder mapping approach. *Construction Management & Economics*, 21(8):841-848.
- Paukštys, B., Cooper, A.H. & Arustiene, J. 1999. Planning for gypsum geohazards in Lithuania and England. *Engineering Geology*, 52(1):93-103.
- Peters, R.G., Covello, V.T. & McCallum, D.B. 1997. The determinants of trust and credibility in environmental risk communication: An empirical study. *Risk Analysis*, 17(1):43-54.
- Potgieter, A.S. 2012. The development of a dolomite risk management strategy for the Tlokwe City Council / Abraham Stephanus Potgieter.
- Potgieter, A.S. 2016. Integration of a Dolomite Risk Management Programme in local governance in South Africa: Tlokwe City Council
- Potgieter, A.S., Pretorius, S.J. & Van Der Walt, I.J. 2016. Integration of a Dolomite Risk Management Programme in Local Governance in South Africa: Tlokwe City Council. *Journal of Environmental Protection*, 7(07):1041.
- Pretorius, H. 2016. Timeline of settlement development in Tlokwe in context of dolomite information and guidelines for development. Potchefstroom.
- Pretorius, P. 2012a. The implementation of a geo-environmental decision support system for development on dolomite. North-West University.

- Pretorius, S.J. 2012b. TCC Dolomite Stakeholder Analysis. POtchefstroom.
- Reed, M.S. 2008. Stakeholder participation for environmental management: A literature review. *Biological Conservation*, 141(10):2417-2431.
- Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H. & Stringer, L.C. 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, 90(5):1933-1949.
- Reynolds, B. & W. Seeger, M. 2005. Crisis and Emergency Risk Communication as an Integrative Model. *Journal of Health Communication*, 10(1):43-55.
- Reynolds, B.J. 2011. When the facts are just not enough: Credibly communicating about risk is riskier when emotions run high and time is short. *Toxicology and Applied Pharmacology*, 254:206-214.
- Richardson, S. 2013. Sinkhole and subsidence record in the Chuniespoort Group dolomite, Gauteng, South Africa. University of Pretoria.
- Roux, P. 1984. Geotegniese ondersoek vir dorpsontwikkeling in dolomietgebiede. University of Pretoria. (Unpublished Thesis).
- SANS. 2012. South African National Standards (SANS) 1936 Development on dolomite land Part 4: risk management.
- Schuitema, B. 2012. Spooktown of the far west rand. <http://schuitemaberend.blogspot.co.za/2012/01/lord-himself-laid-them-to-rest.html> Date of access: 26 January 2012 2016.
- Sen, S. 2000. Involving stakeholders in aquaculture policy-making, planning and management. (In. *Aquaculture in the Third Millennium*». Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand organised by. p. 20-25).
- South Africa. 1996. Constitution of the Republic of South Africa Act 108 Of 1996.
- South Africa. 1998a. Municipal Structures Act 117 of 1998.
- South Africa. 1998b. White paper on Local Government 1998.
- South Africa. 2000. Municipal Systems Act 32 of 2000.
- South Africa. 2007. National Policy Framework for PublicParticipation.
- Tihansky, A.B. 1999. Sinkholes, west-central Florida. *Land subsidence in the United States: US geological survey circular*, 1182:121-140.

- Tlokwe City Council. 2004. Public Participation Bylaw.
- Tlokwe City Council. 2009. Municipal Manager Resolution 75/2009-05-09.
- Tlokwe City Council. 2010. Council Resolution C120/2010-06-09.
- Tlokwe City Council. 2011a. Council Resolution 244/2011-11-29.
- Tlokwe City Council. 2011b. MM Resolution 163/2011-11-22.
- Tlokwe City Council. 2012. Council resolution C122/2012-06-19.
- Tlokwe City Council. 2013. Council resolution C145/2013-07-02.
- Tlokwe City Council. 2014a. Council resolution C143/2014-09-30: Department Housing and Planning: Dolomite Events: Kanana and Sarafina: Acquisition of Properties.
- Tlokwe City Council. 2014b. Council resolution C196/2014-12-09: Department Housing and Planning: Determination of New Delegated Powers for Approval of Building Plans in Dolomite Affected Areas.
- Van Eeden, E. & Nealer, E. 2011. Interdisciplinary reflections on the challenge of environmental management in dolomitic areas of South Africa: The case of Delmas and Merafong city local municipalities.
- Van Rensburg, F.J. 2006. The first "white" town north of the Vaal : inequality and apartheid in Potchefstroom. *New Contree*(51):133-149.
- Wagener, F.v.M. 1984. Engineering construction on dolomite: Geotechnical Division of the South African Institution of Civil Engineers.
- Walaski, P. 2011. Developing a Risk and Crisis Communications Plan. Risk and Crisis Communications. John Wiley & Sons, Inc. p. 121-131).
- Walker, D.H., Bourne, L.M. & Shelley, A. 2008. Influence, stakeholder mapping and visualization. *Construction Management and Economics*, 26(6):645-658.
- Waltham, T., Bell, F.G. & Culshaw, M. 2007. Sinkholes and subsidence: karst and cavernous rocks in engineering and construction: Springer Science & Business Media.
- Wiggill, M.N. 2013. Communication management during the veld fires of 23 August 2011 in the Tlokwe Local Municipality: A cautionary tale. *Jàmbá: Journal of Disaster Risk Studies*, 5(2):9 pages.
- Wiggill, M.N. 2016. The Tlokwe City Council Dolomite Management Desk: a communication and relationship management perspective. *Environmental Hazards*, 15(1):43-57.

Williams, P. & Fong, Y. 2008. World map of carbonate rock outcrops v3. 0.  
[http://web.env.auckland.ac.nz/our\\_research/karst/#karst5](http://web.env.auckland.ac.nz/our_research/karst/#karst5) Date of access: 12 June 2016.

Wisner, B., Gaillard, J.C. & Kelman, I. 2012. Handbook of hazards and disaster risk reduction and management: Routledge.