

**THE CURRENT RISK OF ASBESTOS EXPOSURE TO THE
CITIZENS OF THE PRIESKA AREA, NORTHERN CAPE
PROVINCE IN SOUTH AFRICA.**

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degree Magister in Environmental Management at the North-West University.**

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Abstract

The objective of this study was to determine the current risk of asbestos exposure to the citizens of the Prieska area, in the Northern Cape Province of South Africa.

The extraction of asbestos ceased a long time ago, but the people of Prieska and the surrounding townships are still working and living in a much polluted environment. Today numerous people have asbestos-related diseases, and many may still be diagnosed. In order to address the health risk, the need for rehabilitation of these areas has to be quantified.

In order to achieve the objective of the study, the following sub-questions were formulated:

- a. What are the exact levels of asbestos contamination in Prieska?
- b. How big is the risk of exposure due to asbestos contamination of the environment in Prieska?
- c. Can the need for rehabilitation be prioritised?

The study area was divided into 4 sub-areas: Rooiblok, Ethembeni, Bontheuwel and the town of Prieska. The levels of asbestos contamination in the Prieska area were determined, and the risk of exposure for the citizens was quantified.

Results have shown that the stands in each sub-area could be prioritised. Stands that were open fields have a lower need for rehabilitation because no people live there and therefore the risk of exposure to asbestos fibres is limited. There were also other stands that weren't open fields, but had a lower Asbestos Prioritisation Index (API), because the buildings were in a good condition, the fibres were fixed, or otherwise no asbestos fibres were extracted from the samples. The overall API for the 4 sub-areas were compared to each other. Rooiblok and Ethembeni had the highest need for rehabilitation, then the town of Prieska, and the lowest was Bontheuwel.

The results were clear on the Geographic Information Systems (GIS) and could therefore assist in prioritising areas in Prieska with regard to their need for rehabilitation.

Opsomming

Die doel van die studie was om vas te stel wat die huidige risiko van asbesblootstelling vir die inwoners van die Prieska area, in die Noord-Kaap Provinsie van Suid-Afrika, is.

Alhoewel die ontginning van asbes reeds lank gelede gestaak is, werk en leef die mense van Prieska en die omliggende nedersettings steeds in 'n erg besoedelde omgewing. Daar is vandag nog mense met asbes-verwante siektes, en baie ongeïdentifiseerdes. Om te verseker dat die gesondheidsrisiko aangespreek word, moet die noodsaaklikheid vir rehabilitasie gekwantifiseer word.

Om die doelwit van die studie te bereik is die volgende sub-vrae geformuleer:

- a. Wat is die presiese vlak van asbes kontaminasie in Prieska?
- b. Hoe groot is die risiko van blootstelling a.g.v asbes kontaminasie in die Prieska omgewing?
- c. Kan die noodsaaklikheid van rehabilitasie geprioritiseer word?

Die studie area was verdeel in 4 sub-areas: Rooiblok, Ethembeni, Bontheuwel en die Prieska dorpsgebied. Die vlak van asbeskontaminasie in die studiegebied is bepaal en die risiko van blootstelling aan asbesvesels is gekwantifiseer.

Die resultate toon dat die erwe in elke sub-area geprioritiseer kon word. Die erwe wat in hul natuurlike staat is, het 'n laer prioriteit vir rehabilitasie weens die kleiner risiko van blootstelling. Sommige erwe waarop reeds ontwikkeling plaasgevind het, het ook 'n laer Asbes Prioritisering Index (API) aangetoon, weens die feit dat die gebou in 'n goeie toestand was, die vesels nie vrygestel kon word nie, of waar die ontleding van die monsters geen aanduiding van die teenwoordigheid van asbesvesels getoon het nie. Die API van die totale area kon bestudeer word en die 4 sub-areas met mekaar vergelyk word. Rooiblok en Ethembeni het die hoogste prioriteit vir rehabilitasie getoon, gevolg deur die Prieska dorpsgebied, en laastens Bontheuwel.

Die duidelike resultate op die Geografiese Inligting Stelsels (GIS) kon gebruik word om die areas in in die studie gebied te klassifiseer volgens hulle prioriteit vir rehabilitasie.

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Chapter 1: Introduction

1.1. Background of Problem

Asbestos is one of the oldest minerals known to man. It was already being used around 2000 years ago in China, Egypt and Greece. Its name was derived from the Greek for 'inextinguishable flame'. This indicates that one of its earliest applications was as a virtually indestructible wick for oil lamps (Hart, 1988:185; Van der Walt, 1992:2). Asbestos is also the name that was applied to these fibrous varieties of silicate minerals. In industry the usefulness of asbestos fibres largely depends on their resistance to heat and on the strength and flexibility of their fibres (Howling, 1937:5).

Commercial production of asbestos began in the 1850s, at the height of the industrial revolution and the demand for the mineral increased rapidly (Hart, 1988:185). One of its main uses was as an insulation material for steam engines. Because of its unique and useful characteristics, being chemical, electrical and thermal neutrality, fibrous strength, fire resistance and sound absorption, asbestos was used in a wide variety of everyday products (Hart, 1988:188). More than three quarters of all asbestos mined is used in the manufacturing of asbestos-cement products, such as prefabricated wall sections, corrugated roof sections and tiles, water pipes and tanks, and house-hold goods such as garden furniture and flower pots.

Three types of asbestos are found in nature, namely Chrysotile, Amosite and Crocidolite. Crocidolite was used in asbestos-cement products (including pipes, sheets and cement in buildings), as well as acid-resistant filters, isolation material and protective clothing. Amosite was used for the isolation of pipes and steam-kettles, and as additives for plastics, rubber and cement. Chrysotile had the widest range of uses, for example: tiles, additives for paint, plastics, disc-brake pads, brake drums, protective clothing and electrical insulation (Burger, 1969:16; Hart, 1988:189; Howling, 1937:34).

- Types and Characteristics of Asbestos

Asbestos is a generic name for six naturally occurring asbestiform or fibrous minerals from the amphibole and serpentine group of rock-forming minerals

(Figure 1). The following are the three principal varieties of asbestos: Chrysotile (part of the serpentine group) and Crocidolite and Amosite (both classified under the amphibole group) (Hart, 1988:186).

South Africa is the only country in the world which has reserves of all three of these varieties of asbestos (Hart, 1988:187):

- i. Chrysotile
 $(\text{Mg}_6[(\text{OH})_4\text{Si}_2\text{O}_5]_2)$ Hydrated magnesium silicate
- ii. Crocidolite
 $(\text{Na}_2\text{Fe}_3[(\text{OH})\text{Si}_4\text{O}_{11}]_2)$ Complex sodium-iron silicate
- iii. Amosite
 $(\text{MgFe}_6[(\text{OH})\text{Si}_4\text{O}_{11}]_2)$ Iron-magnesium silicate

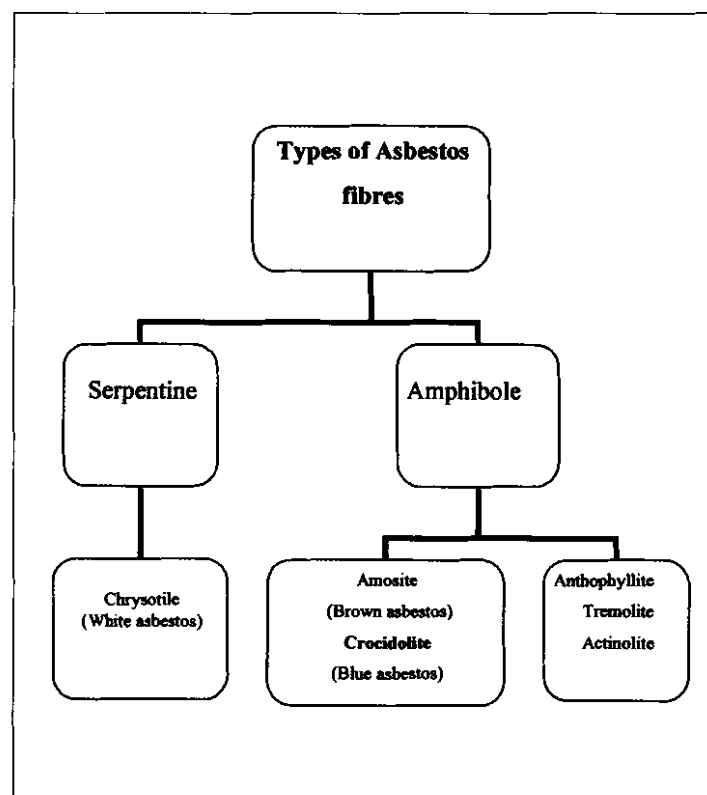


Figure 1: Diagram of types of asbestos fibres

1.2. History of Asbestos in South Africa

Canada, Zimbabwe, and South Africa were the most important asbestos producing countries in the British Empire (Howling, 1937:5). Canada was by far the largest producer of asbestos in the world, and South Africa possessed the only deposits of amosite and crocidolite (Howling, 1937:5). The principal consuming countries were the United States, Great Britain, the Soviet Union, Japan, Germany, Belgium and France (Howling, 1937:5).

In South Africa, asbestos mining began in the 1930s. In the decades thereafter, it attracted a multitude of big and small companies, and even individuals (Hart, 1988:185).

By 1981, the foreign companies had withdrawn from active asbestos mining in South Africa. The number of major producers was reduced to two: The Griqualand Exploration & Finance Company (Gefco) and Msauli Asbes. Gefco produced the amphiboles crocidolite and amosite – commonly known as blue and brown asbestos. Msauli produced chrysotile, or white asbestos (Hart, 1988:185; Van der Walt, 1992:2).

The Cape Company operated in 2 areas: the blue asbestos fields in the Northern Cape and the brown asbestos mines in Mpumalanga and Limpopo Province (Coombes, 2002:4).

Chrysotile was the first type of asbestos to be known to man, and the deposits of crocidolite first attracted attention around 1893 when exploitation commenced in the Cape Province in South Africa. This fibre was commonly known as “Cape blue”. A Dutch geologist, named Lichenstein, discovered ‘asbestos with a blue colour’ near Prieska, in the early years of the nineteenth century (Burger, 1969:4; Howling, 1937:34). Amosite was discovered in the old Transvaal Province and only occurs in South Africa. According to Coombes (2002:8) the word Amosite comes from “Asbestos Mines of South Africa”, or AMOSA for short, which became one of the Cape Company’s subsidiaries (Coombes, 2002:8).

Exports of blue asbestos (crocidolite) and brown asbestos (amosite) from South Africa peaked in 1977, when it exported 380 000 tons of asbestos. At its peak in the 1970’s the South African asbestos mining industry employed 20 000 asbestos miners (Coombes, 2002:4).

The vast majority of blue asbestos or crocidolite came from the Northern Cape Province in South Africa. The Wittenoom mine in Western Australia contributed 3% of the world's production of blue asbestos from 1944 to 1966 after which it closed. South Africa produced the rest (Coombes, 2002:4).

The Cape Company began in Prieska in 1893 as an offshoot of De Beers diamond operation in Kimberley. It withdrew in 1979. The Cape Company's biggest mine in the Prieska area was at Koegas, 40km north of Prieska (Coombes, 2002:4).

1.2.1. Asbestos fields in South Africa

South Africa is unique in the fact that it is the only country in the world that possesses commercial deposits of all three important varieties of asbestos, namely chrysotile, crocidolite and amosite.

i. Chrysotile (White Asbestos)

There are many deposits of chrysotile in the Limpopo Province and Kwa-Zulu Natal. The most important are those located in the Barberton areas of the Mpumalanga Province. According to Hart (1988:187), chrysotile deposits were not of any economic value when it was first discovered. This type of asbestos forms cross-fibre veins but is restricted to areas where there is contact between altered dolomite and a sill of dolerite (Hart, 1988:188, Howling, 1937:32).

ii. Crocidolite (Blue Asbestos)

Crocidolite occurs mainly in the North-West province and the Northern-Cape Province. This is the only variety of asbestos that was mined in the Northern-Cape Province. The Cape Crocidolite Field lies mainly in Griqualand West, and extends northwards, commencing 50km south of Prieska, on the Orange River, past Griquatown and Kuruman to its known, most northern occurrence in Botswana (Hart, 1988:188).

The crocidolite is developed in banded ironstone of the Asbestos Hills Formation from the Griquatown Group. It generally occurs in seams of cross-fibre that range in thickness from less than a millimetre to about 50mm; the maximum fibre length is about 150mm (Hart, 1988:188, Howling, 1937:34).

The southern section of this asbestos field included most of the Cape Asbestos Company's workings. Koegas mine, which is close to Prieska, was their headquarters.

iii. Amosite (Brown Asbestos)

Amosite is found almost exclusively in the Mpumalanga and Limpopo Provinces. The Amosite field occupies portions of the Polokwane (Pietersburg) and Letaba districts (Hart, 1988:188). In this region, the asbestos is formed in the banded ironstone of the Penge Formation from the Chuniespoort Group (Hart, 1988:188, Howling, 1937:32).

Figure 2 shows the distribution of the derelict and ownerless asbestos mines in South Africa today. The green dots on the map indicate the asbestos mines which have already been environmentally rehabilitated. The red dots indicate mines that have not yet been rehabilitated and the yellow dots, those mines that are partially rehabilitated, or in the process of rehabilitation.

It is clear that the exposure to asbestos is still a very big problem in South Africa, especially in the Northern Cape Province.

1.2.2. Legislation

Companies, which mined asbestos in South Africa before 1956, were not bound by law to conserve the environment (Booyesen & Nel, 2002:5), neither did any legislation exist regarding the allowable fibre concentrations in the industrial and ambient atmosphere. The result of unregulated and irresponsible mining practices presents the current problem of environmental and secondary pollution by old and disused asbestos tailing dumps.

The first legislation applicable to asbestos in South Africa was introduced in 1976 under the Atmospheric Pollution Prevention Act (Act no.45 of 1965) when asbestos-producing areas in South Africa were declared as dust pollution areas (Booyesen & Nel, 2002:5).

The earliest research on the rehabilitation of asbestos contamination started in 1986 in the Limpopo Province at Bewaarkloof and the guidelines for the rehabilitation of asbestos was published at the beginning of 1989 (Booyesen & Nel, 2002:5). The Minerals Act (Act no.50 of 1991) is the first Act indicating

the rehabilitation responsibilities of mine operations, specifically in section 12 of the Act, which states that the holder of such mining authorization remains liable for complying with the relevant provisions of the Act until a certificate has been issued to the effect that the said provisions have been complied with (Booyesen & Nel, 2002:5). Where a mine has been closed in terms of this section and the mine dumps rehabilitated satisfactorily, an exonerating certificate is issued to the holder.

The national Departments of Tourism, Environment & Conservation (DTEC) and Minerals and Energy (DME) budget for funds on an annual basis for the rehabilitation of derelict and ownerless asbestos mines. The DME steers the physical rehabilitation of these dumps.

Once an area has been rehabilitated to the satisfaction of a government department and the affected parties, and is declared as such by the DTEC, then the responsibility for future maintenance of installed rehabilitation measures, if required to prevent possible contamination pollution of the environment (by asbestos fibres to the adjacent residential area), will rest with the landowner (Booyesen & Nel, 2002:7).

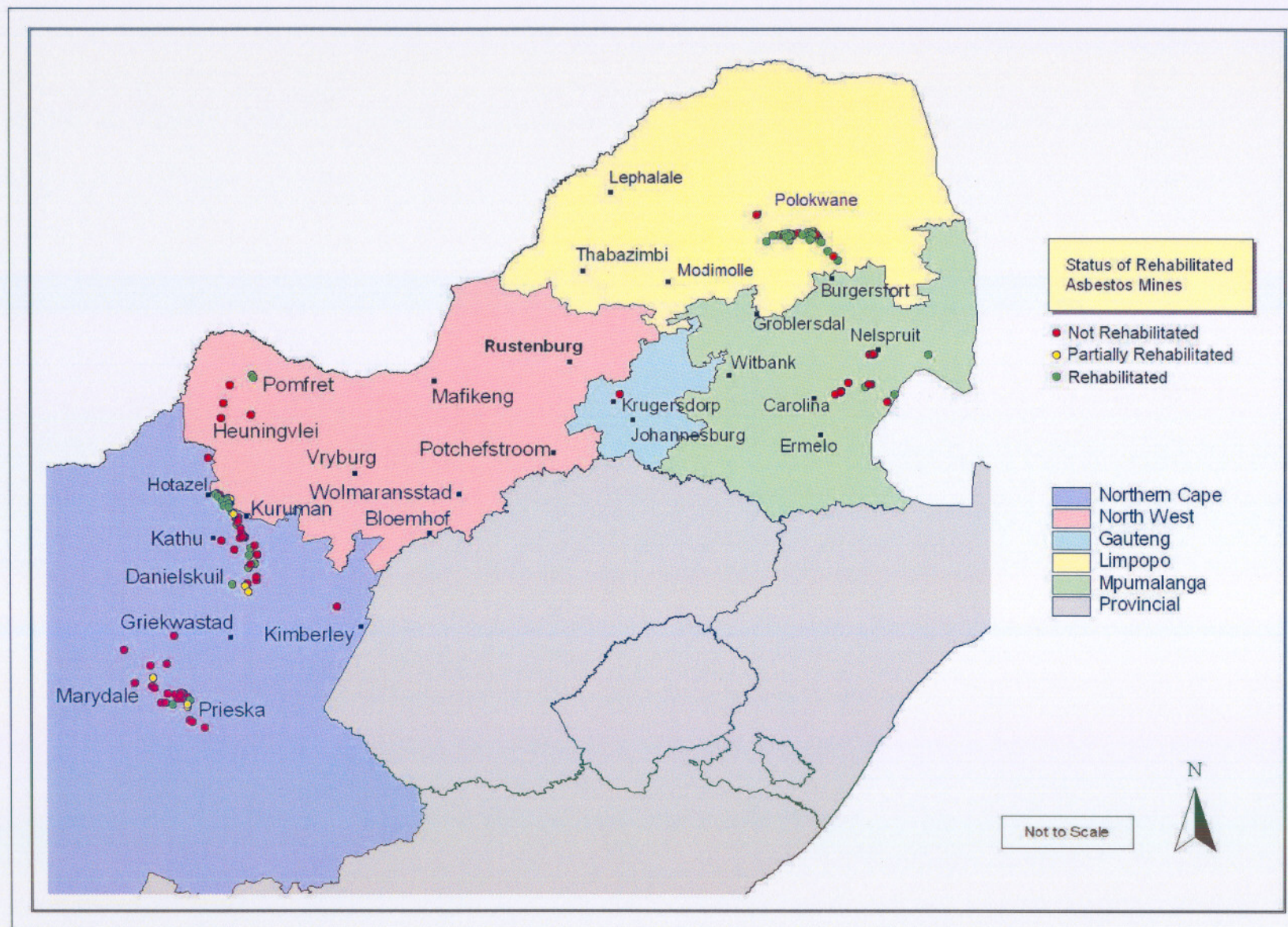


Figure 2: Distribution of the derelict and ownerless asbestos mines in South Africa today (Asbestos Prioritisation Database, 2003).

1.3. Health Related Risks Associated with Asbestos

During mining operations, asbestos fibres presented a health hazard if the recovery process had inadequate dust control. Inhalation of high concentrations of fibres over a number of years may lead to a scarring of the lung tissue, a condition that is known as asbestosis. Asbestosis is pulmonary fibrosis caused by the accumulation of asbestos fibres in the lungs (Landrigan, 1991:258). Symptoms include shortness of breath, coughing and fatigue, accompanied by the person feeling vaguely sick. In severe cases death may be caused by respiratory or cardiac failure (Cherry, 1989:131). Pulmonary asbestosis was first diagnosed in 1900, in the Charing Cross Hospital in Britain. Since 1930 it has been recognised as an industrial disease (Burger, 1969:23).

Scarring of the lung lining gives rise to pleural plaques, which do not produce any disability unless they are very extensive (Hart, 1988:195). There is also a known association between asbestos inhalation and malignancy of the lung, otherwise known as bronchial cancer. A rare asbestos-related disease is mesothelioma, a malignancy in the lining of the lung or the peritoneum (Landrigan, 1991:258). Symptoms include shortness of breath, pain in the walls of the chest, or abdominal pain. Mesothelioma is always fatal (Cherry, 1989:131).

The subject of the majority of articles that were published in the 1980s, relating to dangerous substances in the atmosphere, was about the health risk that the inhalation of asbestos fibres holds for man (Du Toit 1984b:1). Since the fifties, knowledge of the effects that asbestos fibres have on man has increased. This was the reason for more strict regulations concerning the fibre concentrations in the atmosphere of industrial asbestos-environments (Van der Walt, 1992:4). Over the years, the asbestos-mining industry has made great progress in its efforts to contain all possible health hazards at its mines and mills, and in their environments (Hart, 1988:195). Employees were provided with respirators, and improvements were incorporated to the final product, which included the following: it was packed in dust-proof bags, palletized, shrink-wrapped, and often containerized before dispatched from the mines. Dust levels were controlled at and around the mines, through air quality monitoring programmes (Hart, 1988:195; Van der Walt, 1992:4).

The question however remains, why there are still numerous cases of asbestos related diseases still being identified today, and the answer to this question lies in the fact that asbestosis has a much longer latency period for the development of a malignancy, than lung cancer (Landrigan, 1991:258). The period between the exposure to asbestos and the onset of the disease varies between 20 and 50 years, and the malignancies that are now being diagnosed are a result of exposure during the period before the controls were instituted (Hart, 1988:197; Cherry, 1989:131). Another factor is that the inhalation of asbestos-dust is not limited to the mine and its employees. People that are working and living in the area of un-rehabilitated asbestos-mines and dumps are also exposed to inhalation of asbestos-fibres.

1.3.1. Fibre Characteristics

The environmental pollution of asbestos occurs by means of the following (Booyesen & Nel, 2002:5):

- Natural erosion of:
 1. Soil or rock, containing asbestos
 2. Manufactured material containing asbestos fibres
 3. Asbestos tailing dumps
- Factory and mining emissions of asbestos fibres.
- Spillage of asbestos fibre during transportation.
- Uncontrolled use and dumping of asbestos fibres or materials containing asbestos.

Only asbestos fibres which comply with certain physical criteria are able to enter the human body and cause asbestos related diseases. The three criteria acknowledged is that (Booyesen & Nel, 2002:5):

- i.) a diameter of fibre must be less than 3 microns,
- ii.) the length less than 5 microns and
- iii.) the length/diameter ratio greater than 3.

Fibres complying with these characteristics can be breathed in through the human nose and throat and enter the air passages, in the same manner as dust and bacteria does (Booyesen & Nel, 2002:5). Most of these particles then stick to the bronchial walls, which are coated with sticky mucus, and are then coughed up and either spat out or swallowed.

If some of these particles proceed to pass through the throat and into the lungs, a specific white cell called a macrophage, defends the body against the intruders acting as a scavenger and moves around in the lung spaces mopping up all the dust and germs it finds there (Booyesen & Nel, 2002:5). It does this by swallowing the particles whole and then either digesting them or moving them out of the way. The macrophage produced digestive juices, which are very acidic, with a pH below 4 (Booyesen & Nel, 2002:6). Because of the structure of chrysotile or amosite they puncture the macrophage cells when swallowed, which causes the macrophage to die and release the acids. This is what actually causes the lung scarring in the long term (Booyesen & Nel, 2002:6). It is therefore evident that the visible asbestos fibres are not the asbestos that should be worried about, but rather the asbestos that cannot be seen and is suspended in the air due to wind erosion.

The following table summarizes the properties of the three types of asbestos fibres (Howling, 1937:8).

Table 1: Properties of the three types of asbestos fibres

Property	Chrysotile	Crocidolite	Amosite
Fibre length (usual maximum)	38-51mm	38-76mm	178mm
Tensile strength	High	Higher than chrysotile.	Good
Flexibility	High	High	Good
Fineness of fibre	Very fine	Fine	Fine
Resistance to heat	Good, but becomes brittle.	Poor	Good, but becomes brittle.
Resistance to acids, alkalis and sea water	Poor	Good	Good
Electrical-insulating value	Fair to good.	Good	-----
Heat-insulating value	Good	Good for moderate heat.	Good
Spinnability	Excellent	Fair	Fair

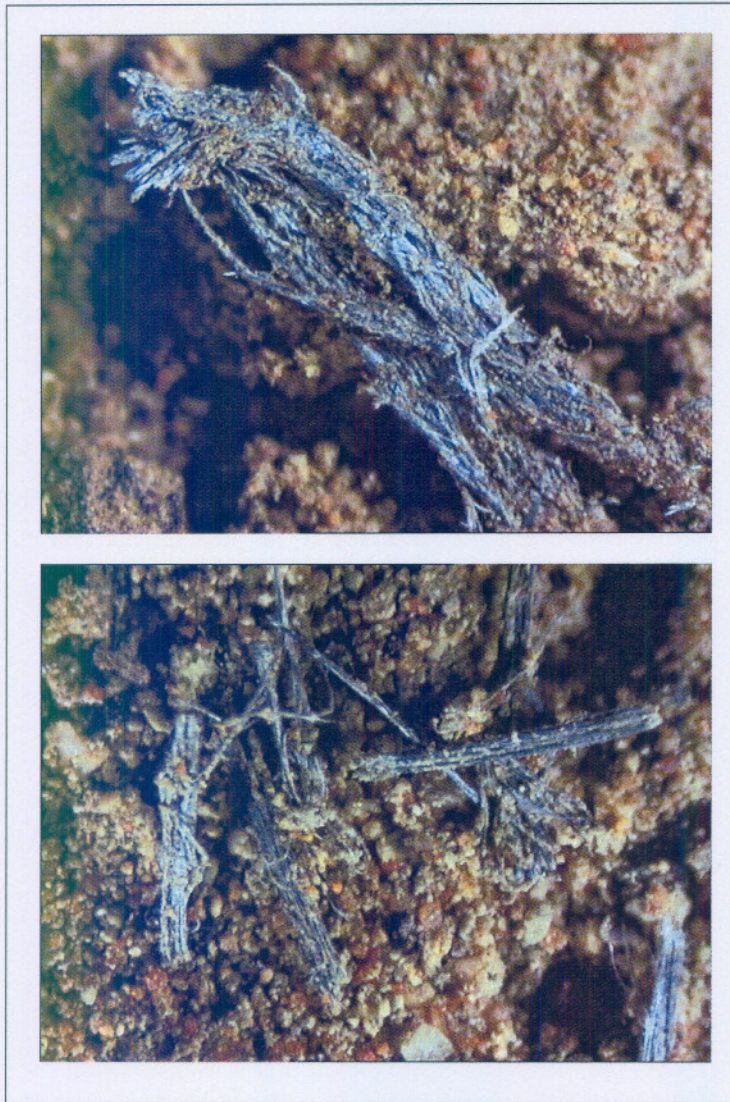


Figure 3: Soil contaminated with crocidolite / blue asbestos fibres.

A few characteristics of the blue asbestos fibres / crocidolite can be seen clearly in figure 3. The colour, shape, and texture are evident, and support the discussion of the properties and the danger of these fibres.

1.3.2. History of health related risks associated with asbestos

Shortly after the first factory production of asbestos fibre commenced, the public health risk associated with it began to immerge. Between 1890 and 1895, sixteen out of the seventy workers of a French asbestos-weaving

factory had died (Booyesen & Nel, 2002:3). By 1899, 11 men, all aged about 30, who spent their working lives in an asbestos spinning factory in the UK had also died (Booyesen & Nel, 2002:3). In 1906 the first modern record of an asbestos related disease was recorded in England when Montague-Murray of Caring Cross Hospital in London reported in the autopsy of an asbestos worker, of fibrosis in the lung (Du Toit 1984:1; Booyesen & Nel, 2002:3). However, it was not until 1927 that Cooke suggested asbestos as the causative agent in pulmonary fibrosis and used the term "asbestosis" for the first time (Booyesen & Nel, 2002:3). From 1938 to 1949 numerous autopsy reports indicated that a high proportion of persons dying of asbestosis also had lung cancer (Booyesen & Nel, 2002:3).

In 1960 Wagner identified an association between asbestos exposure and mesothelioma amongst the chrysotile miners of the Northern Cape, which raised a major new scare (Booyesen & Nel, 2002:3; Du Toit 1984b:1).

Asbestosis was not mentioned in a Department of Mines annual report until 1968, 75 years after asbestos mining commenced in South Africa (McCulloch, 2002:75). The annals of toxic corporate crime are replete with horrific stories of inhumanity, but the story of asbestos mining in South Africa is in a class of its own. A central player in this story is the Cape Company, a British multinational corporation that managed contract mining employment under conditions that were usually harsh even for South Africa.

The Cape Company operated a mill in the centre of the town of Prieska to separate the deadly blue (chrocidolite) asbestos from its host rock. Mine tailing wastes were strewn all around the town (McCulloch, 2002:80). Environmental contamination from mining included the surfacing of roads with mine tailings, children playing on the dumps, women washing clothes in the Orange River next to the tailings dumps, infants sleeping on asbestos sacks, and the common use of tailings and mud to make bricks and plaster the walls of homes (McCulloch, 2002:80). The contamination remains a mortal threat to the people living there, to this day.

According to Coombes (2002:7) asbestos milling is far more hazardous than asbestos mining. Although asbestos mining does involve exposure to asbestos the major risks associated with mining crocidolite began with processing the ore.

This began with cobbing, where rock and asbestos were separated, usually with a hammer. Following cobbing, the bags of separated asbestos were sent for milling where risks of exposure were potentially the highest (Coombes, 2002:7).

During the years when the crushing mill operated in the town of Prieska, long term residents of the town who were not employed in asbestos mining or milling were still exposed through environmental contamination to a sufficient dose of asbestos, which caused them to develop interstitial pulmonary fibrosis or asbestosis (Coombes, 2002:7). Lesser exposures would have been considered to be responsible for cases of mesothelioma, asbestos related pleural plaques and diffuse pleural thickening, as has been documented in the various studies of the town's population (Coombes, 2002:7).

One thing that is clear is that the asbestos milling operation in Prieska was responsible for causing continuous heavy environmental asbestos pollution for a period of around 50 years. This pollution affected the whole town and its environment.

1.3.3. Diseases associated with asbestos exposure

Because it is so hard to destroy asbestos fibres, the body cannot break them down or remove them once they are in the lung tissue. They remain in the tissue, where they can cause fatal diseases (Figure 4).

There is still a lot of speculation on the risk of asbestos fibres getting into the digestive system through the intake of contaminated food or fluids, and there has been very little agreement on this topic.

Asbestosis (Pulmonary Fibrosis)

This is a non-malignant lung disease associated with exposure to amphiboles, and because it can take various forms (some of which may be caused by other pollutants) it comprises a mixture of symptoms (Booyesen & Nel, 2002:2). Asbestosis generally implies the disease associated with scarring of the lungs and general fibrosis, both within the lung and the chest cavity (Landrigan, 1991:258).

This disease can be caused by working chrysotile dust, but only if it is at very high concentrations and for extended, continuous periods (Booyesen & Nel, 2002:2). Such conditions are optimal for causing lung disease, regardless of the nature of dust. With extreme exposure asbestosis may continue to develop even after the exposure has stopped. In advanced stages, asbestosis causes shortness of breath and may also affect the heart indirectly, leading to a higher than normal chance of respiratory or heart failure (Booyesen & Nel, 2002:2; Cherry, 1989:131). There is no treatment for asbestosis, the disease is usually disabling or fatal.

In the Northern Cape there have been several cases of residents who never had occupational exposure to asbestos fibre, and yet still developed an asbestos related disease due to environmental exposure. Although mining of asbestos ceased during the late 60's and early 70's, residents are still being diagnosed with asbestos related diseases to this day – nearly 30 years later.

Pleural Effusion

This is an accumulation of fluid between the layers of the membrane lining, the lung and the chest cavity (Booyesen & Nel, 2002:2; Cherry, 1989:131). Pleural Fluid is normally formed in small amounts, to lubricate the surfaces of the pleura or the thin membrane that lines the chest cavity and surrounds the lungs. A Pleural Effusion is therefore an abnormal collection of this fluid (Booyesen & Nel, 2002:2; Cherry, 1989:131).

There are two different types of effusions that can develop. The first type is transudative pleural effusions, which is usually caused by a disorder of the normal pressure in the lung (Landrigan, 1991:258; Booyesen & Nel, 2002:2; Cherry, 1989:131). Congestive heart failure is the most commonly known type of transudative pleural effusion. The second type of pleural effusion is exudative effusions, which form as a result of inflammation of the pleura, and is often caused by lung disease (Booyesen & Nel, 2002:2; Cherry, 1989:131). Asbestosis, cancer, tuberculosis and certain other lung infections and drug reactions are some of the conditions that can cause exudative pleural effusions (Booyesen & Nel, 2002:2; Cherry, 1989:131).

Mesothelioma

This is usually fatal, and is an inoperable malignancy of the lung lining (Booyesen & Nel, 2002:3; Cherry, 1989:131). It is a rare form of cancer which

often occurs in the thin membrane lining of the lungs, chest, and abdomen, and occasionally in the heart (Booyesen & Nel, 2002:3; Cherry, 1989:131).

People who worked in asbestos mines, asbestos mills, factories and shipyards have an increased risk of mesothelioma (Booyesen & Nel, 2002:3; Cherry, 1989:131). People who lived with asbestos workers, or lived nearby a shipyard that produced high quantities of asbestos fibres, were also greatly at risk. Progressive pain and shortness of breath are two of the main symptoms which occur (Booyesen & Nel, 2002:3; Cherry, 1989:131). This tumour is usually associated with a pleural effusion.

Lung Cancer

The amphiboles appear to promote other carcinogens which cause lung cancer (Booyesen & Nel, 2002:2). Cigarette smoke is however the primary carcinogenic risk factor which causes asbestosis to develop into lung cancer. Workers who are exposed to asbestos have a slightly higher risk of dying from lung cancer than people who don't smoke and aren't exposed to asbestos either. Alternatively those with asbestosis who do smoke heavily are over 50 times more likely to develop lung cancer than non-exposed workers who did not smoke (Booyesen & Nel, 2002:2).

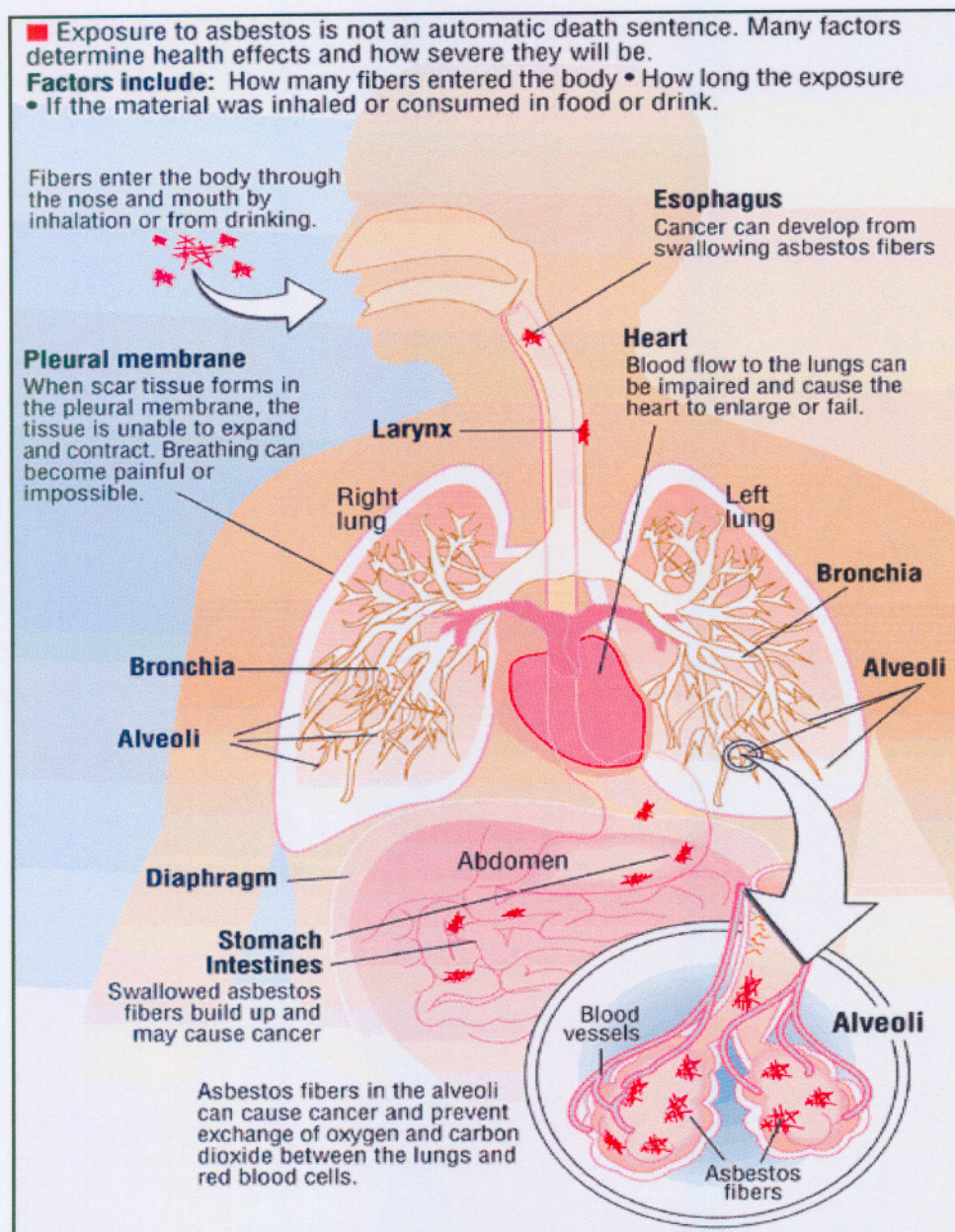


Figure 4: Respiratory system of the human body (Booyesen & Nel, 2002:3).

1.3.4. Impact of asbestos fibres on the environment.

Fauna

The impact of asbestos fibres on aquatic life has not really been studied yet, although it has been found that high concentrations of asbestos fibres in water may influence the growth of plant algae negatively (Lauth & Schurr, 1983:94).

Thornton (1981:22) found that in the diet of a herbivore, the food they consume contains around 15% soil. If the animals are grazing on soil that is contaminated with asbestos, they will consume the fibres as well. Because of the long latency period of asbestos related diseases, herbivores may not develop these diseases before the time of death, but the effect of the inhalation of asbestos fibres by animals still has to be studied or investigated further (Schreier, 1989:86).

Flora

According to Kruckeberg (1979:28), plants that are growing in asbestos contaminated soil, are not growing in optimal conditions. These conditions may lead to a sparse plant covering, slackened growth, colour changes, and other unique characteristics.

Further studies are required in order to calculate the exact impact of asbestos fibres on animal and plant life.

1.4. Problem Question / Statement

Crocidolite or blue-asbestos is the type of fibres present in the houses and other buildings in Prieska. These fibres are disturbed and further induced to weathering by the residents, animals and other natural factors.

This situation gave rise to the formulation of the problem question for the study, namely "What is the current risk of asbestos exposure to the citizens of the Prieska area, in the Northern Cape Province in South-Africa?"

The aim of this study is therefore to determine the current risk of asbestos exposure to the citizens of the Prieska area, in the Northern Cape Province of South-Africa.

Research Questions

In order to answer the problem question, the following sub-questions were formulated:

- a. What are the exact levels of asbestos contamination in the town and surrounding townships of Prieska?
- b. How big is the risk of exposure due to asbestos contamination of the environment in Prieska?
- c. Can the need for rehabilitation be prioritised?

The scope of this work will encompass only the Prieska area within the Siyathemba Municipality. It will focus exclusively on the audit of buildings in the study area, even though other infrastructure may also be contaminated.

Although the extraction of asbestos ceased a long time ago and the mill site has already been rehabilitated, the people of Prieska and the surrounding townships are still working and living in a much polluted environment.

Today there are many people with asbestos-related diseases and many still to be diagnosed due to exposure to Crocidolite in Prieska. Examples of remaining sources of Crocidolite in Prieska are shown in figures 5 and 6. The need for rehabilitation of these areas has to be quantified.



Figure 5: Contaminated building in Prieska. (See blue asbestos in foundation)

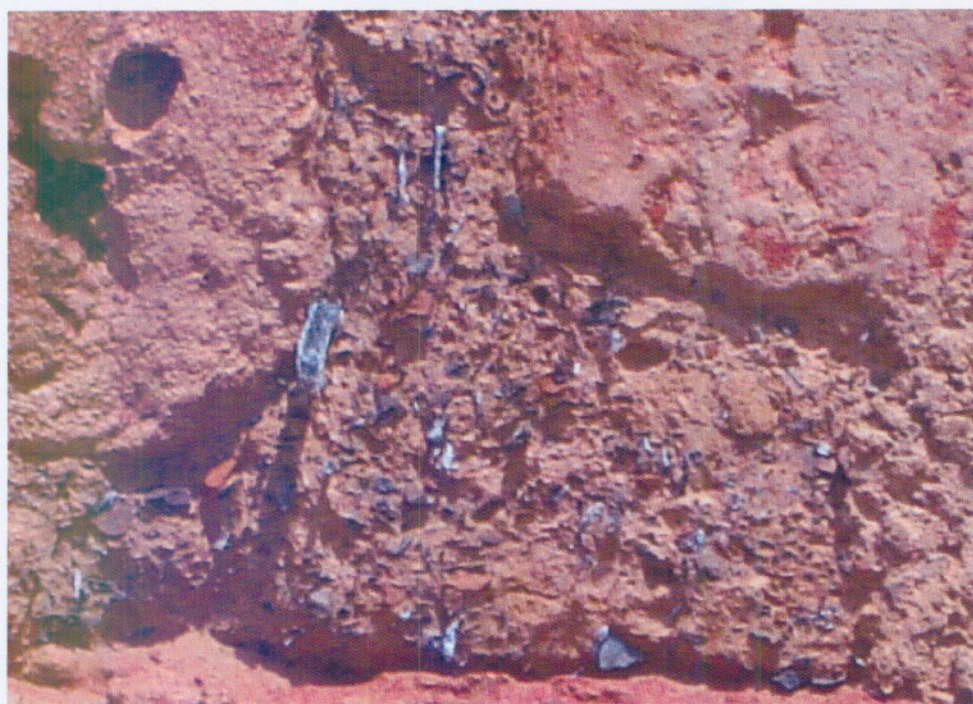


Figure 6: Blue asbestos fibres / crocidolite in the cement or building material of a building in Prieska.

1.5. Geographic Information Systems (GIS)

What is GIS?

Many definitions of GIS have been suggested over the years, and none of them are entirely satisfactory. But the following definitions are particularly helpful (Longley. et. al, 2005:16):

- A container of maps in digital form;
- A computerized tool for solving geographic problems;
- A tool for revealing what is otherwise invisible in geographic information.

According to Davis (2002:13), GIS is a computer-based technology and methodology for collecting, managing, analyzing, modelling, and presenting geographic data for a wide range of applications. GIS refers to three integrated elements:

- Geography: The real world; spatial realities.
- Information: Data and information; their meaning and use.
- Systems: Computer technology and its support infrastructure.

The application of GIS for this study:

Digital maps can be generated for each of the 4 sub-areas, showing the API distribution. Information can be revealed, which would usually be invisible and only contained in a large data base. Therefore, the quantitative and qualitative data, which would only be interpreted as a lot of numbers and tables without a GIS, can now be generated into digital maps that show the bigger picture and make sense out of all the raw data. According to Davis (2001:11), a map gives the best initial impression of what the information means. Visualization is the presentation of data in graphic form (Davis, 2001:11).

GIS Project Management:

The six component parts of a GIS are (Longley. et. al, 2005:18):

1. Software

ArcView is the program which was used during this study. It is a simple system designed for viewing, analyzing and mapping data (Longley. et. al, 2005:24).

2. Hardware

The components of a GIS hardware infrastructure are the data input, data management and analysis, and the data output (Davis, 2001:20). The input of this data was done manually, because each data gathering form and lab result had to be captured in a database. The management and analysis of the data was done on a computer that was not connected to a server or workstations. For the data output, printers were used to plot the maps and the database was stored on a CD.

3. Network

For this study, a network was not used, because it is not part of a bigger integrated GIS.

4. People

Different people were part of the data gathering and management of the project.

5. Data

To follow the procedures in a GIS, all the data must be gathered to form a reasonable result or outcome.

6. Procedures

This is the numerous functions of the GIS, which deals with geographic data from input to output. They also give a background of how GIS was used for this study. These concepts are the following (Davis, 2001:14):

1. Collection

This included the data gathering from the various sources, people and the field work.

2. Storage and Management

Efficient digital storage is necessary. It was important to keep track of all the data, as well as the integration of the various types of datasets into a database. Database management replaces the physical map storage structure.

3. Analysis

This is the process of analysing data, to produce insight and new information. Various techniques of data investigation were used, as described in the methodology.

4. Conversion

Changing data from one form to another makes the data more useful. The tables in the database (Microsoft-Excel) were imported into a Microsoft- Access database, in order to convert it to a database file format, making it more user friendly to import it to ArcView.

5. Modeling

The data was simplified, for the user to understand what it means. This was done by classifying the data in each sub-area, in order to view the API.

6. Retrieval

This is the easy and efficient selection and viewing of data. Each of the maps was observed in ArcView as a separate layout.

7. Display

The data was presented on maps, and printed on A3 paper, for easy understanding.

This shows the importance of the procedures and data. Each of the above mentioned parts cannot function without the other. For a successful GIS, the data collection and procedures followed should be done very carefully, and therefore planning is very important.

1.6. Structure of mini-dissertation

This study is part of a bigger project of Redco-services (Rehabilitation Design & Construction services (Pty.) Ltd.), in Potchefstroom, which is done for the DTEC (Department of Tourism, Environment and Conservation).

Chapter 1

This is the introduction to the study, which includes the background of the problem, the history of asbestos in South Africa and the health related risks associated with asbestos. The problem question and methodology used to answer it are also discussed.

Chapter 2

The study area and specifically the town of Prieska are described in this chapter. Furthermore, the period when the asbestos mills were still operating in Prieska, and when the citizens were directly exposed to the asbestos fibres are also discussed.

Chapter 3

The materials and methodology used during this study, and the techniques used during the sampling as well as the methods utilised for the analysis of the data are discussed here. The data gathering procedure and the types of parameters used in the data gathering forms are explained, and the risk determination and asbestos prioritisation index are discussed, together with the formulas and weights used.

Chapter 4

This chapter includes the results of the study, and specifically the tables containing data and the GIS maps for the 4 different sub-areas in the Prieska area.

Chapter 5

The discussion of the above mentioned results occurs in this chapter. The API of each of the sub-areas is explained and the comparisons are made.

Chapter 6

This is the final conclusion of this study and provides an answer to the main problem question. Recommendations are also made for further studies.

Appendices

Appendix A is an example of the data gathering forms and Appendix B contains the CAD drawings for each sub-area.

Appendix C is on the enclosed CD, and contains the total database of the quantitative and qualitative data. The way the formulas and weights were incorporated into the database, is also illustrated.

Bibliography

The literature referred to in this study was mainly used to explain the background of asbestos, the legislation and the health related information.

The methodology used in the collection and analyses of the samples has however never been used before within this context, and no description thereof was found in literature.

Chapter 2: Study Area

2.1. Description of study area

Prieska is a small, remote town in South Africa (Figure 7), close to a crocidolite asbestos mining area which was productive from 1893 to the late 1960s (Kielkowski et al., 2000:563). Twenty four crocidolite rich deposits had been identified in the Prieska magisterial district by 1930 (Kielkowski et al., 2000:563). These were mined at various times from 1919 to 1943 by the Cape Asbestos Company and from 1929 by smaller companies (Kielkowski et al., 2000:563). Cape had a succession of 3 mills (Coombes, 2002:4).

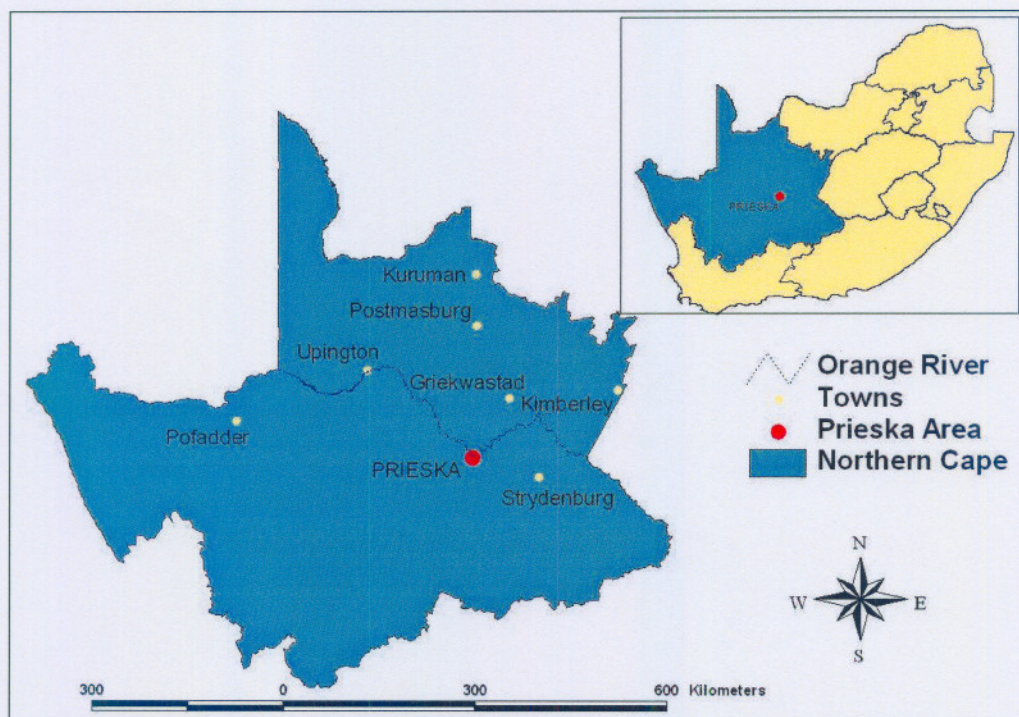


Figure 7: Location of Prieska in the Northern Cape Province in South-Africa.

The last crushing mill was built in Prieska town in 1930, at the corner of Conan Street and Asbestos Street (Figure 8) (Coombes, 2002:4; Kielkowski et al., 2000:563). Children and residents were exposed to asbestos fibre emissions from the mill which was situated next to a school and close to both the residential and business areas, until 1964 when it was supposedly closed down (Coombes, 2002:4; Kielkowski et al., 2000:563). Local residents

however, remember the mill still working in the late 1970s (Kielkowski et al., 2000:563). The site of the mill had been environmentally rehabilitated by 1999 (Coombes, 2002:7).

Other sources of exposure were the asbestos dumps (on which children played), spillage of fibres during transport, and tailings which were used for, among other things, surfacing roads and making bricks (Kielkowski et al., 2000:563). The nearest mine dumps to the town were on the other side of the Orange River, less than 2km from the town, and some environmental rehabilitation had also been done on these dumps by 1999 (Coombes, 2002:7). Other sources of asbestos contamination include roads and buildings. The practice of using asbestos tailings to repair roads was still being carried out in 1981 (Coombes, 2002:6).

Asbestos cement building blocks are another highly undesirable domestic contaminant. Such bricks deteriorate over the years and, unless meticulously enclosed, constitute a source of ongoing asbestos exposure for the residents (Coombes, 2002:6). The last major store of asbestos was removed from the town in 1982 (Kielkowski et al., 2000:563). Homes are however still polluted through years of wind blown fibres accumulating in the ceilings, and asbestos which was used as part of the building material.



Figure 8: Asbestos Street in Prieska Town

2.1. Border Area

The blue asbestos seams stretch 50km wide and 400km in length, north towards the Botswana border (Coombes, 2002:4). The borders of this study area will however, only be the town of Prieska and the surrounding townships. The smaller plots next to the residential areas will not be a part of the study area.

2.2. Climate

Prieska is a very dry and warm area, with a strong westerly wind which blows occasionally (Coombes, 2002:4). Residents still claim that during the time of asbestos milling, if the wind blew, asbestos dust could easily be seen with the naked eye in the mill at Koegas, as well as in Prieska itself (Coombes, 2002:4). The rainfall ranges from 150 – 350mm per annum (Acocks, 1988:81).

2.3. Vegetation & Geology

According to Acocks (1988:81), this area is in the *Typical Orange River Broken Veld* type of South Africa. It occurs on a variety of rocks, e.g. banded ironstone, dolomite, quartzite and granite. Typical trees of the area are *Acacia erioloba*, *Aloe dichotoma* and *Euphorbia avasmontana*. The smaller plants

include, amongst others, a rich flora, even though there is sparse vegetation. The flora includes *Barleria rigida*, *Monechma spartioides* and *Aizoon burchellii*. In this type of veld identification, grasses are important. A few common types are *Aristida diffusa*, *Digitaria eriantha* and *Cenchrus ciliaris* (Acocks, 1988:82).

2.4. Topography

The topography of the area is relatively flat, sloping to the east. The site is on the edge of the town, between the town and the Orange River. Prieska is in the Karoo, with flat scrubland and the Asbestos Mountains in the distance (Coombes, 2002:4). According to Acocks (1988:81), altitudes in this area range from 750 – 1350m above sea level.

2.5. Demographics

Prieska is a very small town with a population of around twenty thousand people (17 513 people). There are three townships at Prieska, namely Rooiblok, Ethembeni and Bontheuwel. The neighbouring villages are Marydale and Niekerkshoop. The predominant language in Prieska is Afrikaans. Most of the people especially youth are literate and they can read and write, and only a few of the elders are illiterate. There are four primary schools and two high schools in Prieska. One of the schools named JJ Dryer was built with materials containing asbestos.

The details for the establishment of the community profile were conducted by the Redco/Nemai Consortium (for DME) with the aid of the 2001 census data:

- **Predominant Languages**

The predominantly spoken languages in Prieska are Afrikaans and Setswana. 93% of the community speaks Afrikaans in comparison with 4.7% of the people who speak Setswana (Lesego & Pretorius, 2005:11).

- **Age groups**

34% of the population is younger than 15 years of age and 60% of people are between 15 and 65 (Lesego & Pretorius, 2005:11).

- **Household size**

70% of households have 4 or less people in comparison to the remaining 30% of households, which have in excess of 4 people (Lesego & Pretorius, 2005:11).

- **Level of education**

33% of children do not attend school and 21% of adults can be considered as illiterate (Lesego & Pretorius, 2005:11).

2.6. Additional information about the study area

2.6.1. **Income levels**

From the census 2001 information it can be gathered that 64% of the people in Prieska do not have a formal source of income (Lesego & Pretorius, 2005:12).

2.6.2. **Services**

- **Institutions**

Schools, places of worship, government and municipal departments, banks, shops, hospitals, doctors, clinics, police and emergency services are amongst the various institutions that are available in Prieska (Lesego & Pretorius, 2005:12).

- **Electricity**

85% of the community has electricity, which is supplied by the Siyathemba Municipality. 12% of the community uses candles for lighting (Lesego & Pretorius, 2005:12).

- **Telecommunication**

56% of the community has access to a private telephone, and 34% of the people rely on public telephones to communicate (Lesego & Pretorius, 2005:12).

- **Sanitation**

74% of the community uses flush toilets, and the rest of the people have access to other forms of latrines (Lesego & Pretorius, 2005:12).

- ***Roads and transport***

The main mode of transport for people in the area is by means of walking and only 10% use road transport. A large component of the roads is gravel. It is expected that some of the roads are also contaminated with asbestos and the majority of people are walking on, and living nearby these contaminated gravel roads (Lesego & Pretorius, 2005:13).

- ***Retail***

The majority of the community does their shopping in Prieska. People from rural regions also frequently visit the retailers in town (Lesego & Pretorius, 2005:13).

Chapter 3: Materials and Research Methodology

3.1. Survey (general view or description)

This study is part of a bigger project of Redco-services (Rehabilitation Design & Construction services (pty.) Ltd.) which is done for DTEC (Department of Tourism, Environment and Conservation).

The bigger project entails an audit of all the asbestos contaminated infrastructures in four affected municipal areas in the Northern Cape (Figure 9) for the purposes of rehabilitation. The municipalities involved are

- Siyathemba (Karoo District Municipality) – Prieska and Marydale
- Siyacuma (Karoo District Municipality) – Griekwastad
- Ga-Segonyana (Kgalagadi District Municipality) – Kuruman
- Kgatelopele (Siyanda District Municipality) – Daniëlskuil

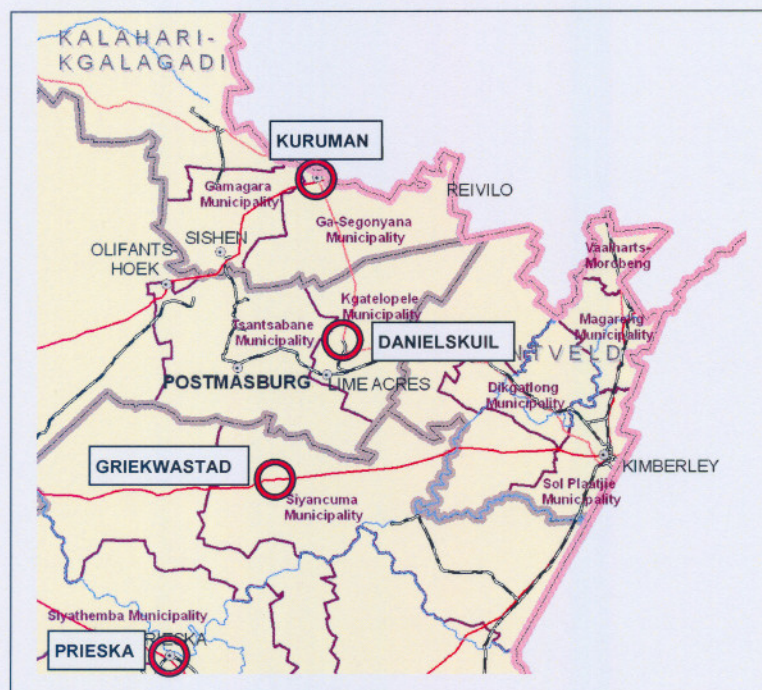


Figure 9: The four affected municipal areas in the Northern Cape for the purposes of rehabilitation (Vorster, 2002).

The scope of this study will encompass only the Prieska area within the Siyathemba Municipality.

The three research questions will be answered by following a certain research methodology, which is described below.

a. What are the exact levels of asbestos contamination in the town and surrounding townships of Prieska?

To determine the exact levels of asbestos contamination in the study area, samples were taken on each stand in the Prieska Town as well as the surrounding townships. The asbestos content in each sample was calculated.

b. How big is the risk of exposure due to asbestos contamination of the environment in Prieska?

To determine how big the risk of exposure due to asbestos contamination of the environment in Prieska is, it is important to inspect each of the buildings in Prieska and the surrounding townships.

The potential of the crocidolite asbestos to release free fibres into the air causes a very large health and environmental hazard. Due to the chemical structure and straight needle-like fibres, it is highly bio-persistent. The determination of the fibres that are already airborne, or the potential for fibres to become airborne, is therefore important.

The degree of asbestos contamination and risk of exposure is therefore linked to the *quantity* of asbestos present in infrastructure, and the *condition* thereof, which determines the potential to release fibres. It is important to note that building materials containing asbestos, such as bricks or asbestos cement, may pose a relatively small health risk if it is properly maintained and in a good condition. However, if the building is in disrepair, in a poor state, or if such a building is demolished, it presents a high risk.

Therefore, to determine the risks posed by buildings, the buildings had to be physically inspected to determine the asbestos it contains (bricks, cement, ceiling, foundations, plaster, fill material, floors, etc.) as well as the building materials such as pipes and roofing sheets that have been manufactured from

asbestos. The condition of each building and the maintenance in place also had to be determined.

c. Can the need for rehabilitation be prioritised?

When all of the above have been determined and captured in a database, an Asbestos Priority Index (API) will be developed. The need for rehabilitation can then be prioritised from the highest to the lowest API, and illustrated on the GIS.

3.2. Sampling:

- Redco recruited fieldworkers in Prieska. People from the community and interested groups were used to perform the data gathering. Supervision and assistance were provided to the group, during the period of the data gathering and sampling.
- Since the fieldworkers were already exposed to asbestos, or living in this polluted area, and their exposure to asbestos (whilst doing the data gathering) will be for a short period, they did not go for any medical tests before starting with the work.
- Redco provided training to the fieldworkers, to enable them to do the sampling and data gathering. The sampling included:

1) *The major types* of samples that had to be taken;

Soil- and Material samples (as indicated on the data gathering forms)

2) *The source* of the samples;

a. *Soil samples* – consisting of dust which had settled on the **ceiling**, and **soil** at random locations on the stand, surrounding the building, and

Material samples – consisting of a sample of **brick** and **cement** from the main house or separate building on the stand.

b. These samples were each given a certain code or id, in order to identify its source. This was given in a way that made it easy for the fieldworkers to understand and use, as they are predominantly Afrikaans speaking:

Ceiling – "P" (Plafon)
Soil – "G" (Grond)
Brick – "S" (Stene)
Cement – "C" (Cement)

Soil samples: Soil samples were necessary because the environment surrounding the buildings on the stand or fill material, contains unacceptable levels of asbestos fibres. These samples were analysed in the laboratory for the actual fibre content.

3) *How* the samples had to be taken;

- a. A sample of the dust and soil were taken with a small shovel, and a small piece of a brick and cement were chipped off the buildings. These samples were then put in small plastic bags and transported to the laboratory.
- b. There is a field on the data gathering form to indicate which of the abovementioned samples were taken at each stand, by ticking off the relevant samples on the form (Figure ...)
- c. A small card or piece of paper was placed into the plastic bag, which contained the Stand number, ID number of the gathering form and the type of sample that was in that specific plastic bag (P, G, S or C). This is to identify the specific sample and link it to its relevant stand and the information on its data gathering form.

4) *Techniques* to seal and transport the samples;

The plastic bags were sealed in such a way that there was no chance of any dust or fibres to be released into the air. The samples were transported in bigger containers that were also sealed. The vehicle in which the samples were transported had to have an Asbestos Warning Sign (Figure 10) on it, since people should be aware that this is a hazardous material in transit.

For the transportation, the samples had to be handled as prescribed by the Asbestos Regulations of 2001 and the Occupational Health & Safety Act (OHSA) (Act no.85 of 1993). After testing/ analysing the samples, they were disposed of at mines that Redco is currently rehabilitating.



Figure 10: Asbestos Warning Sign

- Redco also provided training to the fieldworkers regarding the Health and Safety precautions when working with asbestos. They were provided with Personal Protective Equipment (PPE), which included dust masks (approved for asbestos dust; FFP2), overalls, a hat and T-shirt for easy identification and safety boots. When they were taking the samples, they had to wear their PPE.

3.3. Analysis:

To determine the actual fibre content, samples were crushed in an asbestos testing plant. There is only one such testing facility available in South Africa, which is located at the North-West University in Potchefstroom. In the past this plant was used to analyse samples for asbestos content, but a minimum of 10kg material was needed for the analysis. This would not be feasible for analysing the number of samples for this project, so a new method for analysing the samples had to be developed or adapted from other laboratory analysing methods to be accurate, quick and cost effective. Prieska typically has approximately 3235 stands and if 3 to 4 samples are taken per stand it would amount to between 10 000 and 12 000 samples.

- Eko-Analytica in Potchefstroom, was the laboratory that was used to process the samples, by using the following method to extract the asbestos fibres from the initial sample:
 - 1) The cement and stone samples were crushed with a mortar and pestle until fine.

- 2) If any of the samples (cement, stone, soil, dust) were wet or moist they were dried in an oven.
 - 3) The samples were sieved through a series of sieves ranging from 53 μm to approximately 2.3 mm. The content on each sieve was examined and the asbestos fibres were removed with a tweezer.
 - 4) In samples which contained a lot of asbestos fibres on the smaller sieves, the fibres were picked up by means of a vacuum pump with a film of paper towel covering the tube.
 - 5) Both the initial sample, and the amount of asbestos recovered, was weighed to calculate a percentage value. This was done for each sample on every stand.
- This quantitative data from the laboratory was then used to determine the exact levels of asbestos contamination in the town and surrounding townships of Prieska.

3.4. Data Gathering:

- The Siyathemba Municipality provided maps of the study area, with each stand's number (Appendix B).
The study area was divided into 4 sub-areas (Figure 11).
 1. Rooiblok township,
 2. Ethembeni township,
 3. Bontheuwel township &
 4. Prieska town
- This is also the order in which the samples were taken. Therefore, the first samples were taken from the stands in Rooiblok.
- The method that was followed is a door to door investigation. Data gathering forms were used (Appendix A), which were also available in Afrikaans, being the predominant language in Prieska.

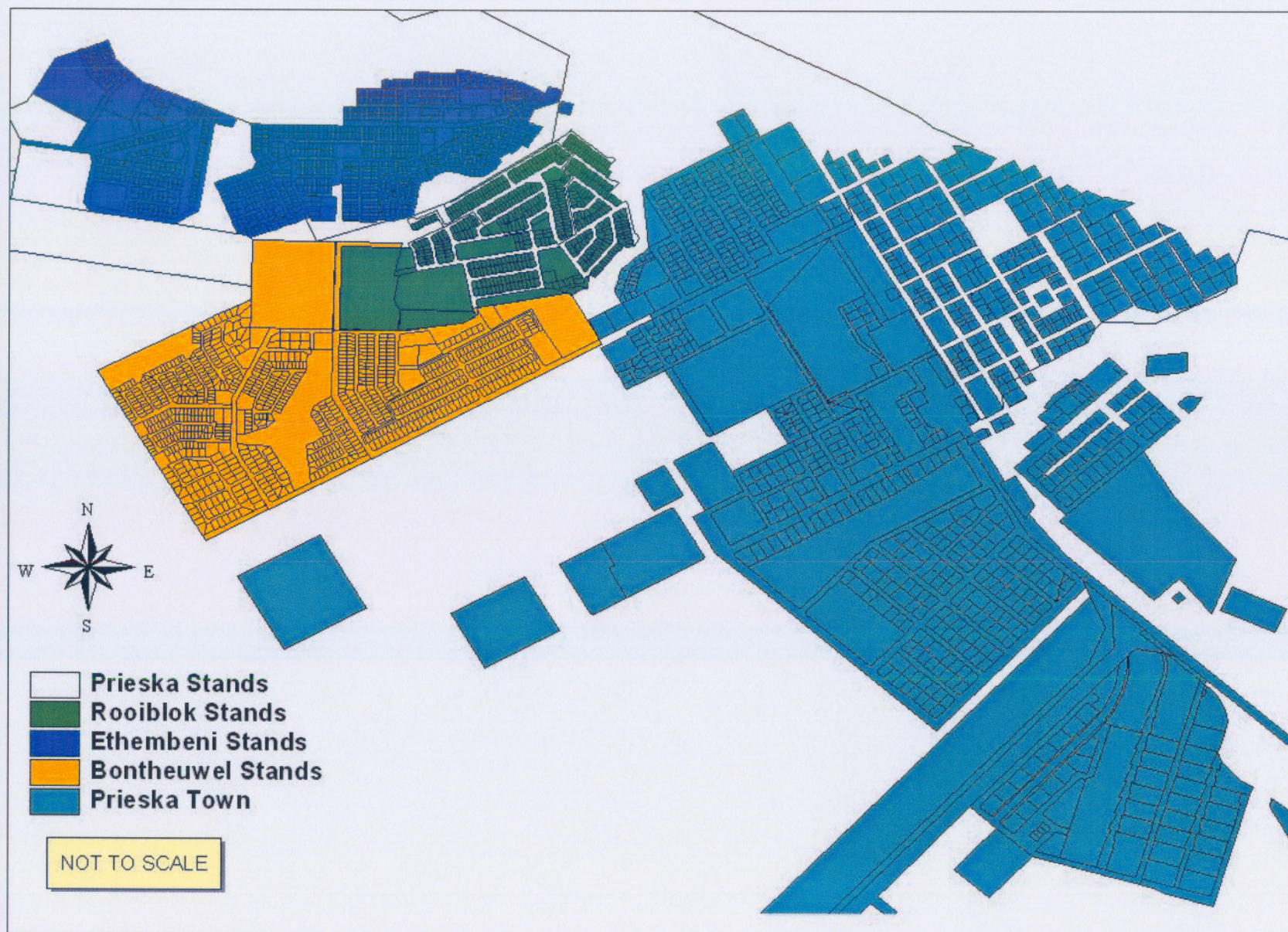


Figure 11: Map of the 4 sub-areas in the study area.

- Two fieldworkers worked together, with the one taking the samples on the stand, and the other one doing the qualitative data gathering.
- The following information/data was gathered by interviewing the owner or resident of that specific house on the stand (Specific field names of the database are indicated in brackets):
 - Suburb, street name and the house and stand number
 - Name of the owner
 - Number of residents and their age distribution (OC1-4)
- The rest of the qualitative data was physically inspected (Specific field names of the database are indicated in brackets):
 - Occurrence of contamination
 - Foundation & filling
 - Bricks
 - Mortar
 - Plaster
 - Loose fibre on ceiling
 - Loose fibre in yard
 - Pre-fabricated asbestos containing building products
 - Roof sheets & fascias
 - Pipes
 - Condition of these products
 - Solid (or not weathered)
 - Weathered (with loose fibres)
 - Sealed (painted)
 - Condition/state of the fibres in the building (SFI1-3)
 - Sealed (painted)
 - Fixed
 - Loose
 - Condition of Material/Building (CON1-2)
 - Good
 - Poor
 - The part of the building/which building was the samples taken from (PB1-3)
 - Main house

- Extension
- Separate Outbuilding
- Additional data to be inspected in more detail for future research
(Specific field names of the database are indicated in brackets):
 - Land use
(LU1-3)
 - Residential
 - Industrial
 - Commercial
 - Other additional information
(OR1-4)
 - Streets
 - Drainage Patterns
 - Traffic
 - Wind Factor

3.5. Risk Determination

Determination of the extent of asbestos pollution

The main goal was to develop a complete register, in the form of an interactive database of asbestos pollution on each stand in the Prieska Town and surrounding townships.

This register/database had to be computerized, and needed to provide information in order to prioritize these stands for rehabilitation purposes, according to the potential asbestos hazards.

Process of data capturing/processing in the database:

(See Appendix C)

Quantitative data:

The lab sent/faxed the tables, containing the results of the samples that were analysed, on a continuous basis. It was then recorded / captured into the database to calculate the % of asbestos fibres present in each of

the samples (See table 2 for an example of the way in which data was captured).

In the table below, the 1900 is the stand number and the "C" means that this specific sample is the *cement* sample. The *total (gram)* is the mass of the initial cement sample and the *asbestos (gram)* is the mass of the asbestos recovered.

Table 2: Example of a table containing the results from the laboratory

Sample	Total (gram)	Asbestos (gram)
1900C	42.3465	0.4274
1900G	33.6801	0
1900S	64.52	0

Table 3 shows the quantitative data for the soil sample (G) at that specific stand. The samples for P (ceiling), S (bricks) and C (cement) has the same parameters and is calculated in the same way.

Table 3: Percentage asbestos fibres in the soil samples.

Weight: 50		MAX: 498.5908517			
G (soil)	TOTAL (gram)	ASBESTOS (gram)	% FIBRES	Weighed%	Normalised
Y	22.2406	0.0031	0.013938473	0.696923644	0.00139779

The percentage asbestos fibres in the soil sample were calculated as follows:

$$\% \text{ FIBRES: } [\text{ASBESTOS (gram)} \div \text{TOTAL (gram)}] \times 100$$

The free fibres extracted from the sample, is therefore expressed as a percentage of the total mass.

The weighed % was calculated as follows:

$$\text{Weighed\%: } (\% \text{ FIBRES}) \times \text{Weight}$$

In the database, formulas were used and predetermined weights were allocated to the different fields in the data gathering forms. The Asbestos Prioritising Index (API) could then be calculated as explained under the Rehabilitation Prioritisation Index (RPI).

Qualitative data:

All of the qualitative data on the data gathering forms were captured into the database.

Table 4: General description of data

Form number	Stand No.	Sample in lab	Form comments
6437	1		OPEN SPACE
6438	2	X	NO ENTRY IN YARD

For each stand there is a data gathering form with a unique id, which is the form number. There were forms for each of the stands captured in the database. Before being analysed, the samples were checked to the data gathering forms to ensure that there is a form for every sample.

If there is an "X" in the database-column for "Sample in lab", it means that the sample is missing or not in the lab, although there is a form for that specific sample. If there is a form number, but no sample, the fieldworkers should have made form comments, and thus provided a reason for this, e.g. that the owners of that stands did not want the fieldworkers to take samples, or enter their yards (Table 4).

The following information/data was also captured in the database:

- Number of residents and their age distribution
- Condition/state of the fibres in the building
 - Sealed,
 - Fixed or
 - Loose
- Condition of Material/Building
 - Good or
 - Poor
- The part of the building/which building on the stand was the samples taken from

- Main house,
- Extension or
- Separate Outbuilding

3.6. Rehabilitation Prioritisation

In order to be able to determine a prioritisation index, Van Rensburg (1998:2) from the North West University, in conjunction with DME developed the Rehabilitation Priority Index (RPI). The DME is currently using the RPI approach to determine asbestos rehabilitation priorities. The RPI is based on a database of asbestos mines, taking into account a combination of factors, including population demography, economic profiles, asbestos pollution, type of asbestos, health risks, status of the infrastructure, and the social issues.

This way all of the asbestos mines in South Africa were prioritised from the most to the least in need of rehabilitation. By using this method the DME knows where to start with the rehabilitation of asbestos mines in South Africa.

3.6.1. The development of a prioritization model

The results of the above investigations, site inspections, building material tests and samples, were used to develop a prioritization model indicating risks and rehabilitation priorities. The development of such a model is a collaborative effort between the consultant and all interested parties per municipal area. Because of the sensational and emotional aspects surrounding asbestos, public opinion is very often not objective in terms of setting up priorities. The emphasis should be to find an objective approach which will yield the same result, regardless of who is responsible for setting priorities.

Based on the RPI developed for the DME, it should have two equally important segments, namely a quantitative component and qualitative component. Various parameters have to be defined during the consultation process, under leadership of the consultant. It normally includes the quantitative asbestos presence, demographic data, building conditions and number of occupants.

A computer model/database was developed, which can calculate the various indices representing a rehabilitation priority profile. This model is based on a GIS system which gives a spatial picture of the asbestos contamination problem, and rehabilitation requirements.

The following are important points in developing a prioritisation model:

1. Define the parameters needed for the prioritisation.
2. Agree on the weight of the different parameters in relation to each other
3. Develop a computer model to calculate the priority indices
4. Agree to what level the priority calculation should be done. Consider representing the priorities per residential area as well as the whole area.
5. Represent the data on an elementary GIS system to give a spatial picture of the asbestos contamination problem.

3.6.2. Determination of the Asbestos Prioritisation Index (API)

The goal is to quantify the asbestos content (quantitative data) and use that together with the qualitative data on the data gathering forms, in order to calculate the Asbestos Prioritisation Index. For this study the Rehabilitation Priority Index (RPI) was called the Asbestos polluted area Prioritisation Index (API).

The aim of the calculation is to try and achieve some measure of unbiased and objective assessment based on real data. This does not mean that the prioritisation is absolutely correct, and therefore it remains open for debate in order to refine it in the future.

The parameters needed for the prioritisation and the weights of the different parameters in relation to each other:

The contribution of parameters to the calculation of the API value is not equal and is allocated a weight according to their relative importance.

The following discussion relates to the diagrammatic representation for the calculation of the API, as shown in figure 12.

- Quantitative data

The quantitative data used in the calculation of the API is made up of 4 components, each of which contributes a specific weight towards the total of the quantitative data.

The weights allocated to the components are based on the degree of exposure people have to them, as follows:

- i.) The soil contributes the highest weight (50), because it represents the element to which the people living in this area are most exposed to.
- ii.) The ceiling carries a weight of 25, because people are less exposed to the fibres accumulating in the ceilings, and furthermore a large number of the buildings in the study area do not have any ceilings.
- iii.) Cement carries a weight of 15, because asbestos fibres are relatively fixed in this medium, and are therefore less likely to become airborne.
- iv.) Asbestos fibres in the bricks are the least exposed to people, because it is more fixed than the fibres in cement. Therefore it carries the lowest weight of 10.

- Qualitative data

The qualitative data used in the calculation of the API is made up of 9 components. These 9 components have been allocated weights based on unique risk factors, as follows:

- i.) The number of occupants on a stand carries the highest weight (10), because the more people live on the stand, the higher the exposure to asbestos fibres and the greater the risk for asbestos related diseases.

- A further 4 sub-categories exist under the number of occupants.

These sub-categories are allocated a unique weight based on the age distribution of the occupants.

People between 0-20 years carry the highest weight (50) and people older than 60 years the lowest (10). The reason for this is that older people have a high probability of already having an asbestos related disease, due to many years of exposure to asbestos fibres, whereas children and younger people have a higher risk of still being infected. Furthermore another factor to consider is the long latency period of asbestos related diseases. Due to the average life

expectancy in South Africa, if a person older than 60 is infected there is a lower chance of that person to develop an asbestos related disease due to the long latency period.

Occurrence of asbestos in buildings:

- ii.) The state of the fibres carries the highest weight (6) in this part where the parameters for the occurrence of asbestos in buildings were calculated. Therefore, it is important to know whether the fibres were sealed, fixed or loose because this will influence the risk of exposure to people.
- iii.) The condition of the material/building carries a weight of 3. It is important to know whether the condition of the building is good or poor. If the building is not in a good condition the risk of exposure to asbestos fibres is increased. This also indicates what the recommendations for rehabilitation will be, for example whether it needs to be repaired or rebuilt.
- iv.) The part of the building (i.e. main house, extension or separate outbuilding) has a lower weight of 2 because if any one of the buildings on the stand is contaminated with asbestos fibres, the people on that stand will be exposed regardless of where it occurs.
- v.) The weight of the type of land use is relatively high (5) because this contributes to the nature and duration of exposure of the people who are present on the stand. This is made up of 3 sub-categories which have different weights:
 - If the stand is on a residential area, it will have the highest weight (50), because the period of exposure to asbestos fibres on that specific stand will be the longest, since people live there every day and night. A stand on a industrial area will have a higher weight (30), than a stand on a commercial area (20), because there will be people working in the industrial areas for longer periods and in more harsh environments, than in a commercial area. The commercial land uses also includes the open fields, which don't have any people working or living there every day. The only people who are exposed are the people walking through, passing by, or living nearby.

Other data:

The following 4 parameters were added to the database subsequent to the actual data gathering, and therefore do not appear on the data gathering forms. It has been included in the database because it could also be relevant for the calculation of the API. Because of a limited time and budget framework, these parameters were not done in detail. This should be done in more detail for further studies.

vi.) Traffic

The traffic parameter carries a weight of 3. The more traffic there is, the higher the risk is for asbestos fibres to become airborne and get into the atmosphere.

vii.) Streets

The streets can either be gravel roads or tar roads. The streets carry a weight of 2, since it is less important than the other qualitative factors, but still needs to be considered in the study.

viii.) Drainage patterns

The drainage patterns should be calculated or determined through specialist studies. In this case it carries a weight of 1, since it no studies were performed on it, but it still needs to be given some consideration in the study.

ix.) Wind factor

There are two factors that can be determined to calculate this parameter. Firstly the wind speed could play a role in the distribution of the loose asbestos fibres, and secondly the wind direction is also important. In this case the wind could carry airborne fibres, resulting in more extensive pollution. The weight of the wind factor for this study was 1.

- Ratio of qualitative/quantitative data

To calculate the API, the sum of the quantitative and qualitative data is calculated (see table 12). The total of the quantitative data is given a weight of 75% and the qualitative data a weight of 25%, shown in point (c).

The quantitative data has a higher weight because this is very accurate and analysed data. It is also important because this gives the exact level of asbestos fibres in each of the four different samples taken at each of the stands.

The qualitative data, regarding numbers ii & iii, were a more subjective type of data gathering, and some assumptions and personal opinions could be made by the fieldworkers.

The initial weights of the various parameters were set as shown in the API-diagram (Figure 12):

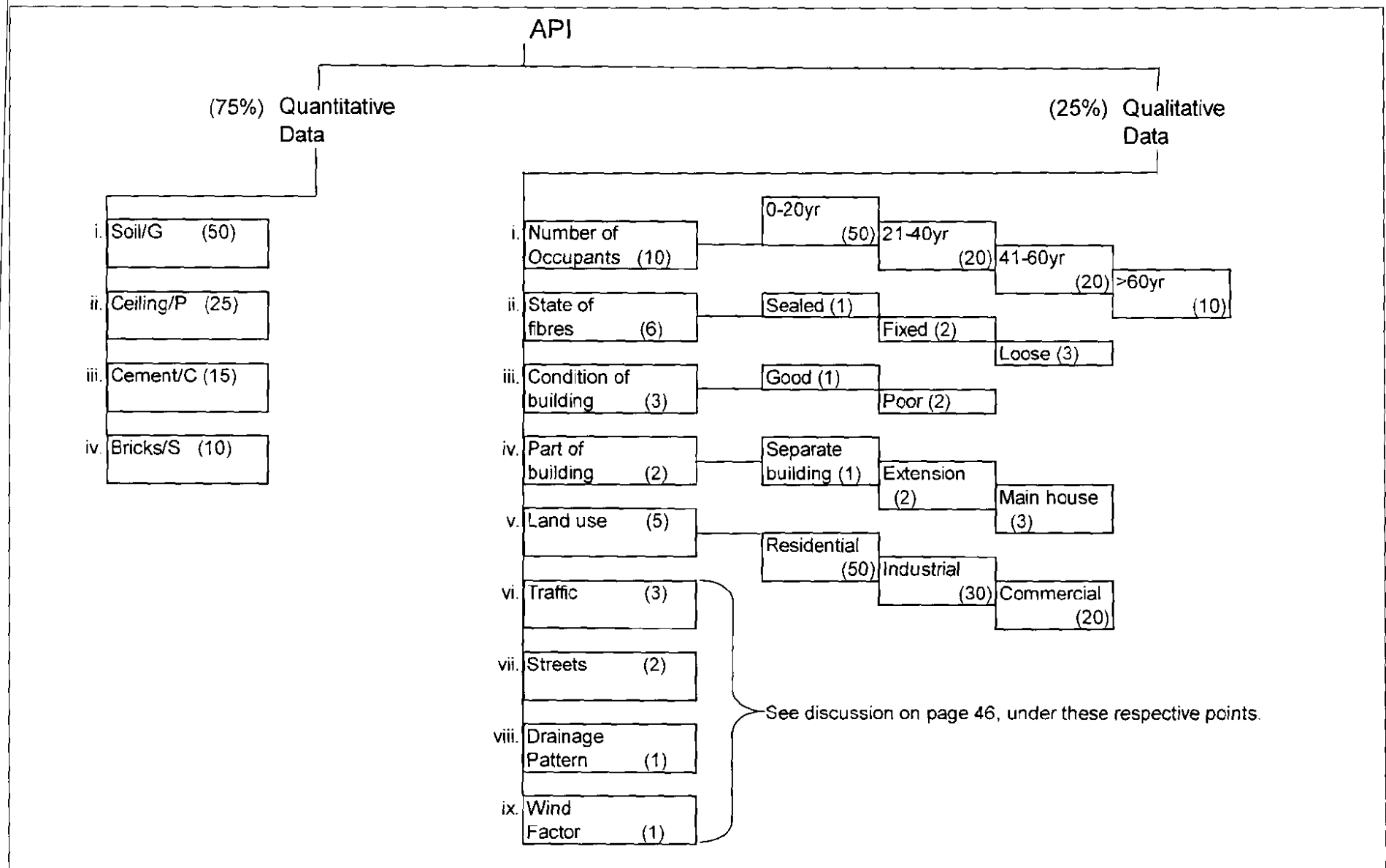


Figure 12: API-diagram showing the initial weights for the different parameters.

a.) Quantitative data: 75%

P (ceiling)	= 25	}	<u>100</u>
G (soil)	= 50		
S (brick)	= 10		
C (cement)	= 15		

b.) Qualitative data: 25%

Occupants = 10

0-20yr	= 50
21-40yr	= 20
40-60yr	= 20
> 60yr	= 10
	100%

Occurrence of asbestos in building:

State of fibres = 6

Condition of material/building = 3

Part of building = 2

Land uses = 5

Residential	= 50
Industrial	= 30
Commercial	= 20
	100%

Streets = 2

Drainage = 1

Traffic = 3

Wind factor = 1

= 33

c.) Quantitative data (100) + Qualitative data (33)

= 133

therefore:

= [(100 ÷ 133) x 100] + [(33 ÷ 133) x 100]

= (75%) + (25%)

= 100%

Developing a computerised database to calculate the priority indices:

The computerisation of the aforementioned and discussed data necessitated the development of a system that can accommodate the data's format, resolution, frequency and reporting requirements. Such an index can be very complicated, therefore it is important to keep it simple and understandable to the end user.

This database is then used to calculate the API (Appendix C). For this study the priorities were represented per residential area.

Discussion of calculations done in the database:

(Also see Appendix C for the complete database)

See pages 38 & 39 for the explanation of the field names / codes used in the tables.

The following important factors will be explained by referring to table 6, using it as an example:

Weight: [=WEIGHTS! C6]

The weights that were discussed above have been captured on a separate worksheet in Excel (see table 6, for portion of worksheet). In the database it was then referred to that specific worksheet (WEIGHTS) and the cell where the appropriate weight is (C6) on that worksheet.

Weighed%: (OC_TOTAL) x Weight

To calculate the weighed percentage, the total for the specified parameter (OC_TOTAL) is multiplied by the weight given to that specific parameter.

MAX: [=MAX (first weighed% value in dataset : last weighed% value)]

The maximum of the weighed% is then calculated by means of a formula, which searches for and returns the highest value of the weighed% field in the database. This was done for each of the four sub-areas in Prieska.

Normalised: [=weighed% on each stand / MAX])

The weighed% is divided by the MAX to get a normalised value on each of the stands. This normalised value expresses each weighed% in the database as a percentage of the largest weighed% in the database (MAX).

Table 5: Different weights assigned to age distribution of occupants

<u>Qualitative Data:</u>		
<u>Occupants:</u>	WEIGHT	10
Age Distribution	Weights	
0-20yr	50	
21-40yr	20	
40-60yr	20	
>60yr	10	
	100	

Calculations for the Occupants Parameter:

Table 6: Calculations for different aspects of the *occupants* parameter

Weight:	10									
Occupants:	Age Distribution						MAX:		10400	
0-20yr	OC1	21-40yr	OC2	40-60yr	OC3	>60yr	OC4	OC_TOTAL	Weighed%	Normalised
	50		20		20		10	100		
1	50	3	60	0	0	0	0	110	1100	0.10576923
0	0	1	20	0	0	1	10	30	300	0.02884615

For each stand, the number of occupants in each of the age distribution categories was captured from the data gathering form, into the database. An "IF-function" was used to calculate the OC_TOTAL.

=IF (comments column ="open space",0, (IF[(0-20) + (21-40) + (40-60) + (>60)] = 0, (Average(0-20) * Factor 50 + Average(21-40) * Factor 20 + Average(40-60) * Factor 20 + Average(>60) * Factor 10], (OC1 + OC2 + OC3))).

If it states in the "form comment" column that this is an open space, the OC_TOTAL will be 0. This is because there won't be any people living on that stand.

If every one of the 4 categories is 0, but it is not an open space, it means that the data gathering form is incomplete. In this event, the average of the 0-20yr category for the database is multiplied by 50 to calculate OC1 for the stand. The same method will be used to calculate OC2, OC3 and OC4. The sum of these values will then equal the OC_TOTAL.

If all of the above mentioned is not true (i.e. not all the categories are 0, or this is an open space), then the number of occupants in the 0-20yr category is multiplied by the weight of 50 to calculate OC1. The same method is used for each of the other categories to calculate OC2, OC3 and OC4. The OC_TOTAL is then calculated by the sum of OC1, OC2, OC3 and OC4.

Calculations for the State of Fibres Parameter:

Table 7: Calculations for different aspects of the *state of fibres* parameters

Weight: 6		Occurrence Of Asbestos Contamination In Buildings:					MAX: 18	Normalised
State of Fibres								
Sealed	SFI1	Fixed	SFI2	Loose	SFI3	SFI_TOTAL		
	0	2	12		0	12		0.66666667
	0		0	3	18	18		1.00000000

If the state of the fibres is sealed, it was captured as a 1, or for fixed fibres as a 2 and loose fibres as a 3. This only shows that loose fibres cause a higher risk of exposure than sealed fibres (Table 7).

To calculate the SFI1, the value in the sealed column was multiplied by the weight (6). The same method will be used for the fixed and loose columns as well to calculate SFI2 and SFI3.

An "IF-function" was used to calculate the SFI_TOTAL.

=IF (comments column ="open space",0, (IF(sealed + fixed + loose =0, 1 * WEIGHT of 6 , SFI1 + SFI2 + SFI3)))

If the "form comment" column states that this is an open space, the value will be 0.

If all of the values in SFI1, SFI2 and SFI3 are 0, but this is not an open space, it may be that the form is incomplete, and then the SFI_TOTAL is calculated by multiplying 1 by the weight (6).

If not one of the above mentioned is true (i.e. not all values are 0, or this is an open space), the SFI_TOTAL is calculated by the sum of the SFI1, SFI2 and SFI3.

Calculations for the Condition of Material Parameter:

Table 8: Calculations for different aspects of the *condition of material* parameters

Weight:	3	MAX: 6				
Condition of Material						Normalised
Good	CON1	Poor	CON2	CON_TOTAL		
1	3		0	3		0.50000000
	0	2	6	6		1.00000000

If the condition of the material / building was good, it was captured as a 1 and if it was poor it was captured as a 2. This indicates that if the building is in a poor condition, there is a higher risk of asbestos fibres being exposed to people (Table 8).

The factor 1, in the column if the building is in a good condition, is multiplied by the weight (3) to calculate CON1. The same method will be used by the poor building condition to calculate CON2.

An "IF-function" was used to calculate the CON_TOTAL.

=IF (comments column ="open space",0, (IF(Good + Poor = 0,1 * WEIGHT of 3, CON1 + CON2)))

If the "form comments" column states that it is an open space, the CON_TOTAL will be 0.

If both the columns for the good and poor building conditions are 0, but this is not an open space, the reason can be that the data gathering form is incomplete. The CON_TOTAL will then be calculated by multiplying 1 by the weight.

If not one of the above mentioned is true (i.e. not all values are 0, or this is an open space), it is calculated by the sum of CON1 and CON2.

Calculations for the Part of Building Parameter:

Table 9: Calculations of the different aspects of the *part of building* parameters

Weight:		2		MAX:			6	
Part of Building							Normalised	
Main house	PB1	Extension	PB2	Separate Outbuilding	PB3	PB_TOTAL		
	0		0		0	6	1.00000000	
3	6		0		0	6	1.00000000	

If thlf the building from which the samples were taken was the main house, it was captured as a 3, an extension as a 2 and a separate outbuilding as a 1. Therefore the exposure to asbestos is a higher risk to people if it is in the main house than if it is in a separate outbuilding (Table 9). People are living in the main house and are thus exposed to the fibres for a longer period. To calculate PB1, the factor 3 in the column for the main house is multiplied by the weight (2). The same method was used for the extension and separate outbuilding columns, to calculate PB2 and PB3.

An "IF-function" was used to calculate the PB_TOTAL.

=IF(comments column ="open space",0, (IF(Main house + Extension + Separate Outbuilding =0,3 * WEIGHT of 2, PB1 + PB2 + PB3)))

If the "form comments" column states that this is an open stand, the PB_TOTAL is 0.

If it is not an open space, but all 3 of the columns; for the main house, extension and separate outbuilding are 0, it means that the data gathering form is incomplete. The PB_TOTAL will then be calculated by multiplying 3 by the weight (2).

If none of the above mentioned is true (i.e. not all values are 0, or this is an open space), it is calculated by the sum of PB1, PB2 and PB3.

Calculations for the Land Uses Parameter:

Table 10: Calculations of the different aspects of *land use* parameter

Land Uses:								
Weight:		5				MAX:		750
Residential	LU1	Industrial	LU2	Commercial	LU3	LU_TOTAL		Weighed
	50		30		20	100		Normalised
3	150	0		0	150	750		1.00000000
3	150	0		0	150	750		1.00000000

If the land use was residential it was captured as a 3, industrial as a 2 and commercial as a 1. This shows that if the land use was residential it has a higher risk of exposure of asbestos to people, than a commercial land use. People are on the residential stands for longer periods than on the industrial or commercial stands (Table 10). The residential factor of 3 is multiplied by the weight of 50 to calculate LU1. The same method is used by the industrial and commercial factors to calculate LU2 and LU3. LU_TOTAL is calculated by the sum of LU1, LU2 and LU3.

Calculations for the Streets, Drainage Pattern, Traffic & Wind Factor Parameters:

Table 11: Calculation for the following four parameters: Streets, Drainage pattern, Traffic and Wind factor

Other:											
Weight:		2		Weight:		1		Weight:		3	
MAX:		4		MAX:		2		MAX:		6	
Streets	OR1	Norm.	Drainage	OR2	Norm.	Traffic	OR3	Norm.	Wind	OR4	Norm.
TOT											
2	4	1.00	2	2	1.00	2	6	1.00	1	1	1.00

As stated earlier, because of the fact that the "other" data was not tested or determined in the gathering forms or sampling, it is based on the following assumptions (Table 11):

The streets can either be tar roads, which will then have a factor of 1 captured in the database, or gravel roads which will then have a factor of 2 captured. Gravel roads will have a higher risk of asbestos exposure to people than tar roads, where the fibres are fixed in the material.

For the purposes of this study, the streets were all given a factor of 2. This is based on the fact that the majority of the streets in the study area are gravel (soil) roads.

To calculate the OR1, the 2 in the streets column is multiplied by the weight (2).

The drainage pattern was also not determined by specialists, but the area is not very flat, and the overall area was therefore given a factor of 2. If there was no pattern at all it would have been captured as a 1. Therefore the drainage pattern was taken into account because this can be important in the transfer of loose asbestos fibres on the ground.

The OR2 was calculated by multiplying the 2 in the drainage pattern column with the weight (1).

The traffic is also an important parameter to consider. A detail traffic count was not done for the purposes of this study. A factor of 2 was given to the overall traffic parameter in this area, because the traffic is moderate. If the traffic was very low, it would have been captured as a 1, and if it was very high it would have been captured as a 3. The traffic could increase the risk of exposure to asbestos fibres, as it causes loose fibres to become airborne. OR3 is calculated by multiplying the 2 in the traffic column by the weight (3).

If specialist studies were done for the wind factor, it could have been done for the wind speed as well as the wind direction in this area. A factor of 1 was allocated to this parameter for the purposes of this study.

To calculate the OR4, multiply the factor 1 in the wind factor column by the weight (1).

Calculations for the Quantitative & Qualitative data and the API:

Table 12: Calculations for the total of the quantitative and the qualitative data and API

%	%	MAX:	2.95220082	
75.00000000	25.00000000		100.00000000	API
Quan_Total	Qual_Total		API	Normalised
0.02892242	1.81810897		1.84703139	0.62564558
0.01504204	2.00721154		2.02225358	0.68499865

The sum of the normalised values calculated for each of the parameters of the quantitative data, calculates the total of the quantitative data (Quan_Total), and the sum of the normalised values calculated for each of the parameters of the qualitative data, calculates the total of the qualitative data (Qual_Total) (Table 12).

The API = (Quan_Total) + (Qual_Total)

The maximum of the API is then determined for each of the datasets of this study area, by means of a formula which searches for and returns the highest value of the API field in the database. To calculate the normalised values of the API, the API is divided by the maximum API value in the database, as returned by the previous formula (MAX). The normalised API is therefore all the API's in the database, expressed as a percentage of the highest API in the database (MAX).

It is these values which were imported into the GIS tables.

3.7. GIS Application:

Existing spatial information and electronic copies of the layout of the town were obtained from the local department of the municipality of Prieska. The town layout plans were presented to the Steering Committee of Prieska to validate their correctness and usefulness for the purposes of the study.

Each of the stands on the layouts have a stand number, making it easier to correspond with the sampling and data gathering forms (See Appendix C).

The electronic shape files (.shp) of the stands as well as their stand numbers were converted into ArcView GIS 3.2. From the theme "P.erf.shp", which shows all the stands in the study area, new themes were created. The 4 sub-areas were created into their own polygons. Rooiblok, Ethernbeni, Bontheuwel and the town of Prieska could now be handled separately. Each of the sub-areas will have their own geographic database table. Therefore, each geographic class (layer) is stored as a table.

The geographic database tables which contain stand numbers for each of the sub-areas in ArcView, can be linked with the information in the database imported from Access, for each sub-area.

Tables are joined together using common row/column values or keys as they are known in the database world (Longley. et. al, 2005:222). Database tables can be joined together to create new views of the database. The stand number was used as the unique id, to join the tables.

In this way the quantitative and qualitative data, of each stand in the study area, were joined with the stand numbers in ArcView (spatial component). Following the join, these tables can be treated as a single table for all GIS operations such as query, display and further analysis (Longley. et. al, 2005:222).

Classification of the API into different values:

The API values were classified into different classes, to distinguish between the highest, middle and lowest need for rehabilitation. In ArcView, the classes were defined in the legend editor. The graduated colour was selected as the legend type. The classify option was used to select 3 classes. All of the above mentioned parameters were showed in the classification field, but the API parameter was selected to give a spatial view of the need for rehabilitation. The classification is shown in Table 13.

Table 13: Different colours and value-intervals were selected for each of the different classes.

Need for Rehabilitation	Class Interval	Colour Displayed on GIS
Significant	0.6 - 1	Red
High	0.35 – 0.6	Pink
Medium-Low	0 – 0.35	Orange

Metadata:

Essentially, metadata is data/information about data (Davis, 2001:185; Longley. et. al, 2005:245). Metadata can include many types of information on data. It is important to know this information of the data because it establishes confidence in the data quality for both the producer and user. Metadata provides a common, uniform set of terminology and definitions for the geographic data (Davis, 2001:185).

Metadata typically includes the following (Davis, 2001:185):

- Identification (title, area, date)
- Data quality (sources of information, attribute accuracy and spatial precision)
- Spatial data organization (raster-vector format, location guides)
- Spatial reference (map projections, grid systems, coordinate systems)
- Features and attributes (database content, feature types and description, naming system)
- Distribution (how to obtain data, contacts, available formats)

In this study the spatial precision is not accurate, and specific Global Positioning System (GPS) coordinates were not used. The data was obtained from the local municipality and location guides included street addresses and stand numbers.

The specific metadata needed for this study are presented in table 14.

Table 14: Specific metadata for the GIS maps included the following:

Figure	13	14	15	16	17
Title	Layout of the API for Rooiblok.	Layout of the API for Ethembeni.	Layout of the API for Bontheuvel.	Layout of the API for Prieska Town.	Layout of the overview for the API in the study area.
Area	The town of Prieska and the surrounding townships.	The town of Prieska and the surrounding townships.	The town of Prieska and the surrounding townships.	The town of Prieska and the surrounding townships.	The town of Prieska and the surrounding townships.
Date	07/11/2006	08/11/2006	09/11/2006	10/11/2006	13/11/2006
Geometry	Polygon	Polygon	Polygon	Polygon	Polygon
Projection	WGS84	WGS84	WGS84	WGS84	WGS84
Features and attributes	The fields and attributes in the columns have names, which were already explained under the methodology. The database content and meaning thereof, are discussed further in the results under point 4.2.				

Chapter 4: Results

The study area was divided into 4 sub-areas, to make data gathering and sampling easy and to distinguish between the different parts of the Prieska area, when calculating the API. The areas are: the Prieska town with 1007 stands, Bontheuwel with 900 stands, Ethembeni with 781 stands and Rooiblok with 547 stands. A total of 3235 stands were sampled during this study.

4.1. Laboratory Asbestos-content Results

See Appendix C for the database which contains all the results and information on the data gathering forms for each stand in the different areas.

Table 15 shows that in Rooiblok a total of 1658 samples were analysed, in Bontheuwel 2257 samples, in Ethembeni 2477 samples and in the Prieska Town 2617 samples.

Table 15: Summary of the total amount of 9009 samples analysed and received from the lab.

Residential Area	Number of samples
Rooiblok	1658
Bontheuwel	2257
Ethembeni	2477
Prieska Town	2617
TOTAL	<u>9009</u>

4.2. Information illustrated in GIS (different attributes and fields in the columns.)

For each of the sub-areas, in ArcView, a table was generated, which contains the information for each stand in that specific sub-area. The type of information that will be illustrated in the GIS is shown by the following 3 tables. If you click for example, on the stand number, "1609" in the Rooiblok view (in ArcView) the following information for that specific stand can be observed (These GIS-tables

are also part of Appendix C, which shows the information of all the stands in the different sub-areas):

Table 1 of 3:

Tu	API	Quan_Total	Qual_Total	P_%Fibres	G_%Fibres	S_%Fibres	C_%Fibres
1609	0.6256	0.0289	1.8181	0.0000	0.0122	0.0000	1.1481
1610	0.6849	0.0150	2.0072	0.0000	0.0262	0.0000	0.3746

The TU-value is the Stand number.

Asbestos Prioritisation Index (API)

= 0.62564558

The total of the quantitative data (Quan_Total)

= 0.02892242

The total of the qualitative data (Qual_Total)

= 1.81810897

The percentage of asbestos fibres in the ceiling (P_%Fibres)

= 0.00000000

The percentage of asbestos fibres in the soil (G_%Fibres)

= 0.01222905

The percentage of asbestos fibres in the bricks (S_%Fibres)

= 0.00000000

The percentage of asbestos fibres in the cement (C_%Fibres)

= 1.14818743

Table 2 of 3:

OCC_0-20yr	OCC_21-40yr	OCC_41-60yr	OCC_>60yr
1	3	0	0
0	1	0	1

The number of occupants between 0-20yr (OCC_0-20yr)

= 1

The number of occupants between 0-20yr (OCC_21-40yr)

= 3

The number of occupants between 0-20yr (OCC_41-60yr)

= 0

The number of occupants between 0-20yr (OCC_>60yr)

= 0

Table 3 of 3:

State_of_Fibres	Condition_of_Building	Part_of_Building	Land_Use
fixed	good	main house	residential
loose	poor	main house	residential

The state of the fibres (State_of_Fibres)

= fixed

The condition of the building (Condition_of_Building)

= good

The part of the building where the samples were taken from (Part_of_Building)

= main house

The land use of that specific stand (Land_Use)

= residential

The figures that follow are to graphically show the API of the 4 sub-areas. They are not cartographically correct and are for illustration purposes only.

Figure 13: Distribution of the API values in Rooiblok

API of Rooiblok

□ Prieska Stands
Rooiblok API

0 - 0.35
0.35 - 0.6
0.6 - 1



0 1 2 Kilometers

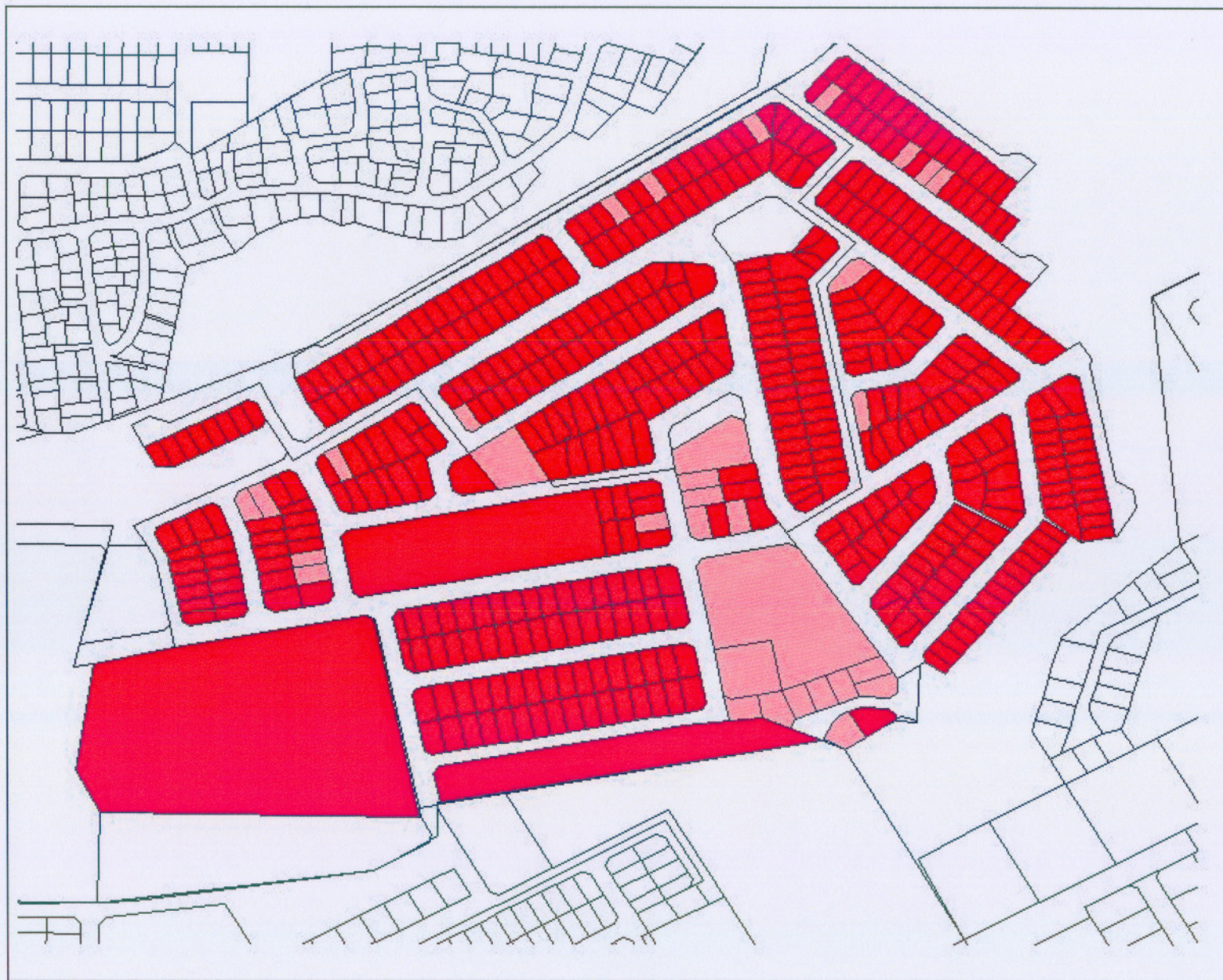
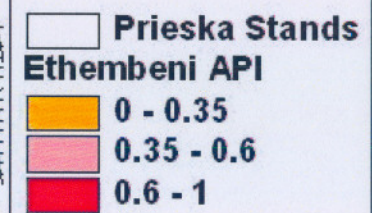


Figure 14: Distribution of the API values in Ethembeni

API of Ethembeni



0 1 2 Kilometers

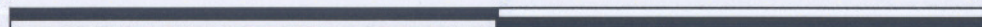
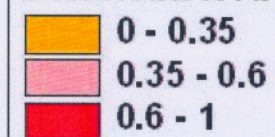


Figure 15: Distribution of the API values in Bontheuwei

API of Bontheuwel

□ Prieska Stands
Bontheuwel API



0 1 2 Kilometers

A horizontal scale bar with markings at 0, 1, and 2 Kilometers. The bar is black with white tick marks.

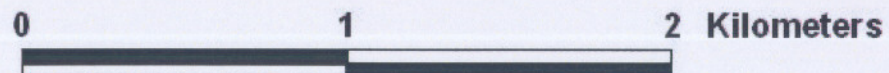
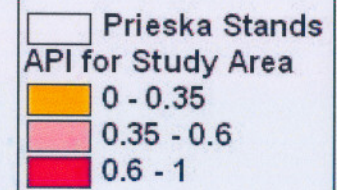
Figure 16: Distribution of the API values in the Prieska Town

API of Prieska Town



Figure 17: Distribution of the API values in the study area

Overview of API for Study Area



Chapter 5: Discussion

5.1. *The database:*

Matching the data sources, which includes the data gathering forms and the tables containing the results from the laboratory, with the locations which it represents, needed special attention. Quantitative data was obtained by an analytical procedure from the laboratory, and special care had to be taken to ensure that the correct values for each specific site were accommodated. The qualitative data was obtained from the data captured by the fieldworkers, on the data gathering forms. Care had to be taken in ensuring the validity of the qualitative data accompanying the quantitative data.

Assumptions, in the case of the qualitative data, are an aspect that needs to be tested in order to ensure mutual acceptability.

In some cases, there are still stands which lack certain qualitative data. The reason for this can be because of the fact that the specific stand did not have a building/house on it, and was an open field (called an "open space" in the database), otherwise the data gathering form may have been incomplete. Thus the number of occupants, condition of the building and other data concerning the building on the stand, could not be captured. In these cases only a soil sample was taken on that stand. The if-functions, as discussed previously, accommodated these types of data in the database.

Some of the larger areas on the maps will show as a residential land use in the database, although it is larger than all of the surrounding stands and looks like an open field. This is because of the fact that there were a few new houses built on that area, but it is not yet captured in the municipality's records. The fieldworkers did take samples at each of these houses. All of these houses were actually on the same stand, they all have the same stand number, but were distinguished by adding an A, B or C to their stand number. In the database, and for purposes of joining with the ArcView tables, this could not work. For all of these houses, averages of the percentage of fibres in each of the samples were calculated for the quantitative data. The worst case scenario was captured for the qualitative data from the data gathering forms, for example if the one form says that the building is in a poor condition, and the other one says that its in a good condition,

the poor condition was captured. Thus, only 1 input for that specific stand number will be seen for each of the parameters.

In some other cases there was 1 house covering an area of 2 stands. In these cases there was only 1 set of samples (at the 1 house), but two data gathering forms for each of the stands. The same quantitative data was captured for both of the stands.

5.2. Maps:

The following maps were generated from the information captured in the database, in order to illustrate the API of every sub-area. The specific stand number can be obtained from Appendix B, which shows the Computer Aided Design (CAD) drawings of each sub-area. The following discussions for each map were made in conjunction with the information in the GIS tables:

5.2.1. Map of the API in Rooiblok (Figure 13)

More than 50% of the stands were in the class between 0.6 -1.0; these stands carry the highest API. No stands were in the class between 0 - 0.35.

The stands in the class between 0.35 - 0.6 are open fields (commercial land use). There are no people living on these stands and therefore no houses, so only soil samples were taken on these stands. The API will be lower because there are no people directly exposed to asbestos fibres. When there were no fibres extracted in the 3 samples (Soil, Cement and Brick), the API will be lower on that stand because the value of the quantitative data will be 0.

Most of the stands in the Rooiblok sub-area are in the highest class for the API. This indicates that most of the stands in Rooiblok are very highly contaminated and the need for rehabilitation of this sub-area is very significant. The stands that were in the middle class for the API were mostly open fields or were cases where the samples did not contain any asbestos fibres, and a small minority were because the building was in a good condition, and the bricks were sealed or plastered.

5.2.2. Map of the API in Ethembeni (Figure 14)

More than 50% of the stands in Ethembeni were in the class between 0.6 – 1, and therefore carry the highest API. There were no stands in the class between 0 – 0.35, which would indicate the lowest API.

All of the stands in the class between 0.35 – 0.6 were open spaces, except for one or two stands, where there weren't any asbestos fibres extracted in the initial samples taken at the specific stands.

The open spaces carry the lowest API in this sub-area. But the rest of the area, which is residential, carries a high API. The need for rehabilitation of this area is very high.

5.2.3. Map of the API in Bontheuwel (Figure 15)

More than 50% of the stands in Bontheuwel were in the class between 0 – 0.35, which carries the lowest API. These stands are open spaces, and therefore only soil samples were taken at these stands. During the analyses no asbestos fibres were extracted from some of these soil samples.

Only a few stands were in the class between 0.35 – 0.6. Some of these stands were open spaces, and on some of the other stands no asbestos fibres were extracted from any of the samples. In other cases the asbestos fibres were fixed and the building was in a good condition. Stands with incomplete data gathering forms also occurred in this class. Where the data gathering forms were incomplete, the average value for that specific parameter in the sub-area was used.

The few, remaining stands were in the class between 0.6 – 1. These stands carry the highest API, because the soil contained an average of 0.005 % (of the initial soil sample) of asbestos fibres, there were an average of 4 children living on that specific stand and/or the building was in a poor condition.

5.2.4. Map of the API in the Prieska town (Figure 16)

Most of the stands in the town of Prieska were in the class between 0.6 – 1, and therefore carry the highest API. No stands were in the class between 0 – 0.35, which carries the lowest API. A few stands were in the class between 0.35 – 0.6 and these were all open spaces.

Because of the method used, by taking the worst case scenario when the data gathering form is incomplete, the town of Prieska showed a very high need for rehabilitation. Many of the owners of the buildings in the town did not want the fieldworkers to take samples from their buildings or to enter their yard. There was therefore no quantitative data for those specific stands, except in the cases where the owner let the fieldworkers take soil samples and/or samples from the ceilings. Another reason for the town's API being so high, is that all of the buildings had ceilings which could accumulate fibres, even though it is a very small percentage.

5.3. Comparison of the percentage asbestos fibres for each sub-area:

Figure 18, is a good indication of the percentage of fibres in the different samples at each sub-area. It can be discussed by comparing the fibres in the samples for each sub-area, as well as comparing the different sub-areas with each other.

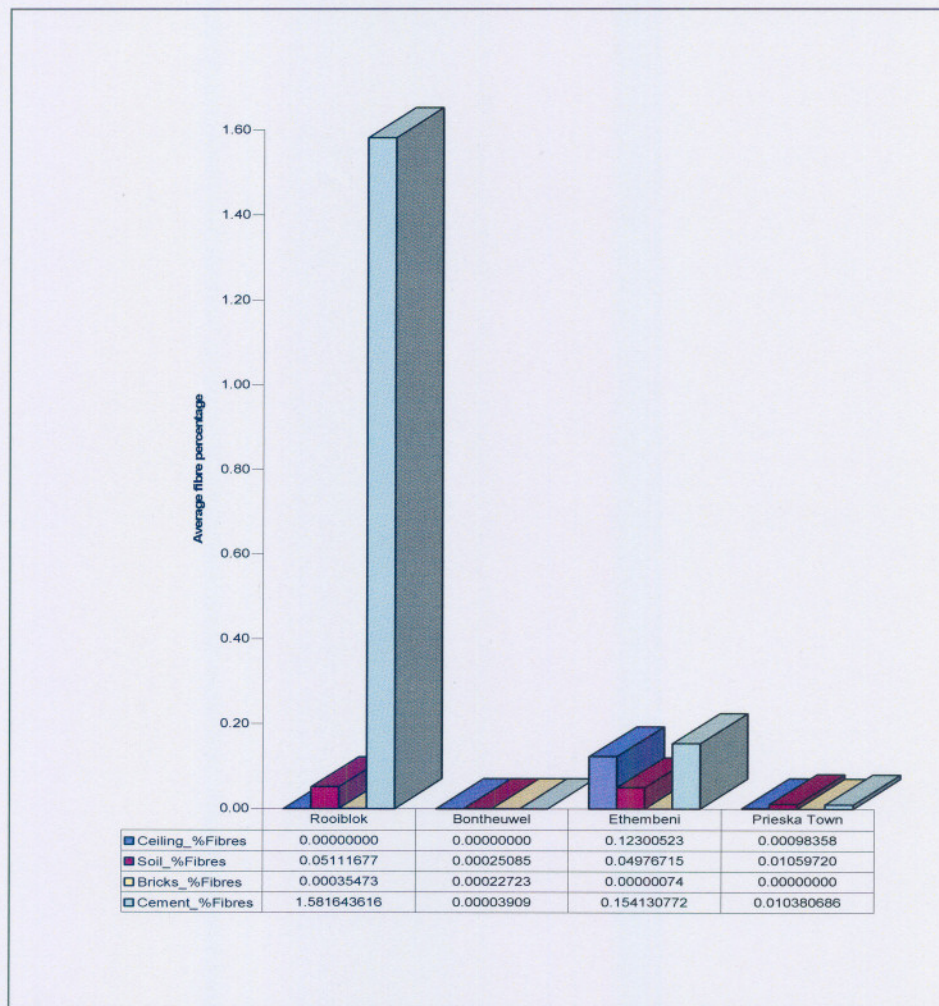


Figure 18: Comparison of the percentage asbestos fibres for each sub-area.

In Rooiblok the order of samples containing the most fibres to the samples containing the least fibres, were cement, soil, bricks and ceiling. The buildings in Rooiblok did not have any ceilings, and therefore no ceiling (P) samples were taken. An assumption can be made that the building material in this area is highly contaminated and that the reason for this is that asbestos fibres were commonly used in the cement mixtures. The general state of fibres is loose and most buildings are in a poor condition, therefore special attention will need to be given to this area when considering the need for rehabilitation. The soil is also highly contaminated, and when considering rehabilitation, this needs to be taken into account.

In Bontheuwel the order of samples containing the most to the least fibres were cement, soil, bricks and the ceiling. Like Rooiblok, the buildings in Bontheuwel didn't have any ceilings either, and therefore no samples were taken for the ceilings. The same assumption can be made concerning the contaminated building material. The average asbestos fibres in this area were, however, very low.

In Ethembeni the cement samples had the most fibres and then the ceiling and soil samples. The samples with the least fibres were the bricks. In Ethembeni, the building material is a very big concern as with the other areas, and the state of fibres is mainly loose, and the condition of the buildings is generally poor. The ceilings were also highly contaminated, and are a very big risk of exposure to the people living or working in those buildings.

In the town of Prieska the most asbestos fibres were extracted from the soil samples, and then the cement and ceilings. The bricks did not have any fibres. An assumption can be made that the majority of these buildings are newly built and asbestos fibres were not commonly been used in the building material. Most of the houses in the town are in a good condition and the fibres are mostly sealed. The fact that the soil in the town is the most contaminated with asbestos fibres may mean that the people are exposed especially when they are outside their homes.

When comparing the different sub areas, the following conclusions can be made: For the average percentage of asbestos fibres in the cement and soil, Rooiblok had the most asbestos fibres, then Ethembeni with Bontheuwel having the least. For the brick's samples, the most asbestos fibres were in Rooiblok and the least in the town of Prieska. For the ceiling's samples the most asbestos fibres were in Ethembeni, and the least in Rooiblok and Bontheuwel where there were no ceilings.

The visual data in the data gathering form, such as the state of fibres or condition of buildings, is very important. The quantitative data would not be sufficient enough to calculate the API for each stand in the different sub-areas. The results from the laboratory show for some of the stands, that there were no asbestos fibres in those samples, but on the data gathering form, the 'state of fibres' column shows that the fibres are loose. It is important to note that it is actually the finer (invisible) fibres that create the biggest risk of exposure to asbestos related

diseases. It is however also important to know that there were actually fibres on that stand, even though it was not extracted in the specific samples collected.

5.4. The relation between the API and risk to citizens of Prieska

In figure 19, for the 'Frequency weight number', all 3 of the API classes were in the number 7 column, because these exposures to asbestos fibres are frequent. The highest class of the API (red) can be observed by the number 14, as illustrated in the matrix. This class has the highest API because it was illustrated that it has the highest hazard description, effect on the community and legal impacts. The middle class of the API (pink) can be observed by the number 12, as illustrated in the matrix. Although it does not have the highest API, it still has a critical hazard description, high effects on the community and legal impacts. The lowest class of the API (orange) can be observed by the number 10, as illustrated in the matrix. It has the lowest API, but the hazard description is medium and still has an effect on the community, and has legal impacts.

The risk matrix therefore shows an overall unacceptably high risk for the API in the study area.

RISK MATRIX							Severity weight	Hazard description	Effects on community	Hygiene effects	Legal impact
8	9	10	11	12	13	14	7	Case business	More than 10 fatalities	More than 100 fatalities	Cease business
7	8	9	10	11	12	13	6	Catastrophic	More than 1 fatality	More than 10 fatalities	Loose plant operating permit
6	7	8	9	10	11	12	5	Very critical	One fatality	More than 1 fatality	May loose plant operating permit provisionally
5	6	7	8	9	10	11	4	Critical	Hospitalisation	One fatality or permanent incapacity	Severe Legal fines
4	5	6	7	8	9	10	3	Medium	Complaints	Reversible incapacity health effects	Legal fines
3	4	5	6	7	8	9	2	Minimal	none	Minimal health effects. Recover in few days.	Reportable incident
2	3	4	5	6	7	8	1	Insignificant	none	Low health effect - recover within hours	none
1	2	3	4	5	6	7	Frequency weight number				
Expected never to happen	Highly unlikely	Not during lifetime of plant	Once in plant lifetime	Once in 10 years	Once per year	More than once a year. Frequently	Frequency for: safety, environment, emergency management				
1/100 000 years	1/10 000 years	1/1000 years	1/100 years	1/10 year	1/year	10/year	Frequency for: safety, environment, emergency management				
Expected never to happen	Highly unlikely	Not during lifetime of plant	Once in 100 years	Once in 10 years	Once per year	Once per week, shift or permanent	Frequency for hygiene				

Figure 19: A typical Risk Matrix as widely used in industry (Van der Walt 2006, pers.comm).

Chapter 6: Conclusion & Recommendations

The issue around asbestos and asbestos related diseases is a very sensitive topic in the Prieska community. Today, they know that they are still living and working in an asbestos contaminated area. What makes it worse is that they now know what the effects of asbestos are, and how it can impact on them and their children.

Redco informed the Prieska community about the intended sampling and data gathering procedures before work commenced. It was done by publishing an article in the local newspaper ("Die Oewernuus") and by distributing pamphlets at large institutions like the schools and businesses. The pamphlets were also delivered to every house where sampling and data gathering was done. The fieldworkers carried a small leaflet with them, to hand out if any resident should have any questions about the sampling. It is clear that public participation and notification were considered and taken into account, to ensure that the people in Prieska and the surrounding townships were aware of this study, and to make them realise that their support during the study would be appreciated and would be to their own benefit.

The current risk of asbestos exposure to the citizens of the Prieska area in the Northern Cape Province of South Africa is determined to be very significant.

The answers to the sub-questions were determined as follows:

a. What are the exact levels of asbestos contamination?

The results of the quantitative data was received from the analysis of the percentage asbestos fibres in each of the samples collected at the stands in the study area. These results give an indication of the levels of asbestos contamination in the Prieska area. In the town of Prieska it was clear that the level of asbestos contamination in the bricks were none. Thus, no brick sample in the town contained any asbestos fibres. In Rooiblok it was evident that the level of asbestos contamination in the cement was very high.

The exact levels could, however, not be determined because sampling was only done in the buildings and soil on each stand in the study area. The surrounding environment and other infrastructure may however also be contaminated. This method may be seen as a tool to determine asbestos

contamination, but can not be seen as the only way or method to calculate these levels.

b. How big is the risk of exposure due to asbestos contamination of the environment in Prieska?

The risk of exposure was determined by the qualitative data on the data gathering forms. In Rooiblok it was clear that the buildings were in a poor condition, thus the risk of exposure to asbestos contamination is very high, whereas the buildings in the town of Prieska were in a good condition and therefore have a lower risk of exposure. Most of the fibres in Ethembeni and Bontheuwel were fixed and therefore the risk of exposure to asbestos contamination is lower in these sub-areas. The Risk Matrix (Figure 19), as previously discussed, also gives a good indication of how big the risk of exposure due to asbestos contamination, is.

c. Can the need for rehabilitation be prioritised?

The need for rehabilitation was prioritised by using the Asbestos Prioritising Index (API). The visual priority for rehabilitation of the stands in each sub-area is clear on the GIS. The GIS helps in comparing the different sub-areas, as well as each stand with each other. This makes it possible to see where the most contamination of asbestos occurred, and gives an indication of the areas which more urgently require rehabilitation, and areas which are less urgent. The API is available for each of the residential areas separately, but an API can also be seen for the whole Prieska area.

In Rooiblok, the majority of the sub-area has a very high need for rehabilitation. In Ethembeni and the town of Prieska the need for rehabilitation is also high. Bontheuwel was the only sub-area with a low need for rehabilitation. The reason for this was that the majority of the sub-area is open fields or ground with no buildings on it. There are therefore not people directly exposed to asbestos contamination, except when they walk across the sites.

Although the mill site has already been rehabilitated, it was evident during the site visit in February 2006 that the previous rehabilitation effort was unsuccessful, because the cover material was eroded by rain, and the asbestos fibres were exposed to the surface. This type of secondary pollution in the environment of

Prieska, together with the fact that this study shows us that the houses and other buildings in Prieska are still very much contaminated, causes a significant risk of asbestos exposure to the citizens of the Prieska area. The Asbestos Rehabilitation Index will help with the future planning of rehabilitation in this area, and in so doing, eliminate the health risks caused by the asbestos contamination.

Recommendations

- For the data gathering process and collection of samples, independent fieldworkers may be a better option. For this study, the fieldworkers were not independent and a risk may exist that they could manipulate the qualitative data in a way to suit their needs. In this case, they may try to make it look worse than it really is, because they want this area to have a high API so that it can be rehabilitated. The risk is however not significant, since the fieldworkers do not have a detailed knowledge of the methodology used to calculate the API.
- The data gathering forms make provision for more detail, which was not used for the purposes of this study. The supervisor should make sure that all of the data on the forms is filled in, for example the date of construction of that specific building. This information could be very important for making a conclusion when discussing the results of the API.
- The supervisor should ensure that all the stands in each sub-area were sampled, and that the data gathering forms for each stand is fully completed.
- The following parameters need to be determined by specialist studies: the streets, drainage patterns, traffic, and a wind factor.
- The database can make provision for more scenarios, and more embedded *if-functions* can be used, when calculating the totals for each parameter. It may not be appropriate to use the worst case scenario for a specific parameter, when the data gathering form is incomplete, because in the case of the town of Prieska, the surrounding buildings were actually in a good condition, but that is not what was reflected in the API.

For further studies:

- *Identify the suitable rehabilitation and maintenance methodology for this study area:*

A suitable rehabilitation and/or maintenance solution for each contaminated area and building location should be proposed. This will largely depend on the nature of each site (whether it is a building or an open field). Alternative approaches should be included, in the event of less severely contaminated stands.

An important aspect of the model developed above is that it should be able to serve as a management system, to monitor the risk areas and manage the rehabilitation programme as it progresses.

Rehabilitation and Maintenance

The rehabilitation and maintenance proposals should take into consideration the fact that the buildings are in most cases, occupied by residents. The following aspects may form part of the proposals (As recommended by Redco-services):

- Cleaning the buildings by approved methods.
 - Cleaning the surrounding yard by approved methods.
 - Fixing asbestos fibres by plastering the buildings or repairing concrete and cement works.
 - Seal the fibres by painting or other method.
 - Remove and replace asbestos cement products that are very weathered.
 - Relocate the residents and demolish the buildings that are structurally unsound. This will only be considered in extreme cases of high exposure risks.
-
- *Similarly, further studies should be undertaken regarding measures to curb the potential of asbestos pollution from the roads, stands and asbestos dumps in the surrounding environment.*

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Appendix A

EXAMPLE OF DATA GATHERING FORM

An Audit of the Asbestos Contaminated Buildings in the Northern Cape Province

DATA GATHERING FORM

no

Complete the information in the spaces provided or mark ☒ the applicable option.

Municipality:			Suburb/Area:		
Stand no.:		Street name:			Street no:
Name of owner:				Date of Construction:	
Occupants:	Age distribution:	0-20yr	21-40yr	40-60yr	>60yr

OCCURRENCE OF ASBESTOS CONTAMINATION IN BUILDINGS

Position	None	Degree / Occurrence (Mark ☒)		State of Fibres (Mark ☒)			Condition of Material (☒)	
		Isolated	General	Sealed	Fixed	Loose	Good	Poor
Foundation / Filling	NO	Isolated	General	Sealed	Fixed	Loose	Good	Poor
Bricks	NO	One wall	All walls	Sealed	Fixed	Loose	Good	Poor
Mortar	NO	One wall	All walls	Sealed	Fixed	Loose	Good	Poor
Plaster	NO	One wall	All walls	Sealed	Fixed	Loose	Good	Poor
		Inside	Outside					
Ceiling (Loose fibre)	NO	YES					Good	Poor
Yard	NO	Isolated	General					
Part of building	Original / Main house		Extension		Separate Outbuilding			
Comments:							Could not verify: Sealed / Good	

PRE-FABRICATED ASBESTOS CONTAINING BUILDING PRODUCTS

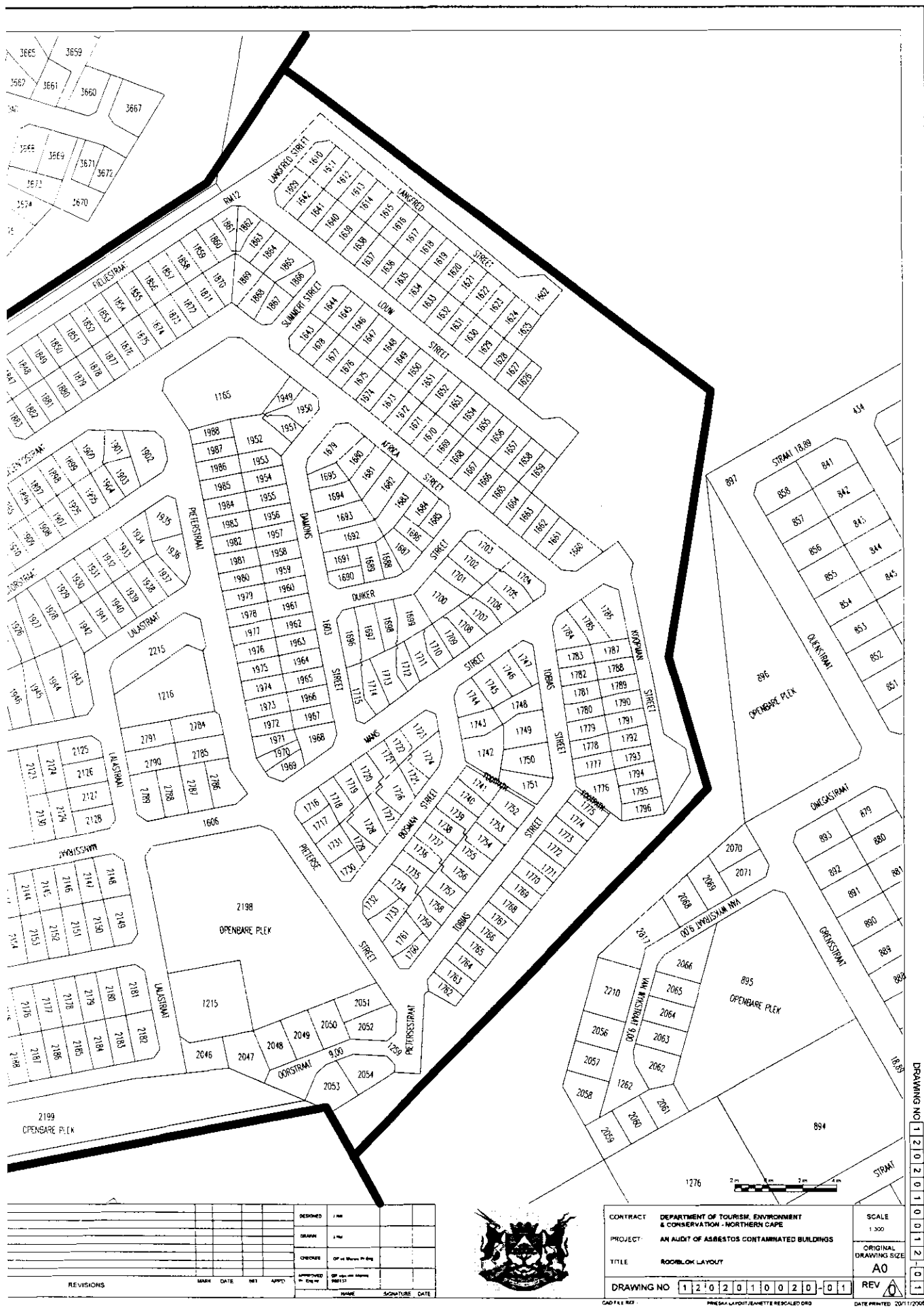
Product			Condition		
Roof sheets	Fascias	Pipes	Solid / Good	Weathered	Sealed
Comments:					

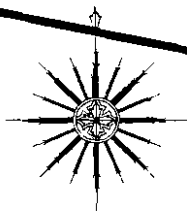
Soil samples:	Material samples:	Air samples:
---------------	-------------------	--------------

Owner Signature:			
Name of Evaluator:		Date of Evaluation:	

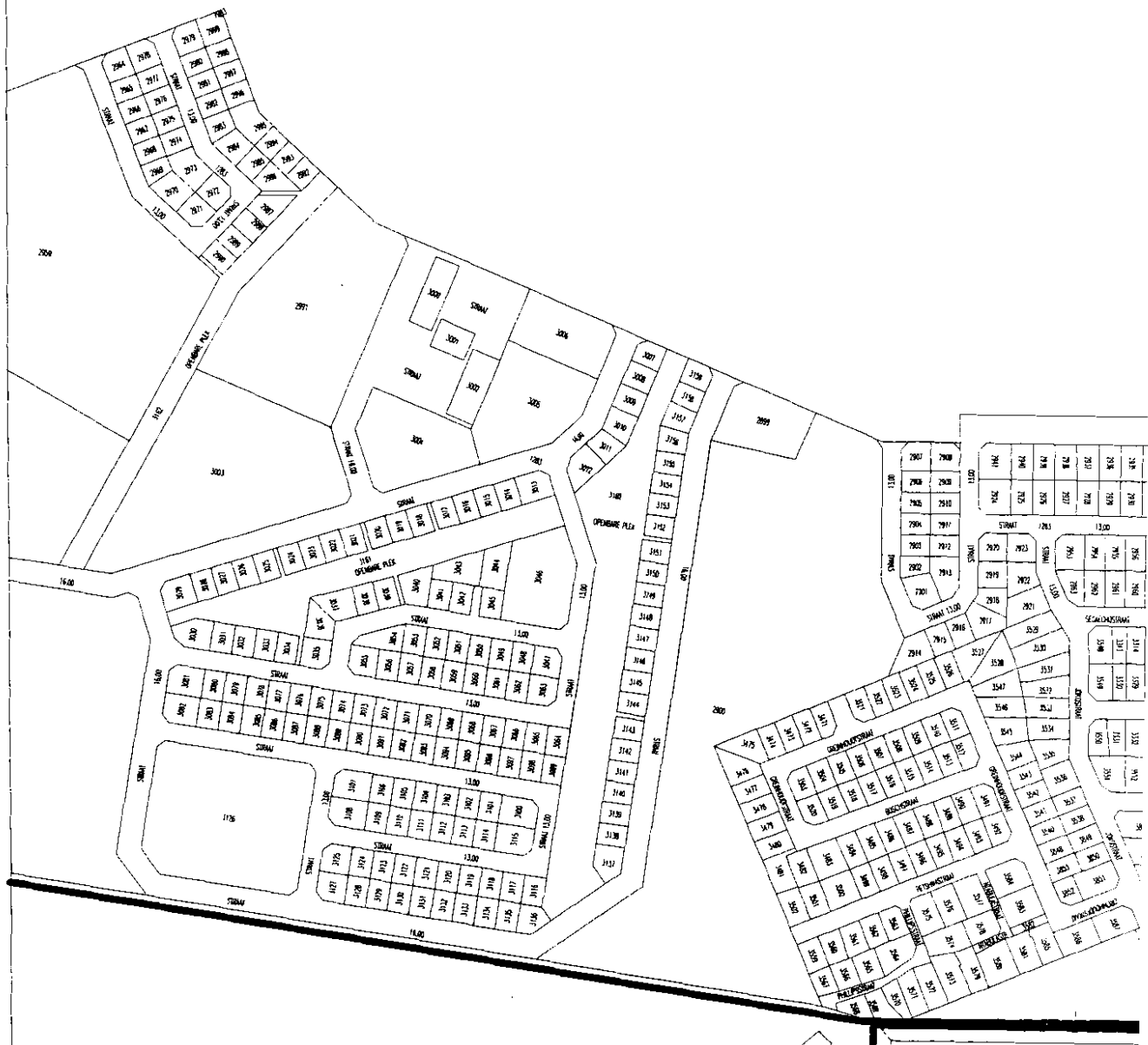
Appendix B

SELF-COMPILED CAD-DRAWINGS OF THE 4 SUB-AREAS IN THE STUDY AREA





1282



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45 Samora Avenue, Harare 1022
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Rehabilitation, Design & Construction Services (Pty) Ltd

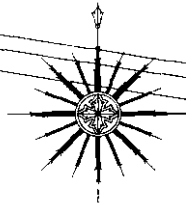
SURVEYOR	Surveyor General
COORDINATE SYSTEM	WGS84 / UTM
CONSTANT	1
BENCHMARK DESCRIPTION	1

ROOIBLOK LAYOUT	12/02/2013/020-01	RE
ETHEMBENI LAYOUT	12/02/2013/020-02	RE
SOUTHEWEL LAYOUT	12/02/2013/020-03	RE
WATERSKA TOWN LAYOUT	12/02/2013/020-04	RE

SURVEY DATA

TITLE	REFERENCE DRAWINGS	DAC NO
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CAD FILE REF: PRESTA LAYOUT JEANETTE RESEALED DRD DATE PRINTED: 30/11/2000



NO. 101, 101A, 101B, 101C, 101D, 101E, 101F, 101G, 101H, 101I, 101J, 101K, 101L, 101M, 101N, 101O, 101P, 101Q, 101R, 101S, 101T, 101U, 101V, 101W, 101X, 101Y, 101Z, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.



SURVEYOR	Surveyor General	PROJECT NO.	1000/000	BLOCK LAYOUT	12/02/01/0000 - 01	REV 1
COORDINATE SYSTEM	WGS84 / UTM	SCALE	1:1000	ETHEMBENI LAYOUT	12/02/01/0000 - 02	REV 2
BENCHMARK DESCRIPTION	Y 0.00	X 1.000 000		PHEKKA TOWN LAYOUT	12/02/01/0000 - 03	
					12/02/01/0000 - 04	
SURVEY DATA				REFERENCE DRAWINGS	Dwg No.	DETAK

[illegible]

[illegible]

CONTRACT	DEPARTMENT OF TOURISM, ENVIRONMENT AND CONSERVATION - NORTHERN CAPE	SCALE: 1:500
PROJECT	AN AUDIT OF ASBESTOS CONTAMINATED BUILDINGS	ORIGINAL DRAWING SIZE
TITLE	PRIESKA TOWN LAYOUT	REV
DRAWING NO	1 2 0 2 0 1 0 0 2 0 - 0 4	A0
CAD FILE REF:	PRIESKA LAYOUT.ASBESTOS RECALC.DWG	DATE PRINTED: 28/11/2006



DRAWING NO	1	2	0	2	0	1	0	0	2	0	-	0	4	2
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REV

Appendix C

CD- DATABASE FOR THE 4 SUB-AREAS IN THE STUDY AREA