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A REPORT ON AN INVESTIGATION OF ENVIRONMENTAL – HEALTH RISKS FOR DEVELOPING LOW – TO – MODERATE INCOME HOUSING ON THE CITY OF JOHANNESBURG'S SOUTH FORMER MINING SITES ALONG THE MAIN REEF ROAD

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'A thesis submitted to the Faculty of Engineering and the built Environment, university of The Witwatersrand, Johannesburg, in fulfillment of the requirements for the degree of Master of Science in Development Planning.'

Declaration

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Master of Science in Development planning in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

_____

(Signature of candidate)

_____day of_____year_____

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Abstract

This research focuses on developing former mining sites situated in the south of the City of Johannesburg that are contaminated with radon gas. This well-located land would be suitable for development of houses for low – to – moderate-income earners, preferably those living +10km away from the city centre. Former mining land has been developed in other countries both in Europe and in America. The results from international experience shows that houses had been developed on sites contaminated with radon and people had lived longer than 35 years without contracting lung cancer. The literature reviewed reveals that radon is the world's second greatest cause of lung cancer after cigarette smoke. There are local and international norms and standards that development of land contaminated with radon should adhere too. In South Africa, the National Nuclear Regulator (NNR) sets the norms and standards for development of land contaminated with radon in which compliance with international norms and standards has been predetermined. Utilisation of the former mining land south of the City of Johannesburg will reduce development of houses at the periphery and will bring people closer to employment opportunities, amenities, transportation, services and facilities required for sustainable housing environment. Radon-contaminated land was visited, and surveys were administered to get different opinions from people who are close to mine dumps and those who are far from the Central Business District. The results show that people are interested and prepared to take the risk of living in areas contaminated with radon. The City of Johannesburg's former mining land should therefore be considered to meet the goals of housing units. Therefore, former mining land should in future be developed for

housing purposes, provided approval has been granted by the relevant government departments.

Acknowledgments

I would like to thank Dr Aly Karam (Development Planning Postgraduate Coordinator at the University of the Witwatersrand) for the direction he gave to this investigation; Professor Robert Simons (Cleveland State University) for introducing the subject and for guiding the investigation through to the final point; Hlengani Baloyi and the 2005 Policy Analysis class for their help in data collection. Also, special thanks goes to Dr. Alex Tsela from the National Nuclear Regulator for his assurance that the land in question could be developed for housing purposes, and Richard Bennet for giving permission and transportation to observe the land and the entire area.

Dedication

A special dedication goes to the late Nomathembiso Johanna Mbokane (my grandmother) who passed away on 26 May 2006. She was both father and mother to me, showing me the way and continuing to monitor the progress I was making. She was everything to me, I could not pay her back for raising me, and now she is no more. This is the only way I could show my appreciation for the good work she has done for me.

List of Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
ANC	African National Congress
ATSDR	Agency for Toxic Substances and Disease Registry
Bq	Becquerel
CBD	Central Business District
CoJ	City of Johannesburg
CV	Contingent Valuation Survey
DNA	Deoxyribonucleic Acid
EAP	Environmental Protection Agency
EMF	Environmental Management Framework
GDACE	Gauteng Department pf Agriculture, Conservation and Environment
HIV	Human Immunodeficiency Virus
IDP	Integrated Development Plan
NIMBY	Not-In-My-Back-Yard
NNR	National Nuclear Regulator
NP	National Party
pCi/L	PicoCuries per liter
RDP	Redistribution and Development Programme
SDF	Spatial Development Framework
SEA	Strategic Environment Assessment
TB	Tuberculosis
TV	Television

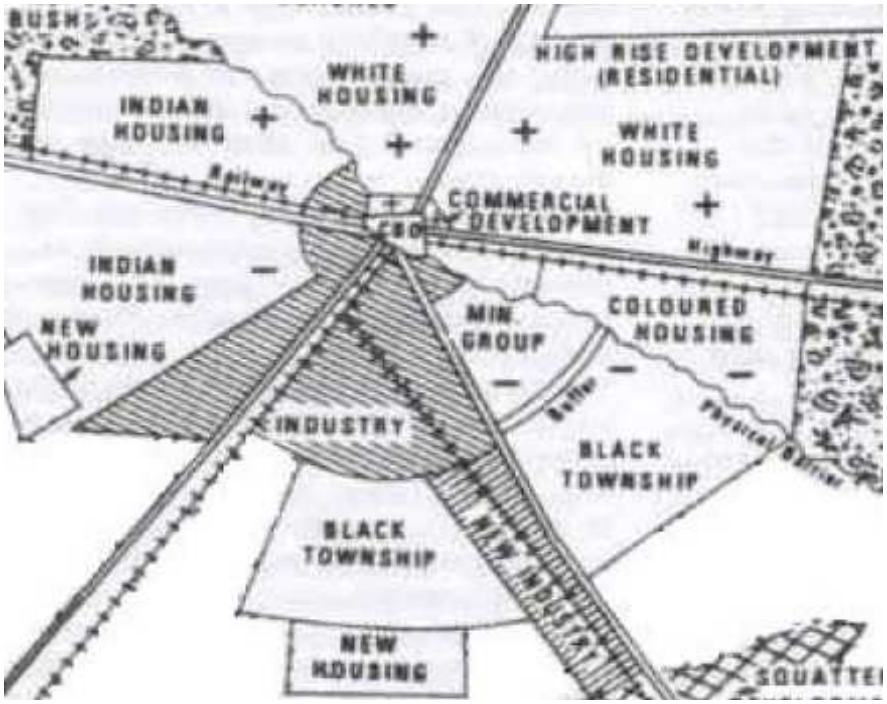
UK	United Kingdom
US	United States
USA	United States of America
WHO	World Health Organisation

Chapter 1

Background

In 1948, the National Party (NP) gained political power and was faced with the task of reconstructing and recreating migrant labour. The NP's task was to sort and control cheap labour as well as putting it into an area where it was suitable (Soni, 1992:40). This operation had led to the drafting and proclamation of the Group Areas Act No. 41 1950. The Act made provision for racially-defined settlements through the formation of buffer zones and walls to create racial barriers between Whites, Indians, Coloureds and Blacks. Map 1.1 illustrates what the apartheid city looked like where Blacks, Indians and Coloureds were forced to live far from the city. This resulted in segregation and economical instability within the country and cities. The 1994 elections marked a turning point for South Africans who had been oppressed by the apartheid legislation.

The ANC-led government that took over from the National Party government (1994) found a huge housing backlog. This backlog was created by the



Map 1.1 The Apartheid City
Source: Cheetham, 2001

apartheid legislation and planning that introduced compulsory removal of Blacks, Indians and Colourds to be relocated close to industrial areas (Cheetham, 2001; Smith, 2003). According to Parnell (1992), there was an oversupply of housing to white people during apartheid, while Blacks lived in informal shack settlements. The budget on housing provision had favoured whites over Blacks, Indians and Coloureds. These are the facts behind the existing housing backlog in South Africa.

In its attempt to reduce the housing backlog, the ANC-led government developed 1.6 million Reconstruction and Development Programme (RDP) houses countrywide. Some of these houses were developed in the CoJ (City of Johannesburg) with the challenge of area location. According to the Gauteng Housing Annual Report for 2001/2002, most houses built contributed too little to overcome the legacy of the apartheid city.

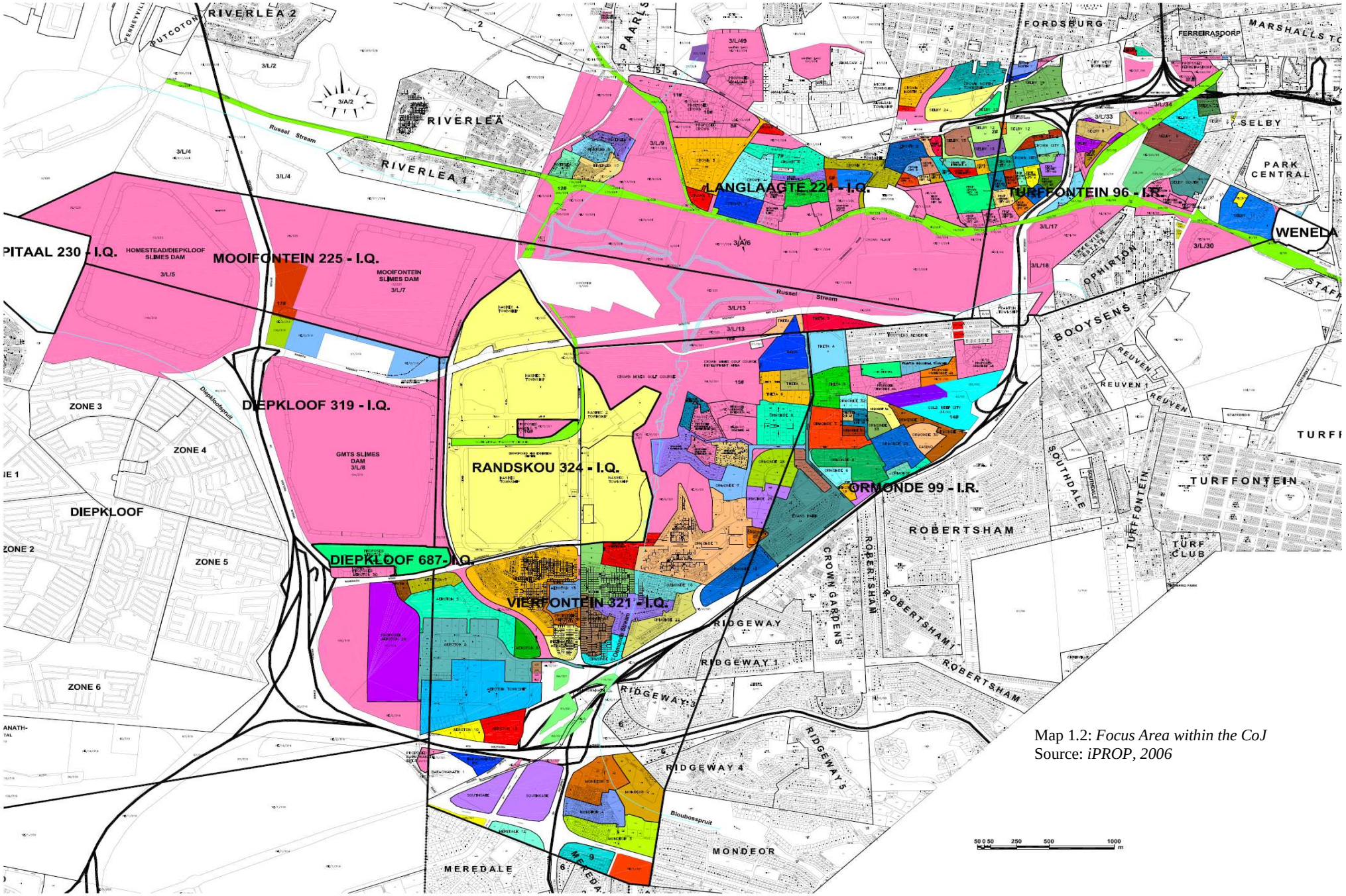
According to the CoJ Spatial Development Framework (2003/2004), there is a need for more than 240 000 units to address the housing backlog. This figure excludes ±100 informal settlements. The challenge remains as to where these structures will be built. RDP houses that were developed within the CoJ in the past 11 years did too little to promote the principle of integrated development set out in the social housing policy. Many of these were developed at the periphery of the city and created problems with regard to transportation, job opportunities, amenities, business opportunities, efficient service provision, energy usage and so on (Breheny, 1996; Hillman, 1996 as quoted by Todes, 2003).

Drawing from the above background analysis of housing development during both the apartheid regime and the democratic era, the CoJ has a huge housing backlog largely created by apartheid planning. Low-income houses, so-called RDP houses, were developed at the periphery during the past eleven (11) years. The CoJ is largely developed, leaving no land for new developments except at the urban edge. The former mining land situated at the south of CoJ is not utilised and is available for development.

This investigation therefore identifies the former mining land south of CoJ as a solution to develop houses on well-located land, contributing to both integration and reduction of the housing backlog. It should be noted that the land poses health risks in which radon is one of the hazardous substances. Other challenges posed by the land are slime dams, bedrock, toxic chemicals, and mine tailings.

Map 1.2 illustrates five different sites that have been identified for development of new houses in the former mining land south of CoJ. Site 1 is situated in the north of Langlaagte and is 120 hectares. Site 2 is in the south east of Riverlea and west of Langlaagte. This site is 20 hectares and is close to existing residential areas. Site 3 is 10 hectares in the east of Riverlea and North West of Langlaagte and has some mine tailings that need to be removed. Site 4 is huge with 300 hectares in the east of Diepkloof Zones 4 and 5, but has slime dams. And lastly, site 5 in Ormonde has a proposal of development of three storey buildings. The site is five hectares and the size of the site made it easier to be cleaned and radon (defined later in chapter 3) has been put under control (iPROP information, 2006).

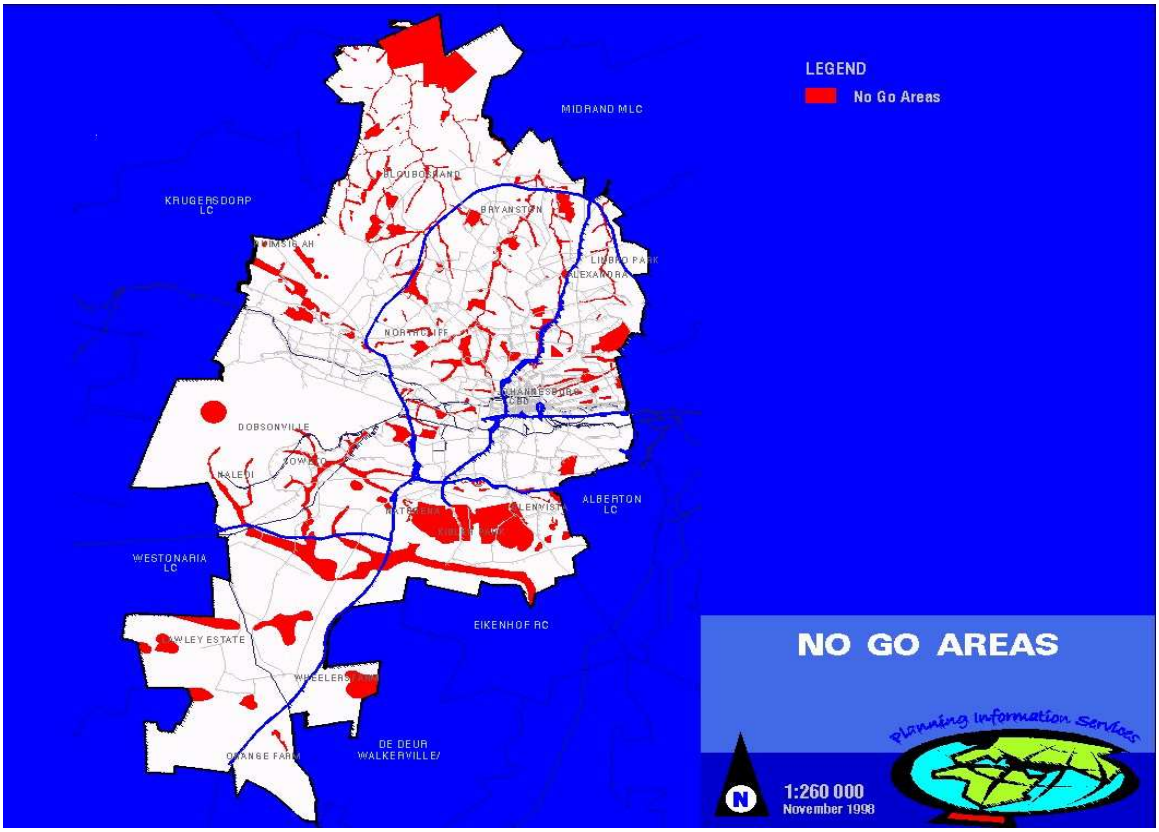
These sites are situated in proximity with major transport routes like the Golden Highway, Nasrec Road, Main Reef Road; water delivery pipelines in which Rand Water has a servitude agreement with iPROP; a sewer system with which the City Council of Johannesburg has a servitude agreement; centre lines for overhead electricity power lines with underground electricity cables where Eskom has signed a servitude agreement with iPROP; and lastly, South African Railways and Harbours Administration for the railway route. Other advantages of these sites include the industrialised nature of the south, offering prospects of employment opportunities, and underground telephone cables. For easy identification, sites on the map below are identified as Site 1 – Re/11/224 south of Langlaagte; Site 2 – Re/8/224 west side of Langlaagte; Site 3 – **3/L/9** Re/11/224 North West of Langlaagte; Site 4 – Diepklook 319 – I.Q. North East of Diepkloof Zone 4 and 5; and lastly, Site 5 – Ormonde 46 which is Ormonde Extension 46.



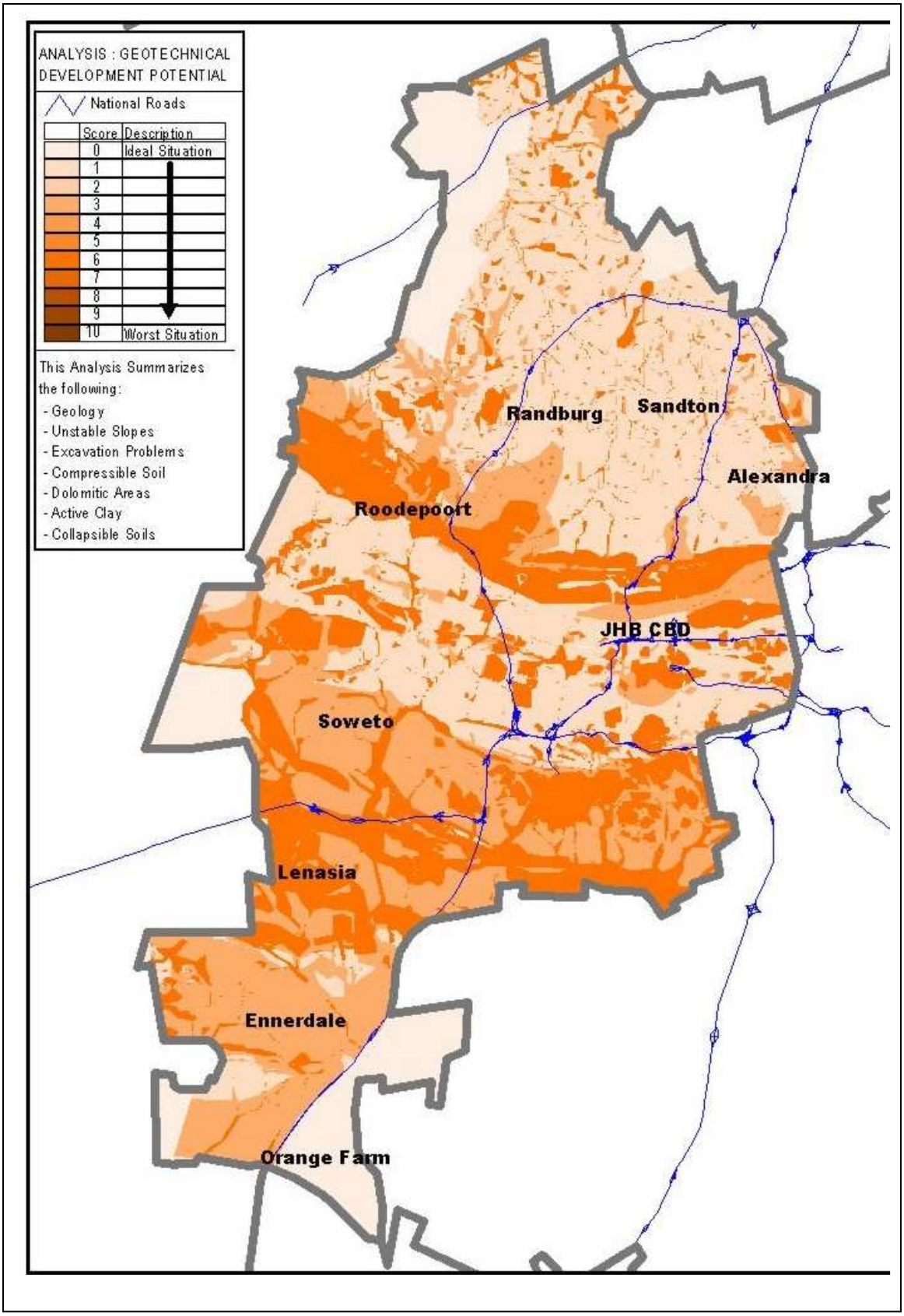
Map 1.2: *Focus Area within the CoJ*
Source: *iPROP, 2006*

Former mining in general is associated with sinkholes and one might assume that no major structures should be developed on such land. The analysis done by iPROP of the land has assured that the area has no sinkholes. A further investigation was conducted into the spatial analysis of the CoJ on so-called protected areas or areas where development of any kind is not permitted. In 2000, the then Greater Johannesburg Metropolitan area published a map identifying sensitive areas in relation to development. The focus area of this report falls outside of those areas identified by the metro. In addition, the CoJ's 2003/2004 Spatial Development Framework proposed that the mining belt in which the identified sites occur, should be used to create a linkage among the north, south, east and west through development of roads, railways and new housing. Therefore, this investigation is in line with development prospects of the CoJ. Map 1.3 shows areas marked with red as sites where any types of development are discouraged. On the other hand, Map 1.4 identifies the potential areas for development in accordance with the geotechnical analysis of the CoJ. From this brief analysis of the maps, we see that the focus area is suitable for development.

Map 1.3: *No Go Areas for Development within the CoJ*
Source: *Greater Johannesburg, 2000*



Map 1.4: *Potential Development Areas within the CoJ*
Source: *Greater Johannesburg, 2000*



Statement of the problem

The City of Johannesburg (CoJ) is currently faced with a housing backlog and ongoing development of low - income houses at the periphery, perpetuating spatial disintegration, creating new inequalities, social unrest and consolidating existing apartheid spatial patterns. The CoJ developed low-income houses in areas such as Tshepisong, Braam Fishersville, Vlakfontein, Diepsloot, and Orange Farm. These settlements perpetuate apartheid planning and do not contribute to the principle of integrated development provided by the National Housing Act of 1997.

According to Charlton (2000), development of low-income housing should be considered as a priority for compaction and integration of the apartheid city. Developing low-income housing within well-located land brings people closer to transport, job opportunities, schools, public facilities, the support of good neighborhoods, and maximizes the use of the existing infrastructure and social investment (Charlton, 2000; Roysten, 2003). Land that is well-located in the CoJ has not been utilized for reasons such as insufficient funds, technical challenges associated with well-located land, and toxic chemicals on former mining sites which are where the majority of the focus area is situated (CoJ Spatial Development Framework, 2003/2004).

According to the CoJ Spatial Development Framework (2003/2004), development of housing should not be conducted in isolation from infrastructural services, social services, transportation, economic opportunities and the natural environment. There are

over 240 000 units that need to be built and approximately 100 informal settlements that need attention. Housing delivery according to the city's SDF has failed to address issues of social and economic development that are necessary to combat the imbalances created by the previous apartheid policies (CoJ SDF, 2003/2004). The use of well-located land would address these issues and former mining land is one of the options available. Developing housing on the mining sites is part of the CoJ's SDF and Integrated Development Plan and the benefits will exceed social, environmental and physical costs. Nevertheless, there are environmental problems with these sites (ibid).

The above discussion has laid down the problem of apartheid spatial planning, the housing backlog and the unavailability of land within the CoJ. The former mining land, especially the five different sites identified earlier, is proposed to promote and support development of new houses. According to Richard Bennet from iPROP, mining land has a high concentration of radon (defined in chapter 3). Only one of the sites has been cleared of radon, though the level of radon at the other sites is not yet known. High concentrations of radon has the potential of causing lung cancer. This land is in demand and has been earmarked for residential purposes by the CoJ council. This demands a study of radon and its relationship with residential areas.

The purpose of this investigation is therefore to examine the impact radon has on development of low-to-moderate income housing on the City of Johannesburg's former mining sites, and the potential health risks to residents. The central focus of the study is the presence of radon and the risk of developing lung cancer. There are factors that

facilitate the development of lung cancer from individuals who are exposed to uncontrolled radon gas. The thrust of this paper is to answer the question: ***what are the environmental-health risks for developing low-to-moderate income housing on the former mining sites south of the City of Johannesburg?*** This land should be utilized, provided it meets the criteria for development within the country (requirements of the National Nuclear Regulator and the Gauteng Department Agriculture, Conservation and Environment). The use of this land will help curtail the development of new houses at the periphery of the city.

Objectives

In order to analyse the discussed problem, this study focuses on the following objectives:

- To use the City of Johannesburg's south former mining sites along the Main Reef Road as a case study.
- To find out what is the relationship between radon and residential development.
- To provide recommendations that incorporate the use of radon-affected land for housing purposes.
- To provide recommendations for the national housing policy to address the presence of radon on mining land.

Limitations

The study area is primarily the former mining sites south of the City of Johannesburg along the Main Reef Road. The area has a lot of potential for people to develop economically. The area is highly industrialised and has opportunities for employment and for the establishment of Small Macro- and Micro-Enterprises. Many people within the country and in Africa would like to live in the CoJ. The area is in a process of becoming the world-class city, competing directly with cities like New York and London.

Other concepts that will be covered in this research are gender, weight, smokers, ex-smokers, and people who are exposed to secondary smoking in an indoor, and the relevance of these factors to lung cancer catalysed by radon.

Research Methodology

In this investigation, two types of research methodologies were utilised for data collection: a qualitative research method to collect data in the form of structured interviews; and a quantitative method to present and analyse the information collected.

Sample frame for the survey

The questions which were prepared for informants were sensitive, as approaching any community would have been difficult and might have posed risks for both interviewees and interviewers. Therefore, the only option was to get access through ward councilors.

In Orange Farm, a ward councilor introduced the interview-team to the community in a ward meeting. In Orlando East, the same procedure was followed and a ward councilor arranged a focus group as a pre-test as well as a meeting with the community. Surveys were administered in both places.

One major problem was the level of income in these communities. For the purposes of this investigation, so as to be 'politically correct' and understanding of the land in question, it was necessary to focus on low – to - middle-income earners. In accordance with day-to-day conversations and the media, people who earn less than R1 601 per month are living below the poverty line. In the sampling, people living below the poverty line had to be excluded to ensure that the people who responded to the surveys understood and ackowledged that they have a choice. The level of income was below what was expected (+R2 500), and accordingly the focus was extended to two different malls, Southgate Mall in the south, close to Soweto, Eastgate Mall in the east of Johannesburg. It was assumed that people doing shopping from these malls live in proximity with former mining land. Again, permission had to be obtained in order to conduct surveys and the management of these places gave access to their premises. In addition, surveys were also administered in Braamfontein in order to obtain opinions from people who are working close to the CBD and who might be living at further distances. In total, 216 surveys were conducted and, as can be seen from Table 1.1, the majority were from Southgate Mall.

Table 1.1: Areas in Johannesburg in which surveys were administered.

Place of interview	#	% of total
Braamfontein	9	4.2%
Eastgate Mall	31	14.4%
Orlando east	41	19.0%
Orange Farm	30	13.9%
Southgate Mall	105	48.6%
TOTAL	**216**	**100.0%**

Source: Simons et al, 2005

Data Collection

Surveys are one of the most-used methods to collect data on different issues and especially on opinions. In designing and implementing the survey, all standard research protocols were followed. The survey was conducted face-to-face. Several steps were followed, from the training of interviewers, pre-testing of the instrument, a focus group and another pre-testing. This ensured the length of time the survey would take and the clarity of the questions. The population to be surveyed had varied degrees of education and clarity was of extreme importance (Neuman, 2000).

A major concern was the language used in the survey as South Africa has 11 official languages. The decision was to conduct the survey in English, except in cases where respondents indicated that they would prefer another official language. We relied on

information from Statistics South Africa, 2001 that the most-used second language is English and it is the most widely understood among the 11 official languages.

The interviewers all spoke English (all were Masters students in the Planning Programme at the University of the Witwatersrand), though it was important to ensure that the other 10 languages were represented. From Table 1.2 below, most interviews were conducted in English, followed by Zulu and Sesotho, which corresponds well with the languages represented in the south of Johannesburg (Simons, et al. 2005).

Table 1.2: Languages in which the interviews were conducted.

Language	#	% of total
Afrikaans	1	0.5%
English	139	64.4%
Pedi	5	2.3%
Sesotho	27	12.5%
Tswana	5	2.3%
Xhosa	3	1.4%
XiTsonga	2	0.9%
Zulu	34	15.7%
TOTAL	**216**	**100.00%**

Source: Simons et al, 2005

Analysis of Data

Contingent Valuation (CV) was used to analyse data presented in this investigation on properties developed on contaminated land. According to Simons and Winson-Geideman

(2005), CV is a survey technique that seeks information from informants using a questionnaire. The questionnaire has a description of the property and its condition. CV is largely used on properties built on land that has contamination. Informants are asked to bid or indicate how much they are likely to pay for a property described. Informants are also asked how they would pay for a type of property described, meaning either by cash or a housing subsidy (Simons and Winson-Geideman, 2005).

Simons and Winson-Geideman (2005) conducted a study on eight different states in the US by telephone, evaluating 1 100 interviewees. They researched properties on land with contamination due to Leaking Underground Storage Tanks (petroleum contamination). The analysis of bidders indicated that a general 20% discount on purchases of these properties was the outcome. In the context of this investigation, radon contamination is investigated rather than petroleum and the research is in South Africa rather than United States of America.

SOME ETHICAL CONSIDERATIONS

Ethical issues are problematic in an information-gathering situation and need to be taken into consideration. According to Neuman (2000), ethics define what moral research involves – what researchers ought to do and what they ought to avoid. Deceiving people is unacceptable in an investigatio. Consequently, debriefing was given to our subjects/informants. It wa possible that our participants could be at risk by giving us information, but all possible hazards were dealt with besides those that were unexpected.

Participants were advised that they have the right to withdraw from the investigation at any time should they wish to do so. Good research is evident when there is mutual respect and confidence between the informants and investigators (Neuman, 2000).

CHAPTER OUTLINE

This report will be comprised of five chapters:

Chapter 1 provides the brief information background on the historical context of the South African spatial and settlement patterns that occurred in South Africa during apartheid. Apartheid planning left a huge housing backlog and spatial disintegration. The task faced by the ANC-led government would be to address these issues. There were and still are challenges in addressing these issues, especially in land acquisition. This forms a build-up to the statement of the problem being investigated, which is radon. A structured survey was used to collect data from those with experience of living near mine dumps. Contingent Valuation was utilised as the best tool in analyzing the development of houses on contaminated land. The New Urbanist's theory gave direction to this investigation.

Chapter Two discusses concepts of contamination, land and redevelopment of contaminated land. The discussion on contamination reveals that contaminated land both man-made and a consequence of natural, day-to-day activities. A higher concentration of contamination on land has the potential of causing harm to humans and the environment .

Redevelopment of contaminated land has numerous challenges, which include financial, geotechnical and competing types of developments.

Chapter Three focuses on the main issue of this investigation, which is radon. There is a higher concentration of radon indoors as compared to outdoors. Smokers and those who are exposed to secondary smoking within a house with radon-contamination above the acceptable standard have a high risk of contracting lung cancer. Taking the risk of living in a house affected by radon is not as big a risk as those that people take each day, for instance, flying in an airplane, taking a taxi, drinking poison, fire in a shack, and so on. International experience shows that land contaminated with radon can be developed for housing purposes and people can live more than 35 years without contracting lung cancer.

Chapter Four discusses the findings of the investigation and analyses them against the literature review. There is a close relationship between the literature and the findings of this investigation. Informants showed an understanding of the subject matter and a willingness to live on land contaminated with radon. Ventilation is the prime solution to indoor radon concentration.

Chapter five concludes with a brief discussion of issues that need to be addressed prior to housing development on the former mining sites south of CoJ. Recommendations are made with regard to development of former mining sites for housing. Recommendations are also made for the housing policy to make provisions for land with contamination for

development of housing.

Theoretical Framework

Earlier on in this chapter, it was discussed that availability of well-located land is an issue within the CoJ. Development of houses has been occurring at the periphery of the city. Former mining land is not utilised even though it is well-situated. The housing policy of South Africa in section 4.5 provides a principle of integrated development planning, advocating physical, spatial, social and economic integration within municipalities and cities. It is therefore against this background that the theory of the new urbanists is introduced as a catalyst to develop the former mining land south of CoJ for housing in promotion and support of the principle of integrated development.

The understanding of integrated development on the part of housing development on the former mining land south of CoJ is in line with the theory of the New Urbanists who are anti – sprawl in nature. This former mining land is well – located in an area earmarked for housing, according to the CoJ's 2003/2004 SDF. The problem faced by CoJ is the availability of land for development of housing for low-income earners. Previous housing development within the city took place at the periphery, doing little to combat disintegration. The theory of the new urbanists accords with this investigation in order to help combat peripheral development and address the benefits of integrated development.

The understanding of integrated development on the part of housing development on CoJ's south former mining land is in line with the theory of the New Urbanists who are anti – sprawl in nature. The CoJ's south former mining is well – located situated in an area earmarked for both housing according to the CoJ's 2003/2004 SDF. The problem faced by CoJ is land for development of housing for low-income earners. Previous housing development within the city had been taking place at the periphery, doing little to combat disintegration. The theory of new urbanists fits in for this investigation in order to help combat peripheral development and address benefits of integrated development.

The New Urbanists

The theory of the new urbanists regards the issue of peripheral development as constructed through the lack of smart growth. They are anti-sprawl in nature and in support of development within the urban area that is geared to achieve good governance, social equity, economic viability, self-containment and sustainability. Marshall (2003) argues in support of the new urbanists' idea that dense, walkable, mixed-use neighborhoods should be encouraged in order to reduce urban expansion by making better use of land within existing urban boundaries; focusing on patterns of land use and transportation to reduce automobile dependence. This will help and regulate expanding development to the greenfields, while infill opportunities could be sought in grey fields or brownfields within developed areas (Irurah and Boshoff, 2003).

In South Africa, including the CoJ, spatial distortion was perpetuated by the Group Areas Act of No. 41 of 1950 with buffer zones separating areas. An effective solution to this problem could be to use buffer areas, some of which are brown fields such as the former mining sites. Housing development of these sites will promote an environment with services, facilities, amenities, transportation, job opportunities and proximity to the Central Business District (CBD). Adequate services are essential for minimum standards of health, safety and convenience (water, electricity, refuse removal, sewerage and waste disposal, public transport, police stations, postal services, health facilities, fire and ambulance services, etc). Minimum social requirements include access to educational, recreational and cultural facilities. In addition, access to shopping, entertainment and employment opportunities is maximized. In the formal Black townships, most of the above-mentioned services are missing or inadequate, and completely lacking in informal settlements. Some houses which were developed since 1994 in the CoJ had some of the above-mentioned services missing. For instance, people from Braam Fisherville, Orange Farm and Diepsloot have to travel more than ±30 Kilometers to the CBD (Corbett, 1992).

Integration by low-cost housing has had many challenges, one of which is the Not-In-My-Back-Yard (NIMBY) phenomenon. According Southworth (2003), the United States (US) Department of Housing in collaboration with the Department of Urban Development overcame this problem in which over 53 000 units were built as infill development. In order to reduce segregation, infill developments should be encouraged and land within developed areas in the CoJ should be utilized for development of low-to-moderate income housing (Beavon, 1992). Diverse housing types will bring people of

diverse ages, race and incomes into daily interaction, strengthening the personal and civic bonds that are essential for an authentic community (Southworth, 2003).

In this chapter, the problem of unavailability of well-located land in the CoJ for housing has been clearly identified and the investigation of the suitability of the city's southern former mining land as a proposed solution for housing development is addressed. The sample used in this investigation is comprised of people who have experience of living close to mine dumps. The former mining land is contaminated with radon, according to Richard Bennet of IPROP. The discussion below looks at issues related to contaminated land and its challenges for redevelopment.

Chapter 2

What is Contaminated Land?

This investigation addresses land that is contaminated with various substances, even though the focus is radon. The chapter on contaminated land has been added to this research to provide an understanding of the entire issue of contamination of land. Issues covered in this chapter do not necessarily focus on radon-contaminated land, but on mining-related contamination. It should also be understood that radon on mining land and its development for housing purpose is still a new concept being explored with few cases being successful abroad. It is therefore important for a better understanding to define contamination and land separately before defining contaminated land.

The East Cambridgeshire District Council and Royal Society of Chemistry in 2001 described contamination as an outcome of various substances that have the potential to pollute and make the environment impure. These substances are a result of previous industrial and agricultural activities. Contamination occurs on , which is the main reason that the Royal Society of Chemistry (2001) has warned that the level of contamination should only be limited to land that has consumed contamination substances above the limit of the land. This means land with contamination that has not reached its limit should not be identified as contaminated.

The Department of Sustainability and Environment in Victoria (USA) (2003) states that adjacent and current use of an area also causes contamination. Contamination is both man-made and a consequence of natural day-to-day activities that include gas or chemical works, land use for industrial purposes, landfill sites, illegal dumping and former sewage works (Frowe, 2004). The Royal Society of Chemistry (2001) has stated that the British Geological Survey in the UK found that 31 natural chemical elements contribute to contamination. Contamination, when exceeding the natural concentration of land, has the potential of causing harm to human health, environmental receptors and pollution of water (Safegrounds, 2005).

There are a number of definitions of land, most of them describing it as a property with natural resources such as water and trees. In this investigation, land is considered as available, potentially developable property, which has to be researched with regard to types of dangerous gases and chemicals posing health risks to humans. The former mining land south of CoJ has radon contamination, but the magnitude of this gas has not been established yet due to lack of interest shown for development of this land and the cost of carrying this activity. Another reason, according to Richard Bennet, is that financial returns to iPROP were not established, which prevents the company from appointing consultants to measure the intensity of radon. In addition, a developer can buy the land and do all the cleaning or iPROP can clean the land and sell it at a high price.

All definitions of contaminated land in this investigation tend to embody the concept of risk assessment. This means that there is a possibility of significant harm anticipated from

such land. For instance, the UK Environmental Act of 1995 defines contaminated land as land in, on or under substances which pose significant harm and pollution of controlled water. The Geological Society (2001) defines substances with the potential of contaminating land as heavy metals, organic compounds such as herbicides, pesticides, dyes, solvents, and paints, as well as petroleum products. The British Standards Institution of 1983 (Royal Society of Chemistry, 2001) added that the substance has to be present in sufficient concentration to pose a hazard, which was confirmed by the Royal Society of Chemistry which stated that no land could be identified as contaminated unless the concentration of a contamination source has risen above the limit of the capacity of the land. Cairney (1987 as cited by Royal Society of Chemistry, 2001), in his definition, added the element of direct and indirect harm to humans, environment and other targets. For the purpose of this investigation, developing from these definitions, contaminated land is defined as land with a high concentration of substances that are likely to cause harm directly or indirectly to humans, environment and other targets (Firstfaraday).

Land with contamination has short-falls because of its ability to pose health risks to both human beings and the environment. The land also imposes a risk for investment potentials, regeneration and limits land availability and development, especially in urban areas. This investigation is focused on previous mining sites in the South of Johannesburg which have not been redeveloped for housing, because of the existence of radon gas and mine dumps.

Sources and Signs of Contamination

Many activities cause contamination of land. These activities include, amongst others, mining, quarrying, industrial activities and waste dumping, agricultural practices, and contaminants from the atmosphere (National Society for Clean Air and Environmental protection, 2002). The Public Protection Department (2002) of the UK and the Department of Sustainability and Environment (2005) of Victoria mention more activities that contaminate land (Frowe, 2004). Below are examples of residential development on contaminated land in both Europe and United States of America.

According to Simons (1998), development of brownfields with contamination is possible. In his article, in relation to residential development on contaminated land, he presented a few examples of this kind. These residential developments include the development of 96 low-income houses in Detroit – Michigan on 8.5 acres; New Jersey developed 158 acres of land for a housing complex which consisted of 1100 units; in Auckland, New Zealand, 13 acres were developed for 40 units; and lastly, in Manchester, 254 units were built for sale and renting. The types of contaminants that affected these sites were lead, light hydrocarbons, heavy metals and petroleum.

Conclusions that we can draw from these developments are independent of cost because the cleaning of different toxic substances is different. These developments, unfortunately, were not on former mining land but land with contamination. The baseline is that any

contamination can be cleaned and the land can be utilised for any development, especially housing, in this case.

Identification, Inspection, Remediation and Costs for land with contamination

Local authorities in Scotland have information about the status quo of land within their area of jurisdiction. This is information collected during the development of spatial frameworks and in some other places (excluding Scotland) the environmental management frameworks (some municipalities in South Africa). Other sectors in Scotland who would have information about status of land are planning departments, environmental health, building control departments, Environmental Agencies, Scotland Environmental Protection Agency, and Land Condition Record. In addition, Victoria – USA, has an Environmental Protection Act Priority Sites Registry that has a list of information on sites with clean-up notices. The existence of all these sector departments make it easier for a developer to make calculations about the cost of developing and cleaning up the land by providing necessary information (Scottish Environmental Protection Agency, 2000; National Society for Clean Air and Environmental Protection, 2000; City of Scotland, 2001; Department of Sustainability and Environment, 2005).

Identification and inspection of contaminated land will take the same procedure in normal circumstances. They both have the same goal, which is to determine whether there had been any contamination on, or adjacent to, the site and the potential to harm receptors. According to South Northamptonshire Council (2004), the purpose of identification and

inspection of land with contamination is to provide information about the site and the status of its surrounding areas in relation to the effect of contamination. The report should include current and historical use of the site; historical and current maps; trade directories; aerial photographs; previous planning permissions; and so on. All this information should be referenced. After all this information has been gathered, a visual site inspection should be conducted to identify sources of contamination and an indication of damage (City of Sunderland, 2001; Royal Society of Chemistry, 2001; South Northamptonshire Council 2004).

The land found to be contaminated would require a remediation process. Remediation action includes assessing the condition, undertaking remedial treatment and monitoring the condition. The activity of remediation has an end-removing source of pollutant, removing the receptor, or breaking the pathway. The city of Detroit had lead and arsenic contamination in an 11.4-acre site. The part of the site that was contaminated with lead was removed to a landfill site and an acceptable level of lead was approved on the site. The site was developed for low-income housing. The remediation process took six months for both cleaning up and testing the site. In another example, a site in Michigan was contaminated with metal. The remediation included a removal of six underground tanks, two extra tanks were found later, and the project incurred extra funding not budgeted. Remediation is an action taken after the identification and inspection of the site has been conducted. It is an activity of removing the source of contamination, or, in other cases, removing receptors and breaking the pathway between the receptor and the source of contamination (Simon, 1998).

Costs of cleaning contaminated land vary with regard to the level of contamination. The cost of identifying and inspecting of land is not pre-determined like the cost of removing the source of a pollutant. The unit used for remediation is a dollar per square foot of land. One acre of land costs $100 000 and 90 acres could cost $28 million. The cost for remediation is also charged with percentage of total cost of the project envisaged. According to the Bracknell Forest Borough Council (2006/2007), four people should take up the remediation cost of the land. The person who owns the land has to take responsibility for removing contaminants. The person who bought the land can voluntarily clean the land, provided the seller cannot clean the land and the person responsible for contamination cannot be found. The local authorities can also take up the responsibility of voluntarily cleaning up the land in a case where the land would be used to serve public interest (Simon, 1998).

Redevelopment of Contaminated Land

Development of contaminated sites poses a huge challenge for both the landowner and the developer. The challenge of remediation for contamination processes involved and costs involved have been mentioned above. Other challenges include the demolition of unwanted structures, redundant services and rubble or infill of unacceptable quality (National Society for Clean Air and Environmental Protection, 2002). Abandoned and contaminated lands are very expensive to redevelop as compared to greenfields, because of cleanup cost. The cost of cleaning contaminated land is estimated at 10% of the total

cost for developing the land (Simons, 1998). These lands are normally on well-located, desirable land for integration purposes. Other factors that are at play in the redevelopment process are the quality of the labour force, the earning power of nearby households, the lack of information about the demand of the land in question, and perceptions about crime rates (Simons, 1998).

According to the Public Protection Department (2002) of Wreham Council, the redevelopment process should fulfill all the requirements and obligations of planning, building and environmental legislation. On the same note, the Halton Unitary Development Plan (2002) also considered their Regional Planning Guidance when developing houses on contaminated brownfield land. In Victoria – USA, the Planning and Environment Act of 1987, the State Planning Policy Framework and the Environmental Audit are required for the development of land with contamination (Department of Sustainability and Environment, 2005).

In summary, land with contamination has to be assessed and remediated before development can be approved. There are an extensive number of regulations, policies and legislation requirements, depending on the area and country where these cases are happening. Contaminated land in urban areas enjoys advantageous locations and can be used to limit development of greenfield sites (Simons, 1998). Practical examples of residential developments from land with contamination were successful in Detroit (Michigan), West New York (New Jersey), Auckland (New Zealand), and two in

Manchester (United Kingdom). The level of contamination can be brought down to an acceptable standard and sensitive projects like housing development could be carried out.

Redevelopment of abandoned and contaminated land has a benefit for investors and communities. The investor would get a profit in the end from previously unused land, while the community would get housing, employment and other benefits. This process also has potential of adding value to the quality of life of the community and would minimise the impact of urban sprawl. The Scottish government in 2002 took a resolution to redevelop abandoned and contaminated land to reduce unnecessary developments of greenfields by setting up a target of developing 60% new houses on abandoned and contaminated land (National Society for Clean Air and Environmental Protection, 2002).

Numerous activities can cause contamination of land that are both man-made and naturally determined. The research done in the UK has revealed that there are at least 31 natural causes of contamination of land. Human activities are industrial activities, illegal dumping and so on. Land with contamination can still be redeveloped at a cost, paid in normal circumstances by the person responsible for contamination, or by the local authority that owns the land, who are then obliged to incur the cost of remediation voluntarily. The next discussion focuses on existing literature on radon.

Chapter 3

Radon

This part of the study provides an understanding of the extent of radon. Radon is a dangerous gas that has a potential of causing lung cancer, mostly in higher concentration within indoor areas (USEPA, 2003). Radon is more prevalent where mining (especially uranium, gold, fuel, coal, etc) has taken place. A clear description of radon is part of this paper, including international experience of radon in places where radon is higher than the acceptable level. Risk related to radon and risk comparison in general form part of this chapter (Chambers, et al. 1998).

Radon definition

Radon is defined by Walsh (2001) as a colourless, odourless and tasteless radioactive gas; it is a *natural* phenomenon in soils and is not an artificial or man-made contaminant. In 2003, Cooper and Anderson described radon as an odourless, gaseous radioactive element that occurs on earth and rock, well water and some building materials even though to a lesser extent, but it should be noted that building materials do carry radon. In 2005, the World Health Organisation also described radon as a chemically inert, *naturally* occurring gas produced from radium in the decay chain of uranium, which is found around the world. It is an outcome of radium broken down from uranium during a

decaying stage (Chambers, et al. 1998; Rao, et al. 2001; University of Minnesota-Environmental and Occupation Health).

Radon and Lung Cancer

According to Radon Mitigation & Waterproofing Concrete Sealer (2002), cancer is a group of more than a hundred diseases characterised by the uncontrolled growth and spread of abnormal cells. There are different causes of cancer and radon is one of them. According to Cooper and Anderson (2003), radon atoms decay spontaneously to form radon progeny and radon progeny decay to form alpha radiation. They say that radon progeny can be released to the air and inhaled. When inhaled, electrically charged radon progeny form alpha radiation in the lungs. The alpha radiations disrupt DNA in lung cells and this disruption marks the initial step of lung cancer development. The WHO (2005) also shared the same information on how radon causes lung cancer. The WHO (2005) says the radon daughters or progeny emit heavily ionizing radiation also called alpha particles. These alpha particles are deposited into the lungs and the lining in the airways where they damage the DNA cells and eventually cause lung cancer.

Radon in Homes

The concentration of radon radioactivity is measured in Becquerel (Bq) in a South African context and by pCi/L in other countries. The acceptable limit of radon varies between 5 and 15 Bq/m^3 as well as 0.4 and 4 pCi/L. The concentration of radon in homes

depends on the amount produced through available routes for its passage into houses from rocks and soils. Radon gas penetrates and enters houses via cracks, floor-wall junctions, gaps in the floor, small pores in hollow-block walls, etc. Radon levels are usually high in the basements and other lower structures of the house attached to the soil (Field et al, 2002; ARPNSA, 2002; WHO, 2005; CSTU, 2004; News-Medical-Net, 2004).

Radon concentration is high within other buildings as compared to the outdoors. There are a number of ways to reduce radon concentration indoors. Radon concentration indoors could be reduced by improving the ventilation of the house and avoiding transportation into living rooms, increasing under-floor ventilation, installing a radon sump system in the basement, sealing floors and walls, and installing a positive pressurisation or positive supply ventilation system (Rooper, 1990; ATSDR, 1995 and 2000; Darby, et al 2005; WHO, 2005).

Radon and Smoking

There is a positive relationship between radon and smoking habits. Ex-smokers and those who are exposed to second hand smoking in an indoor environment have a positive relationship with radon towards lung cancer. A survey was conducted in Europe in order to determine the likelihood of developing lung cancer between smokers and non-smokers. The survey discovered that smokers are twenty-five times more likely to develop lung cancer due to radon gas as compared to non-smokers (Condon, 2005). According to the

radon protection agency in Australia (2002), a smoker in a house increases the chances of lung cancer within the entire family from radon inhalation and second hand smoking. If a smoker stops smoking, chances would be reduced, but chances are still high as compared to a family that had never hadthea smoker in a house. Non-smokers as well have their chances increased in the house because of polluted air inhaled. In addition, not only smoking increases chances of developing lung cancer from inhaled radon, age difference and body weight also increases chances (Enflo, 2002).

Radon and risk

The U.S. Environmental Protection Agency in 1993; the ATSDR in 1995 and 2000 conducted a risk comparison between a given level of radon exposure measured in pCi/L and smoking. The risk of developing lung cancer from radon is compared with everyday risk occurrences in general. For instances, the risk of developing lung cancer from radon level of 20 pCi/l is compared with the risk of drowning. Table 3.1 illustrates the level of radon concentration and chances of developing lung cancer compared to other types of common risks happening in everyday life. In addition, the table shows the influence smoking has on chances of developing lung cancer. This information could also be compared with information presented on table 3.2 which presents radon risk per level for people who had never smoked.

According to Krewski, et al (2005) exposure to 100 Bq/m^3 can cause lung cancer in a window period of 5 – 30 years, irrespective of sex, smoking, education level, weight, etc.

They discovered that age difference increases the risk of developing lung cancer. Table 3.1 and 3.2 below show that smoking contributes to a high risk of developing lung cancer as compared to a non – smoker. 0.4 pCi/L of radon level has zero chances of lung cancer development as compared to the two people who are smokers (AARST, 1999; Council for British Archaeology, 2002; Cohen, 2003; ATSDR, 2003).

Table 3.1: *Radon Risk If You Smoke*

Radon Level	**If 1,000 people who smoked were exposed to this level over a lifetime*...**	**The risk of cancer from radon exposure compares to**...**	**WHAT TO DO: Stop smoking and...**
20 pCi/L	About 260 people could get lung cancer	250 times the risk of drowning	Fix your home
10 pCi/L	About 150 people could get lung cancer	200 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 120 people could get lung cancer	30 times the risk of dying in a fall	Fix your home
4 pCi/L	About 62 people could get lung cancer	5 times the risk of dying in a car crash	Fix your home
2 pCi/L	About 32 people could get lung cancer	6 times the risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 20 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult.)
0.4 pCi/L	About 3 people could get lung cancer	(Average outdoor radon level)	
Lifetime risk of lung cancer deaths from EPA Assessment of Risks from Radon in Homes.			

Source: U. S Environmental Protection Agency, 1993; ATSDR, 1995, 2000

Table 3.2: *Radon Risk If you've Never Smoked*

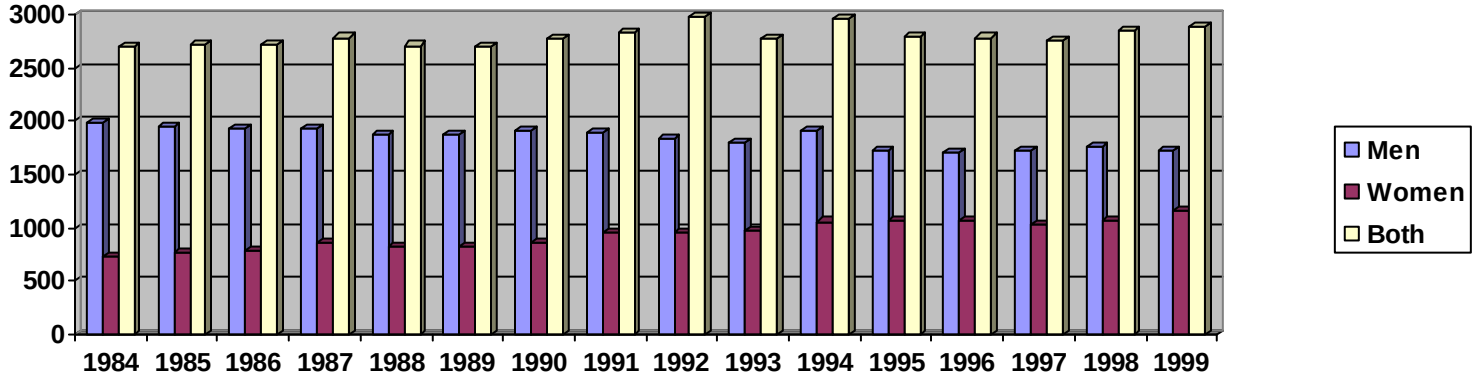
Radon Level	**If 1,000 people who never smoked were exposed to this level over a lifetime*...**	**The risk of cancer from radon exposure compares to**...**	**WHAT TO DO:**
20 pCi/L	About 36 people could get lung cancer	35 times the risk of drowning	Fix your home
10 pCi/L	About 18 people could get lung cancer	20 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 15 people could get lung cancer	4 times the risk of dying in a fall	Fix your home
4 pCi/L	About 7 people could get lung cancer	The risk of dying in a car crash	Fix your home
1.3 pCi/L	About 2 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult.)
0.4 pCi/L		(Average outdoor radon level)	
Lifetime risk of lung cancer deaths from EPA Assessment of Risks from Radon in Homes			

Source: U. S Environmental Protection Agency, 1993; ATSDR, 1995, 2000

According to the research conducted in Sweden between 1984 and 1999, in relation to gender, men are more at risk of developing lung cancer from radon exposure compared to women. The number of men developing lung cancer in Sweden fluctuated, going down,

but that of women increased each year. This research in Sweden has revealed figures that were used to develop statistics presented in figure 3.1 conducted by Enflo in 2002. This research showed that age difference has an effect in women to develop lung cancer from radon exposure. Given this information, it is therefore clearly demonstrated that gender and radon exposure have a positive relationship (HSE, www.hse.gov.uk/pubnsindg163.pdf; Post Report Summary, 1996; Pershagen, 1994).

Figure: 3.1: *Statistics of gender and radon exposure in Sweden*



Source: Graph developed from Enflo 2002

Risk Comparison

Table 3.3: *The following is a table of life expectancy lost for several causes*

Health Risk	**Estimated life expectancy lost**
Smoking 20 cigs a day	6 years
Overweight	2 years
All accidents	207 days
All Natural Hazards	7 days
Alcohol (US aver.)	1 year

Source: Cohen and Lee, 1991

Cigarette Smoking: 50 000-lung deaths each year per 50 million smokers consuming 20 cigarettes a day or one death per 7.3 million cigarettes smoked

Highway Driving: 56 000 deaths each year per 100 million drivers, each covering 10 000 miles or one death per 18 million miles driving

Radiation Induced Fatal Cancer: 4% Sv (100 rem) for exposure to low doses and dose rates (Radiation information Network's, www.physics.isu.edu/radinf/risk.htm).

A relative Risk of 1 in a million chances of dying of activities common to our society:

- Smoking 1.4 cigarettes
- Eating 40 tablespoons of peanut butter
- Driving 40 miles in a car

- Flying 2500 miles in a jet
- Receiving 10 mrem of radiation

All human beings do take a risk for a certain benefit. For instance, you want to go somewhere in a hurry, you accept the risk of driving for this benefit. In relation to radon, the risk is a small increase in lung cancer. But the risk comparison above illustrates that radiation is a small risk when compared to risks we take everyday (Radiation information Network's, www.physics.isu.edu/radinf/risk.htm).

Treatment and Management of Radon Risk

The level of radon in the indoor environment could be reduced with increased ventilation (Roper, 1990). According to the United States Department of Health and Human Services, the most effective way to avoid lung cancer induced from radon is to keep away from radon exposure and risk factors such as smoking. The department found that people, especially in New Jersey, take the potential risk of radon lightly and this discourages testing and treatment. Out of nine European countries that were studied by Darby, et al. cited by Institute of Physics Publishing (2005), only 2% of all lung cancer deaths in Europe are a result of residential radon. It was also discovered in the same case study that the increased risk of lung cancer is 16% per 100 Bq/m^3 increase in usual radon concentration (ATSDR, 1995; 2000; Institute of Physics Building, 2005 News and Information. Journal of Radiological).

Table 3.4 below is from the work done by Albright and Barbour (1999) when they were looking at risks in everyday life that have a potential of accidental death. These results are from Colorado and the United States.

Table 3.4: *Risks in everyday life in Colorado and United States of America*

Activity in both US and Colorado	**Annual risk**		**Lifetime risk**	
From falls in home	66 per million	31 per million	4600 deaths per million in Colorado	2200 deaths per million in America
Car accidents	170 per million in Colorado	160 per million in America	8500 deaths per million in Colorado	8000 deaths per million in America
Pedestrian	21 per million in Colorado	23 per million in America	1500 deaths per million in Colorado	1600 deaths per million in America

Source: Albright and Barbour, 1999

Every individual is exposed to a daily background of radiation which poses a risk of cancer, more specifically lung cancer. Causes of radiation may be natural or artificial. Amongst the natural sources, radon contributes the highest towards radiation exposure. Radon itself decays into alpha-emitting radioactive solids which can be deposited in the lungs when inhaled. Other sources of radiation include intercontinental flight, eating bananas, high background levels, watching TV, and medical tests/x-rays (Albright and

Barbour, 1999). The research done by Albright and Barbour (1999) demonstrates that radon is not the sole cause of death which could be feared most. For instance, car accidents are a high risk which could result in sudden death. On the other hand, radon can cause death in the long term and it is not inevitable that the person exposed to radon would die of lung cancer (Idaho State University, 1992).

According to the statistics provided by the US Environmental protection Agency, the potential risk of developing lung cancer from radon is fully dependent on the level of exposure. For instance, table 3.2 shows that an estimated 36 people out of a thousand who are exposed to 20 pCi/L of radon are likely to develop lung cancer. This figure only presents those who are non-smokers and possibly not exposed to second-hand cigarette smoking. Smokers are the ones who are facing a serious risk of developing lung cancer when exposed to high or even low levels of radon exposure. Table 3.1 below shows that at least 260 smokers who are exposed to 20 pCi/L of radon would develop lung cancer. This information, collected by the agency in the US, clarifies that lung cancer due to radon exposure is dependent on the level of radon exposure and on whether you are smoking or exposed to second-hand smoking on an everyday basis (US EPA. www.epa.gov/radon/riskcht.html).

International Examples of Radon Experiences

Robinson (1996) found that people living in Barley and Krasnokamensk, which are two towns in Russia, were living in a situation where radon was 10 – 20 times higher than the

internationally acceptable standards. Unexpectedly, there were no radon deaths or lung cancer patients reported. In Russia, the acceptable level of radon is at 200 Bq/m^3 which is 50 units more than the US's 4 pCi/L. Excluding the fact that the area is a former mining site, the material used for building was from tailing, which increases the risk. The European Respiratory Society conducted a study in Europe on the relationship between radon and smoking. The research found that there is a high risk between smoking and radon exposure; meanwhile, there is also a risk for no-smokers exposed to radon but at a lower risk as compared to smokers. The study did not concentrate on the number of cigarettes smoked or the numbers of years of exposure. Ex – smokers were found to be also at risk as compared to non-smokers. Barros-Dios et al (2002), in the north west of Spain, discovered that radon risks are high to smokers even if radon levels were reduced to below the official guideline level. There would be still 2.5 chances of developing lung cancer. In the United States, EPA discovered that people in the US are suffering from preventable radon exposure. Each year thousands of people are dying from indoor radon. EPA estimated that 21 000 could die in 2003 if indoor radon is not given serious attention.

Redevelopment of radon contaminated sites

In South Africa, Section 43 of Minerals and Petroleum Resources Development Act of 2002 regulates on the provision of the certificate of mine closure where a contaminated site is required for housing development. The land needs to be rehabilitated first before the certificate can be issued. According to Briel (2005), an application for mine closure

needs to be accompanied by details of environmental risks. The environmental impact assessment has to be conducted and must form part of the application for development. The EIA is required in terms of Section 21 of the Environmental Conservation Act No. 73 of 1989. In addition, the application needs to state the next possible use of the land (Briel, 2005).

The certificate of closure should be submitted to GDACE. GDACE would then issue a Record of Decision to the Department of Mineral and Energy in order to issue a certificate of closure. Also involved in the process is the National Nuclear Regulator (NNR). The NNR has to submit a report with a statement confirming that radon levels are at an acceptable standard (Briel, 2005).

Once the environmental clearances have been granted, the project may continue with land use applications to the Johannesburg Planning Authority. The typical former mining site is zoned for agriculture or mining, and has no development rights or urban zoning for development. Options for development of this land should be weighed and alternatives for final development should be submitted. In case of developing land for residential purposes, the application has to state that other options have been considered, for instance agriculture, demand in area, open space, tourism, commercial, industrial development, recreational areas, grazing and so on. The application should state reasons as to why residential development was considered over other development options. Other considerations include infrastructure (extension of bulk services), current zoning of land;

municipal IDP, SDF, EMF, SEA, urban edge, topography, geotechnical studies and the distance from watercourses (Briel, 2005).

In this chapter, the concept of radon has been simplified and broken down according to understandings in different parts of the world. There is a risk of developing lung cancer from radon exposure if you are a smoker and non – smokers are at risk if they do not control the level of radon. Exposure to radon for 5 – 30 years, and even more, does not necessarily cause lung cancer. According to the study conducted by Enflo (2002) in 1999, there were numerous incidents of lung cancer between the ages 0 to 19, while there were only two between the age of 20 and 25. The risk is extremely high from the age of 45 to the age of 79 years: there were 1925 incidents of lung cancer from radon exposure in this age group (Enflo, 2002). In South Africa, just as much as is in other parts of the world, land contaminated with radon could be developed for housing purposes and the level could be kept to an internationally acceptable level. Table 3.5 below shows a number of authors who have investigated the concept of radon and its dynamics. The research shows that radon is more dangerous indoors as compared to outdoors given that there is no proper ventilation.

Investigations have also revealed that there is a positive relationship between radon and smoking, ex – smokers, gender, body weight, secondary exposure to smoking, and age differences. The risk of contracting lung cancer is related to the increase of radon levels per measurement. Robinson (1996) reported that in Barley and Krasnokamensk people living within these cities had been exposed to 170 Bq/m^3 radiation level for 17 years

without treatment. There were no cancer related illnesses reported from residents, irrespective of the fact that Barley residents were suffering from radiation levels of 2800 – 3000 Bq/m^3. The norms and standards on radon exposure of 200 Bq/m^3 are that 3 – 5% of the total population will contract lung cancer (Winter, 2000 - Newsletter). Drawing from the above-mentioned factors, radon is a long-term risk. The table below (3.5) gives a general understanding on how far radon, its concentration level, and risk have been researched in the years. Table 3.5 illustrates a summary of most articles read on radon.

Table 3.5 *Authors on radon contamination*

Author	**Studied**	**Outcomes**	**Acceptable radon level**
Australian Radiation protection and Nuclear Agency, 2002. *Radiation and Health Information.* www.arpansa.gov.au/is_radon.htm	Conducted a nationwide survey	Most homes were found be at 10Bq/m^3	Below 200 Bq/m^3
Kreswki, D.; Lubin, J. H.; Zielinski, J. M.; Alavanja, M.; Catalan, V. S.; Field, R. W.; Klotz, J. B.; Letourneau, E. G.; Lynch, C. F.; Lyon, J. I.; Sandler, D. P.; Schoenberg, J. B. Steck, D. J. Stolwijk, J. A. Weinberg, C. and Wilcox, H. B. 2005. Residential Radon and Risk of Lung Cancer: A Combined Analysis of 7 North American Case-Control Studies. *Epidemiology.* Vol. 16, no. 2.	Residential radon in North America	The risk of contracting lung cancer increased with an increased level of radon concentration	100Bq/m^3 will result in contracting lung cancer in a period of between 5-30 years of exposure to radon.

Table 3.5 *Authors on radon contamination*

Author	**Studied**	**Outcomes**	**Acceptable radon level (country)**
Pershagen, G. Ruano-Ravina, A.; Ruosteenoja, E.; Schaffrath Raosario, A. Tirmarche, M. Tomasek, L.; Whitley, E.; Wichmann, H-E.; and Doll, R. 2004. Radon in Homes and Risk of Lung Cancer: Collaborative Analysis of Individual Data from 13 European Case-Control Studies. http://bmjjournals.com/cgi/content/full/330/7485/223.	13 countries in Europe for radon related lung cancer (most countries included males and females except Finland with only males and Stockholm with females; the other countries were England, France, Eastern Germany, Western Germany, Italy, Spain, Stockholm, Austria, Czech Republic, Sweden,) six of these countries had respondents who were never smokers, some were ex-smokers and variation of age group	The results showed that current and ex-smokers had a high risk depending on their history of smoking and the age at which they started smoking as well as gender was a determinant.	46 Bq/m^3

Table 3.5 *Authors on radon contamination*

Author	**Studied**	**Outcomes**	**Acceptable radon level**
Johnson, D.; O'Connor Jr., R.; Tarrag, M. D. and Tucker, P., 2001. Case Studies in Environmental Medicine.	Radon risk if you were a smoker or a non-smoker	Smokers are more likely to contract lung cancer than non-smokers	0.4 pCi/L
World Health Organisation, 2005. Radon and Cancer. www.who.int/medacentre/factsheets/fs291/en/	Concentration of radon in homes in different countries	Radon is a serious hazard that can be easily mitigated. Radon was found to be higher in countries where houses were built on soils with high uranium. [1000 Bq/m^3]	5-15 Bq/m^3

Table 3.5 *Authors on radon contamination*

Author	**Studied**	**Outcomes**	**Acceptable radon level**
European Respiratory Society. Position paper of the European Society on the consultation launched by the commission on the thematic domains of the 7th framework Programme Research. www.ersnet.org	Respiratory problems and major causes of high deaths of lung cancer	Radon act synergically with smoking to increase the risk of contracting lung cancer, non-smokers are also at risk	
Potential for human exposure	Transportation of radon to indoor	Building materials contribute little risk. Radon released from groundwater to the air is estimated at 100-600 pCi/L which is equal to 22.2 Bq/m (3). The major source of radon in a dwelling is the soil under the building. High ventilation is the most important tool to reduce radon concentration.	0.150 pCi/L or 5.55 Bq/m^3

Table 3.5 *Authors on radon contamination*

Author	**Studied**	**Outcomes**	**Acceptable radon level**
Europe's Cancer Burden. http://www.uicc.org/fileadmin /manual/5burden. pdf#search =%22Europe's%20cancer%20burden%22	Sources of cancer that could be avoidable	Radon contributed at least .2% of all cancer death that could be avoidable	N/A
Robinson, P. 1996. Environmental Damage and policy issues in the Uranium and Gold Mining Districts of Chita Oblast in the Russian Far East. South West Research and Information Centre. www.sric.org/mining/docs/chitafin.html	The problem of radiation exposure of Barley and kransnokamensk	The population of these two towns was exposed to the release of 170-radiation level for more than 17 years without treatment. In Beley alone the radiation rate was reported to be between 2800-3000 Bq/m^3 compared the Russian acceptable standard of 200 Bq/m^3. In both towns it is	150 Bq/m^3

Table 3.5 *Authors on radon contamination*

Author	**Studied**	**Outcomes**	**Acceptable radon level**
		estimated that more than1 000 homes suffer from radiation exposure above the acceptable international action level.	
Roper, W. L., 1990. Toxicological profile for radon. http://www.atsdr.cdc.gov/toxprofiles/tp145.html	Effects of radon	Radon has adverse effects on health.	
Newsletter, Environmental Radon: Health risks from radon. Winter 2000, issue 25.	Investigated health risk associated with radon exposure.	The study showed that at least 3% - 5% of people who are exposed to 200 Bq/m^3 of radon would have lung cancer. There are other cancer diseases that results from radon except lung cancer.	200 Bq m (3)

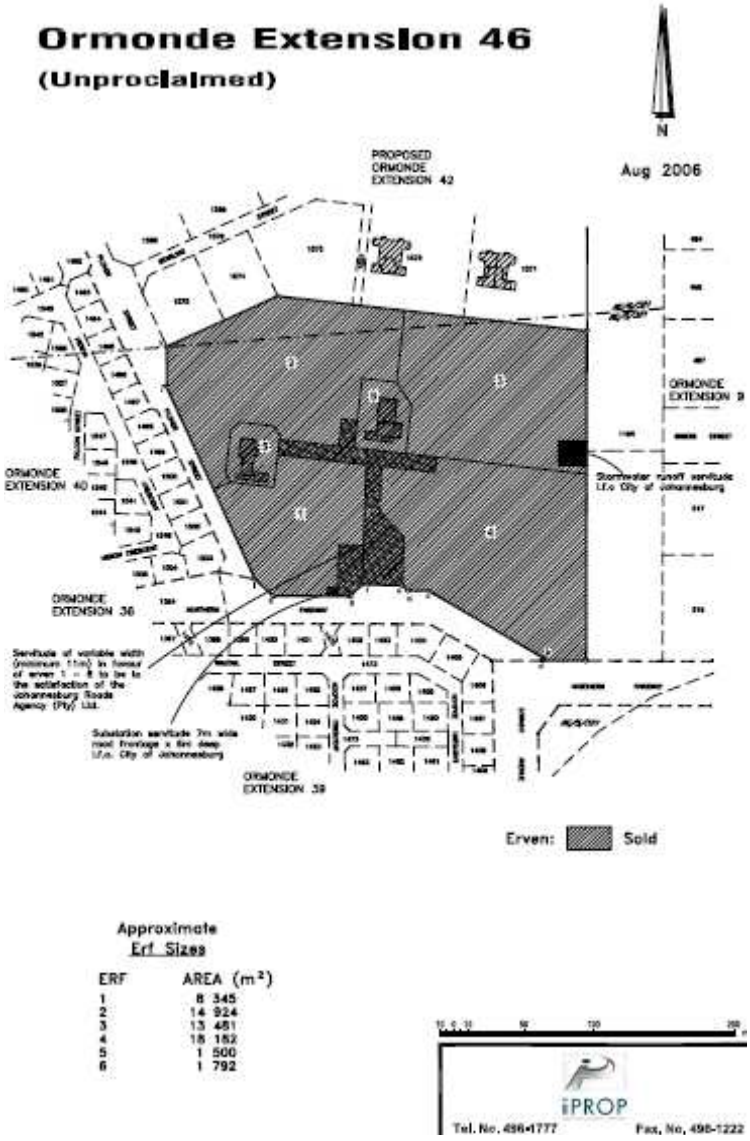
Chapter 4

Findings and Analysis

The land proposed for housing development has radon contamination and exposure to it could result in lung cancer in the long term. The level of radon is only known for site 5 in Ormonde Extension 46 where the area has been fully prepared and ready for development to take place. The map of Ormonde Extension 46 below shows six different Erfs where development of different types of dwellings will be built. In addition, the map shows the sizes of these Erfs in square meters. This site has been done on an add hoc basis over a long period of time. This was the reason it was not possible to establish how much it cost iPROP to clean this land and how much radon there was initially. With regard to the time it took to remove mine tailings which were not that big, it took iPROP nine months and it should be noted that this activity was happening only occasionally because this land was not in high demand back then. Another problem was that developers were unwilling to pay the price requested by iPROP.

It was not easy to tell whether respondents would respond negatively or positively to the survey, given the status of the land and the stigma of lung cancer. The survey provided a section where informants could make a choice about their willingness to take a given type of risk, which was the challenging part because radon was also part of those most feared risks like dying in a taxi accident or contracting HIV/AIDS and dying in ten (10) years'

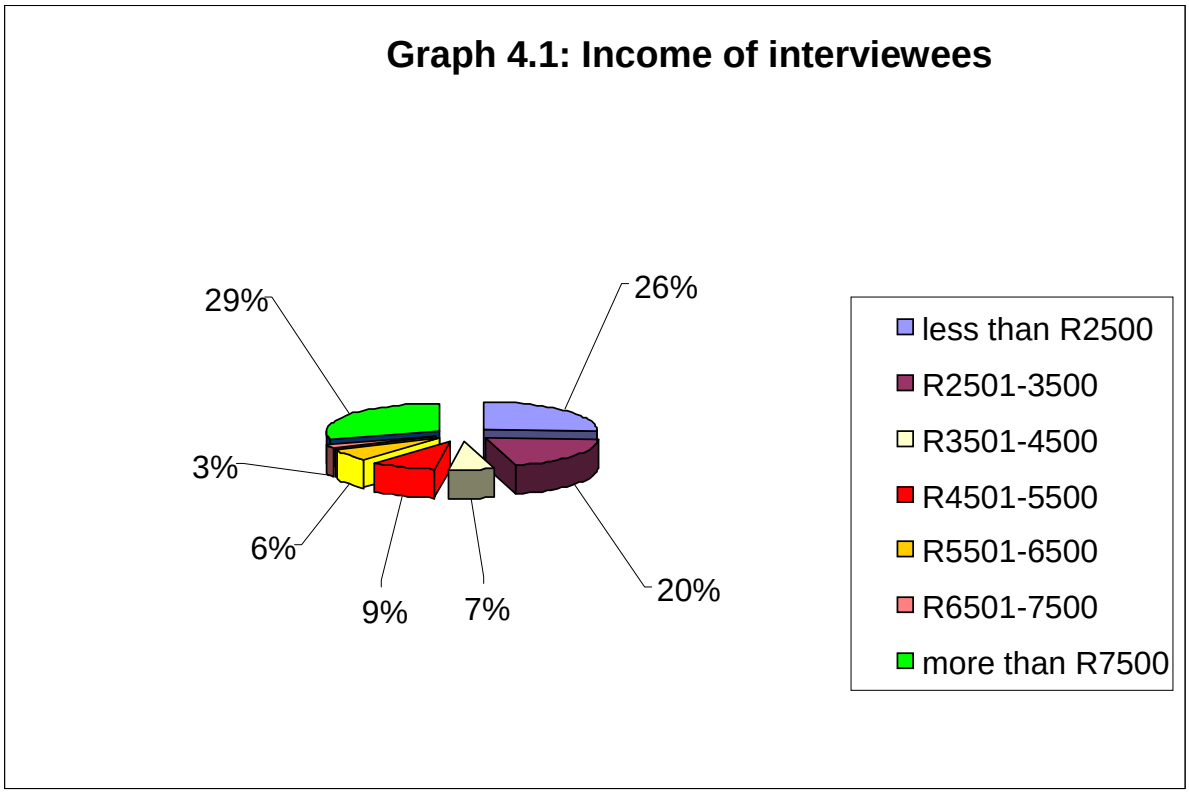
time. Below is the presentation of how interviewees responded to the survey and later on in this chapter, is the analysis of the findings against the literature review.



Findings

The data presented in this investigation were collected by postgraduate Housing and Development Planning students. The author of this report was also part of the data-collection team. A total of 216 surveys were administered in Orange Farm, Orlando East (Soweto), Southgate Mall, Eastgate Mall and Braamfontein. A large number of interviewees were from Southgate Mall with a total of 48%; 19% were from Orlando East; 13% from Orange Farm; 14% from Eastgate Mall and only 4% from Braamfontein. The demographic profiles of informants presented with pie charts below are basically related to the field of investigation. Due to their relevance to the investigation, age distribution, income differences, level of education and sources of transportation were investigated and the results are presented below. Other areas that were investigated are types of risks which participants are able or willing to take and four housing scenarios with different locations in which clean land and proximity were investigated. The results of the survey are presented below.

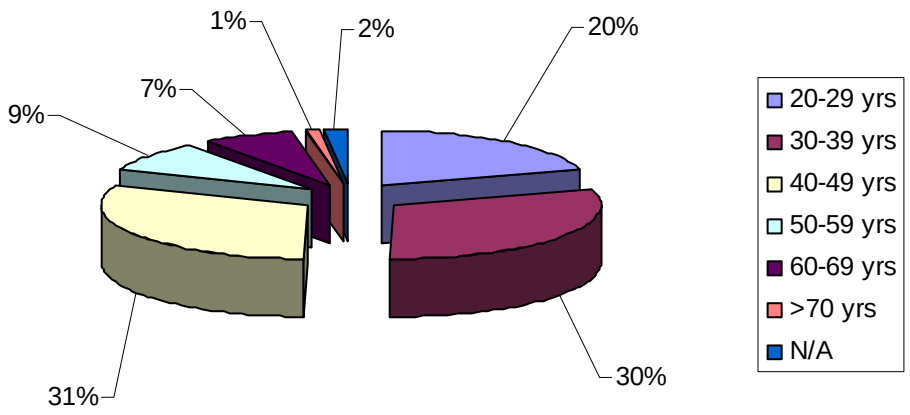
Level of income is very important in pursuit of shelter, especially in areas close to the CBD. It is very difficult for the bank to grant a bond for people who have unstable incomes. The results of income distribution from informants are not what were anticipated. Graph 4.1 below illustrates that at least 26% of informants earn less than R2 500 and 29% have an income above R7 500. The results show that a good number of people have, or are in a position of securing a bond.



Age is an important fact to consider in a situation where lung cancer is a threat to people living around areas with radon. According to an investigation conducted by Enflo (2002) in Sweden, age and lung cancer are closely related. In his investigation, Enflo (2002) discovered that chances of contracting lung cancer are very high between the ages of 50 and +85. Between the ages of 0 and 50, the chances are at least 1 in 100 000. Graph 4.2 below demonstrates that 61% of our respondents are between the ages of 50 and 70. This age group is a vulnerable group to contract lung cancer. On the other hand, Krewski et al. (2005) have argued that there is a window period of between 5 – 30 years before one could contract lung cancer from radon exposure. This is irrespective of exposure to any

substances or factors that have the potential of catalyzing contraction of lung cancer due to radon. On the other hand, the US EPA (1992) have a different idea: they argue that smoking will facilitate development of cancer from individuals exposed to uncontrolled radon. The community of Beley in Russia was exposed to uncontrolled radon limits above local and international standards. This community had lived in this former mining land for 17 years without any diagnosis of lung cancer from their members. It is important to note that these environmental health hazards are context-specific. Nevertheless, one should note that uncontrolled radon will result in lung cancer and smoking will speed up the process.

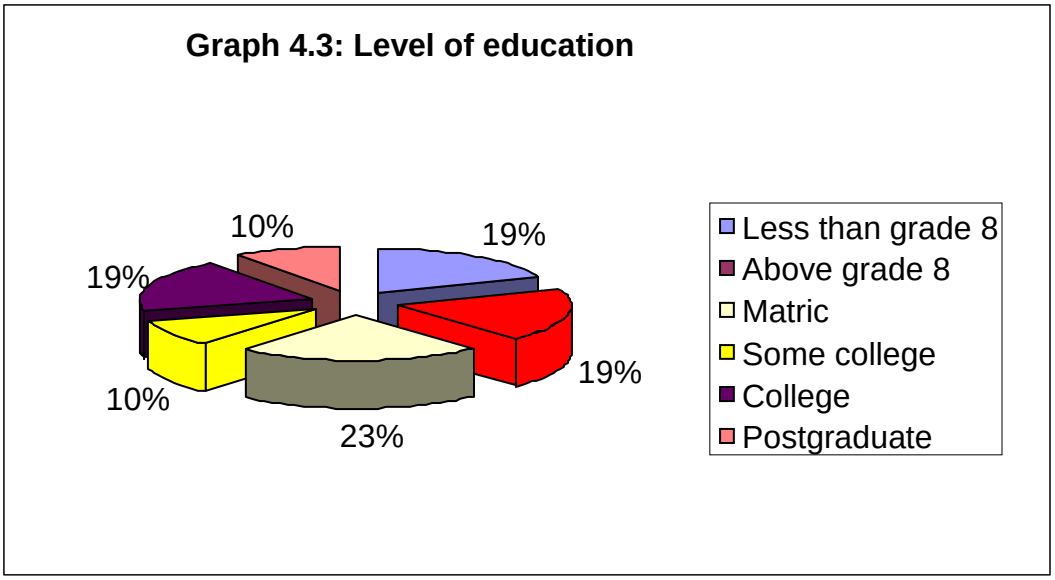
Graph 4. 2: Age distribution of interviewees



In general, people have a belief that educated people are more informed as compared to people with lower level of education or no education at all. According to Priskin (2003), who did a research on tourists' perceptions of environmental degradation caused by their activities, he discovered that high levels of education are related to higher environmental

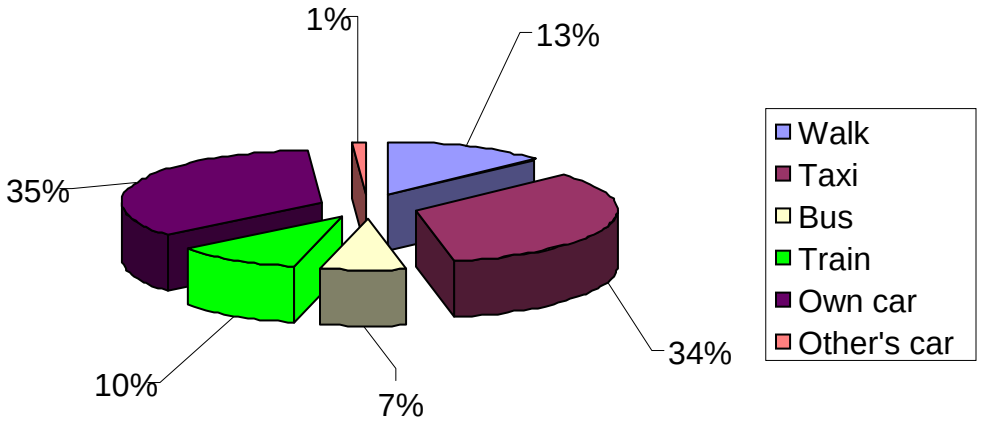
awareness. He also discovered that the attitude of from those with higher levels of education showed ignorance rather than lack of environmental awareness. The results on graph 4.4 show that 38% of respondents do not have a Matric (Standard 10 or Grade 12) certificate, while 39% have been exposed to tertiary education.

Graph 4.3: Level of education



The advocates of city compaction and integrated development have used transport as one big fact for their theories. This was evident in Curitiba which is one of cities in Brazil were city compaction and integration was applied and people are traveling between 4 and 5 kilometers from home to work and from work back home (Todes, 2003). Traveling distances are extremely high in the city of Johannesburg compared with Curitiba. In Orange Farm, traveling distances to the CBD is not less than 30 kilometers, depending on the area from which one is departing. Figure 4.5 shows that 13% of the population walks to work, while 35% use their own cars and there is high reliance on public transport. The results show that 51% of informants rely on taxis, buses and trains.

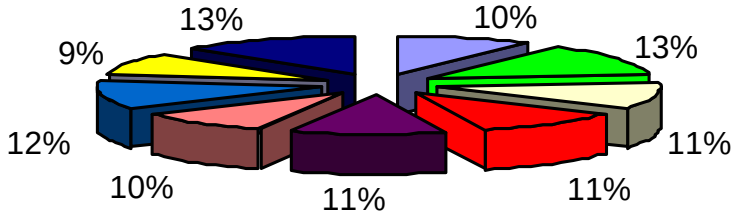
Figure 4.4: Sources of transportation



Everyday activities that we are involved in has one risk or the other. Driving a car has a risk of death, temporary disability, permanent disability and also a risk of taking somebody's life. Other activities could be swimming, working environment, walking on the street and so on. The high percentage of an item shows that people are willing to take that risk. The results from the chart below shows that radon, contaminated water and breathing mine dust are not the most feared. According to the survey, radon makes the top three-feared risk. The researcher had assumed that radon would be highly rated as the most feared risk to take due health hazards associated with it. Respondents feared riding in a taxi and smoking, which both came first with 13%. The survey also asked respondents to give three types of risks that they feared most in their ranking format of the first being the most important, second mid-important and third being the least important. The results on graph 4.5 showed that HIV/AIDS was the most feared risk as it came up with 30% of the total population; and TB came second with 16% and lastly was

getting sick from contaminated water. One can assume that the media affected how respondents made their choice. In the media these days there is lot of news and adverts that are talking about HIV/AIDS; meanwhile TB is also related to HIV/AIDS. In late 2005, there was news coming from many places in South Africa and Africa talking about diseases that are caused by drinking unpurified water.

Figure 4.5: Willingness to take risk



- Getting HIV/AIDS, dying in 10 years
- Riding in a Taxi, maybe having accident
- Getting Tuberculosis (TB), being weak and sick
- Dolomite soils/house collapsing in hole
- Driving on bald tyres and having a car smash
- Breathing problems from blowing mine dust
- Radon and small cancer risk in 20 years
- Getting very sick from contaminated water
- Smoking cigarettes and cancer risk in 20 years

The last part of this investigation was housing scenarios in which the area in Scenario A is clean, but traveling time is 1 hour to the CBD; in Scenario B a vegetable garden cannot

be grown; in Scenario C the area is affected by radon and there is a health risk; and lastly in Scenario D the area has mine tailings that are 30 meters high. In scenario B to D, the traveling time to the CBD with a taxi is 10 minutes and all the houses are of equal size. There were 205 respondents who had taken a choice and decided to bid on four of these scenarios. There was a base that was set and respondents had to bid on it first before they can bid on the other four scenarios. Those who refused to bid on the base were not allowed to bid for the other four scenarios. On scenario A, 95%; Scenario B is 87%; Scenario C is 73%; and, lastly, 67% bidded as is represented on graph 4.6. As the bid was decreasing in percentage, the amount to purchase a house described on scenarios was also going down. This basically means that people are willing live in areas affected by the factors on scenario B to D; but they will need a discount. The table below (graph 4.6) shows percentages of bidders and the negative percentages show depreciation from the base.

Figure 4.6: Results of Contingent Valuation Analysis

Scenario A: Far away			**Scenario B: Close in Flats**		
Invalid bids	9		Invalid bids	16	
Premium bids	14		Premium bids	17	
Total Bids	186	**94.9%**	Total Bids	165	**87.3%**
Average bid	-28.1%		Average bid	-33.7%	
Top 1/2 bid	**-2.8%**		Top 1/2 bid	**-6.1%**	
Top 1/4 bid	**4.9%**		Top 1/4 bid	**6.1%**	
No bid	10		No bid	25	
Total valid bids	196		Total valid bids	189	
Grand total	205		Grand total	205	
Scenario C: Radon			**Scenario D: Mine dust**		
Invalid bids	12		Invalid bids	7	
Premium bids	0		Premium bids	0	
Total Bids	141	**73.1%**	Total Bids	136	**68.7%**
Average bid	-53.9%		Average bid	-68%	
Top 1/2 bid	**-31.4%**		Top 1/2 bid	**-50%**	
Top 1/4 bid	**-20.5%**		Top 1/4 bid	**-36%**	
No bid	52		No bid	62	
Total valid bids	193		Total valid bids	198	
Grand total	205		Grand total	205	

Source: Simons, et al. 2005 pg 17

Analysis

The results show that people have an understanding of radon, contaminated water and mine tailings problems. Overall, respondents perceived taking risk on radon contaminated sites better than any other risks they had been exposed too. There is also an understanding of risk associated with a radon-contaminated housing environment, although it differs as to how it is treated. This suggests that low-to-moderate income housing can be developed and there would be a market amongst those interested in living in the sites identified earlier.

The issue of proximity also influenced some of respondents' positive responses towards housing development on CoJ's former mining sites; even in some other cases some would say that staying away from the family would be an option, but only a few. The responses were expected to show positive results given that most of respondents were from the south and east of Johannesburg where the mining belt is cutting through. However, some alluded that they had been staying in this environment since they were born and a change of environment would be preferable. From this brief analysis of respondents, it shows that a good number of people would like to be around the CBD and be able to commute for few minutes, close to entertainment, services, etc.

People who earn less money normally make fewer choices because they cannot afford higher amounts. It this case, 26% have an income of less than R2 500 which means the positive direction of this investigation was affected by a lack of choice from this group of

people. There is also 29% who have an income of more than R7 500, which means they have more impact to affect the outcome of this investigation positively. Since the target was above R2 500 and only 26% earned less while 74% earned more than R2 500, the conclusion is that that income did not negatively affect the outcomes of this investigation. The income results show that both low and middle-income housing could be developed and the market is available.

According to the literature, reviewed people who are above the age of 45 years have their chances of contracting lung cancer increased. The majority of the age distribution of respondents does not show a positive result, given that from the literature review, people who are above the age of 50 years are not immune from developing lung cancer. It (Enflo, 2002) has also been said that there is a window period of at least 5 – 30 years before one can develop lung cancer. In the literature review, people lived in areas where radon was above the internationally acceptable standards for many years without developing lung cancer. This is basically a biological determination, which it is not being investigated in this report. On the other hand, Richard Bennett of IPROP and Dr. Alex Tsela of NNR, are both assured that development is not allowed until measurements show that internationally (0.4 pCi/L) and locally (100 Bq/m^3) acceptable standards are met. Richard Bennet has said that in some of the sites that had been developed for residential purposes and on those that had been cleaned but no development has taken place as yet, radon had been cleared to a point to where there is almost no trace.

Priskin (2003), in his research that he conducted in Australia about environmental awareness, discovered that higher education was linked to higher environmental awareness, even though he discovered that in some instances people with high education tend to show ignorance. In this analysis, higher education is also linked with higher environmental awareness (understanding of toxicity from contaminated environment), but the impact of the media and other sources of information about environmental awareness is not neglected. The results show that 39% of respondents have some tertiary education, while 61% have Matric or less education level. This could have affected the outcomes in a way that it is assumed that people with lower education levels have lower environmental awareness. On the other hand, people with lower education are aware of problems like illegal dumping. Waste that is dumped on land not identified as a landfill site would pollute land with radon due to different things dumped on the land. Radon is not a common term that is used in everyday language, some people did not know and understand the term. Definitions and explanations of terms were provided, and informants had an understanding of those terms. These were terms that interviewees of the pre-test had problems with.

Transportation, in terms of long distances and a lot of money and time spent on traveling, especially for people who are living in Orange Farm and are suppose to take double transport before could reach the CBD. People do not like long traveling distances and wasting money on traveling rather than saving it or using it for other purposes. In addition, people who are living in Orlando East, even though they are using one means of transportation to reach the CBD; they would also prefer to be closer in order to reduce

traveling distance and save some money. Other people had said that it would be better for them to move out of Orlando East because they had been staying for a long time, for more than 30 years. Issues like this one had also affected the direction and choices people had made about moving closer to the CBD. The city of Curitiba is preferred as an ideal solution for South African apartheid cities. In Curitiba long distance traveling had been reduced where people are not traveling more than 5 km to the CBD. This idea is also supported by the New Urbanists and advocates of smart growth.

The willingness of people to take risk shows that Radon, Contaminated water and breathing mine dust is only 31% of the population and almost a two-third of the population feared any other risk as compared to the three above-mentioned types of risks. Risk is an everyday life activity which means people enter into one risk or another voluntarily and involuntarily. For instance, driving a car or riding in a taxi, having unprotected sex, walking on the street, flying and so on. Some of the risks that we take have immediate results and some are long term. For instance, having unprotected sex and contracting HIV develop fully blown AIDS and dying in ten (10) years time or having your plane crushed and dying immediately.

Types of risks were investigated and respondents were asked to make choices about their most feared risks. The results were not what it had been expected; radon, contaminated water and mine tailings were expected to make the first top three. Respondents had feared most riding in a taxi and smoking cigarette, HIV and AIDS as well as dolomite soils are very scary risks to take, TB included. Apparently people had thought that taxis have more

accidents and people die in the process, so its one risk that they would not take. One of the respondents had eluded that if it was his call to make; taxis would have been taken out of the roads because the number of people that are dying when a taxi is involved in an accident is huge. Radon and all related mining problems were less feared by respondents, especially those who are living in Soweto, Orange Farm and East of Johannesburg. They had been exposed to these problems for a long time and they are still alive even the day when surveys were administered to them. Proximity to the CBD had also affected some of their responses. There are job opportunities and opportunities of opening Small Macro and Micro Enterprises on a business environment as compared to the township.

The outcomes of scenarios were something not anticipated for as 81% of interviewees had accepted that they would stay in a house where a vegetable garden is not possible; there is radon and where mine tailings are 30 meters higher according to the survey. It seemed the least likely and it is the least likely that on scenario C and D because of environmental health problems that those scenarios had portrayed. This high bid of 81% demonstrates that there is a market and this mining land could be used for housing purposes. The South African National Nuclear Regulator would firstly need to assess the land and the level of radon prior to development. There are some areas of this mine land where radon had been cleaned to the point where there is little or traces of radon remaining, this is according to Richard Bennet.

In comparison of both the risk part and scenario part in this investigation, results show that there informants has experience living next to mining land and they do not the land

posing health risks. The risk part does show that 12% of respondents do fear radon related problems and 10% feared mine dust; 11% had feared dolomite situations and lastly 9% were afraid of contaminated water. On the scenario (B-D) part of 205 respondents, 87% had put their bid on an area that would not grow a vegetable garden (for food); 73% would put choice to stay on an area that affected by radon; meanwhile 67% would stay on land that has 30 meters mine dust. The value of the house was reduced for these bids as compared to scenario A.

The results of scenarios and types of risks do not portray the worse about developing previous mining land for housing purposes. The scenarios do show that this land has to be developed for housing but a discount has to be made because of the previous activity of the land and the risk pursued. The international experience in the literature review part does show that land with radon contamination had been developed and people had been living in these lands. There were no worse results reported about their health that could prevent these types of lands to be redeveloped for housing purposes, especially in the case of the City of Johannesburg where land had become a scarce resource. Land on the periphery had been developed for housing purposes, with the examples of Orange Farm, Braam Fishersville, Thula Mtwana, Diepsloot, Vlukfontein and Tshepisong. These are locations where double transport is used to reach the CBD and people are away from their jobs as well as job opportunities or opportunities to make a living for themselves.

Summary of findings and analysis

The data collected shows that people would take a risk of living on land that is contaminated with radon. It should be noted that people did not know that the mine tailings would be removed and radon would be cleaned to a point where there would be no trace of radon remaining on the site. Irrespective of this, respondents with their experience showed that residing on these sites is not a major risk. The literature review had also supported this where many people had lived on land contaminated with radon which is higher than international standards; they continued to live under those conditions even after they had known that they were putting their lives and their kid's lives at risk of contracting lung cancer. Ventilation is the greatest treatment of radon and radon is always higher at the basement as compared to the other levels. It is possible that people know that radon can be treated and scenarios presented to informants had avoided an apartment at the basement even knowing that development would take place when radon had been completely removed.

Chapter 5

Conclusion

This study analyses the former mining sites south of CoJ contaminated with radon for development of low-to-moderate income housing. Apartheid planning left a challenging housing backlog to the ANC-led government. The ANC government developed low-income houses (RDP) at the periphery of cities contributing less to integrated planning. Mining sites were identified within developed housing areas. Mining land has health hazards posed by different substances, radon being one of those. Research performed in different parts of the world concerning contaminated land and radon on mining land is addressed. A survey was conducted amongst residents east, south and south west of the CoJ, soliciting information on voluntarily residing on previous mining land that had been contaminated with radon.

The results of this research show that there are environmental health risks associated with mining land and radon is no exception. There are other factors that facilitate contraction of lung cancer because of radon exposure. These factors, amongst others, include smoking and secondary smoking, body weight, age, gender and poor ventilation. People who are 45 years, women and smokers have increased chances of contracting lung cancer associated with radon exposure. 81% of the interviewees would have no problem residing on land that is contaminated with radon and that is along mine tailings. Radon-

contamination is treated by increasing ventilation and by avoiding living at the basement, ground floor and first floor (to a lesser extent) where the level of radon is high.

Although this research does show that many people are willing to live on land contaminated with radon, it does not mean that if they had a better choice they would still opt for this type of land. The CoJ is in Gauteng and Gauteng is the smallest province within the country with the highest population of about nine million. There are about 100 informal settlements in the CoJ and many people are looking for a place to stay. The former mining land south of CoJ has to be utilised in order to combat growth of informal settlements and developments at the urban edge of the CoJ.

Land contamination, radon and risk have been unpacked in this investigation. The literature review has shown that internationally the problems of both contamination and radon have been acknowledged and dealt with. Land with contamination and land with radon have been developed for both housing and commercial purposes. The experience also shows that the land could be cleaned to a point that no trace of radon would be found or an acceptable international level could be reached which is equivalent to the level of radon gas in the outdoor air.

Recommendation

There is a lack of land suitable for development of houses within built-up areas. Low-income houses have been developed at the periphery of the CoJ, perpetuating the

apartheid spatial planning. The former mining land south of CoJ lies within developed areas and will, if utilized, contribute to the integration of the city. It is due to this background that former mining land in well-located areas should be utilised for development of low-to-moderate income houses.

Radon gas is high on mining land and poses health risks to humans. Ventilation is the only tool that could be used to reduce the concentration of radon. Radon is high at the basement and ground floor, though the first floor is better. People are therefore discouraged to live at the basement and ground floor, and to ensure increased ventilation. In addition, people who are above age 45 should regularly ventilate their houses because they are vulnerable to the development of lung cancer from radon exposure. Smokers, ex-smokers and those who live with people who are smoking in the house have their chances increased of developing lung cancer. Body weight has also been linked to lung cancer due to radon exposure. It is important to note that radon is higher indoors as compared to outdoors. Increasing ventilation indoors neutralises the concentration of radon so as to be the same as radon outdoors. Therefore, people who are smoking and are above the age of 45 should ensure increased ventilation.

Housing delivery within South Africa has not been compliant with some principles of the social housing development. These principles, amongst others, include proximity to amenities, job opportunities, and well-located land benefiting from spin-offs, especially economic opportunities created by the environment. In most cases, these houses are without basic services, job opportunities, social amenities, transport routes and other

major infrastructure. Houses delivered at Orange Farm, Braam Fishersville, Thula Mtwana, Diepsloot lack some important basic services.

This investigation has shown that from international experience, former mining land with one contamination or another could be redeveloped for housing purposes. Site 5 had radon contamination and mine dumps that were removed and the site has now been earmarked for both single and three storey dwellings. It is therefore recommended that Johannesburg, Gauteng and South Africa as a country consider reviewing the housing policy to utilize former mine sites on well-located land.

According to Tomlinson (2001) formal banks do not offer housing finance for low – income earners. Financial institutions should consider offering financial assistance to accommodate people who would like to invest in properties developed on former mining land. Information solicited from scenarios revealed that the market for these types of houses is high, which Boaden and Karam (2000) termed a secondary market. That market created in these mining sites is both primary and secondary for both low-to-moderate income earners. According to Smit, (2003) banks offer R60 000 as the end-user finance which is translated into payments of between R150 and R600 per month. In the same way, Porteous and Naicker (2003) argued that this amount is only for starter homes. On the other hand, South African Housing Scheme offers a housing subsidy to household earners of less than R3 500 (Khan, 2003), while the survey revealed that household incomes are at an average of R5 500. Lastly, it is also recommended that financial

institutions reconsider their standard rate of 20 – 25% on bond repayments. This rate is too high for low – income earners.

The role of local government in housing is to co – ordinate housing development and access funds for infrastructure development (Thring, 2003). Local authorities should take responsibility and promote integration by locating new housing development within developed areas close to amenities, and both social and physical infrastructure. Map 1.1 in Chapter 1 shows that the focus area is on well – located land to promote integration. Local authorities should make use of these areas in order to combat peripheral development. According to Pottie (2003) it is the role of local government to identify land for housing with access to service delivery. This land (in this case the former mining land south of CoJ) is situated close to services and job opportunities, transportation and a stadium for people to explore the economic spin – offs that will develop soon due to the soccer World Cup in 2010.

Policy formulation and analysis is the responsibility of both national and provincial government. Local government can utilise its ability to participate on issues of co-operative governance in which policy development and analysis is a function of all spheres of government (Pottie, 2003). This would be an opportunity for local government to make an input about support and development of former mining land for housing development of both low – to – moderate-income housing.

The provincial sphere of government has a responsibility of ensuring fairness, equity and compliance of housing development within national norms and standards. Other specializations of provincial government are to provide capital grants for housing development and to monitor the progress with the Provincial Housing Board (Pottie). Given these responsibilities of provincial government, including that of policy development and analysis, it is therefore recommended that provincial government consider the use of well-located former mining land for development of low – to – moderate housing.

The most important role of national government is to create an enabling and supportive environment for the development of housing through creation and analysis of policy and supportive legislations. Given the responsibilities of national government, it is therefore recommended that national government take into consideration the availability of former mining land for development of low – to – moderate income housing through policy and legislative development and analysis. National government should also consider offering housing subsidies for low – income earners on former mining sites on well – located land.

The National Nuclear Regulator (NNR) is a competent regulatory body in South Africa for regulating the safe use and handling of radioactive and nuclear material. An application for the release of land with contamination has first to be lodged with the NNR, and, for safety purposes and compliance, the clean-up plan has to be developed, reviewed, implemented and a post – clean-up report has to be written before the land can be released. If safety is ensured, then land can be released for housing purposes.

According to measurements if South Africa through the NNR, radon should not exceed 100 Bq/m^3.

Former mining land remains available and it is recommended that housing developers utilise this land within the country.

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Survey Questions

Hello, my name is _____. I am a Master student at Wits researching about environmental-health risks involve in residential development on Johannesburg's former mining sites. Think about where you live, and where you would like to live and answer to the best of your ability. Thanks for agreeing to talk to me. Please be assured that this is a confidential interview and if you feel uncomfortable, we can stop anytime. Can you do the interview in English, (y/n) ____ or would you prefer another language (what??)_____

How long have you lived in your current house? _____

Do you own or rent your house? _____

If you own, do you have a bond (loan) on your house? (Y/N)_____

If you rent, would you consider getting a bond to buy a house (Y/N)_____

Where do you want to be living in 5 years? _____

Now let me ask you a few questions about taking chances and risk. I am going to mention a few items, and I would like you to tell me how important it would be to avoid these things. We will use the scale of 1-5, where 1 means you are really concerned about it, 3 means you are somewhat concerned, and 5 means you are not worried about it.

Getting HIV/AIDS, dying in 10 years	***1***	***2***	***3***	***4***	***5***
Riding in a Taxi, maybe having accident	**1**	**2**	**3**	**4**	**5**
Getting Tuberculosis (TB), being weak and sick	**1**	**2**	**3**	**4**	**5**
Dolomite soils/house collapsing in hole	**1**	**2**	**3**	**4**	**5**
Driving on bald tyres and having a car smash	**1**	**2**	**3**	**4**	**5**
Breathing problems from blowing mine dust	***1***	***2***	***3***	***4***	***5***
Radon**and small***** cancer risk in 20 years**	**1**	**2**	**3**	**4**	**5**
Getting very sick from contaminated water	**1**	**2**	**3**	**4**	**5**
Smoking cigarettes and cancer risk in 20 years	**1**	**2**	**3**	**4**	**5**

Which are the three risk activities that most concern you?

1_____

2._____

3._____

Now let's talk about transportation to and from work and shopping.

Do you own a car? _____

How did you get to work yesterday (or the last time you went) (tick one):

Walked____ Taxi___ Bus___ Train___ own car____ another's car____

bicycle_____

How long did it take you to go to work one way (minutes): _____(time)

How much do you pay one way to get to work?_____

Scenarios

*Thanks again for answering our questions. The next section asks some 'what-if' questions. Let's suppose you are looking for a new home in a different location. You need to find a home quickly and have been looking for some time. You are looking for a four-room house with registered ownership, with water, a sewer system, electricity, a place to park a car, and you find one that meets your space and location needs. If the neighborhood is also what you are looking for, what is the most you would be willing to offer (total price) to buy the home**?*** (in Rands) _____******

Would you need a government subsidy to buy this? (y/n)___

Now I am going to give you several different scenarios. These scenarios are "what if" situations. Each one is completely independent of the others. In other words, the conditions in one description do not exist in any of the other descriptions. For each scenario, imagine we are talking about the house I just described to you a moment ago and on which you just gave a price. Everything about the home and the area it is located in is the same as for your home except for the additional factors we name in the scenario. After I have read you each scenario I will ask you a few questions about it. OK?___

Scenario A. The house is located about one-hour's taxi ride from the Johannesburg Central Business District. The area is a new development, and is just beginning to have

schools and shopping developed. There are very few trees there. The house has four rooms, and sits on a small stand, and can be expanded as needed. Except for this one factor the rest of the neighborhood is like yours, and the house is very similar to your house.

Using the 1-5 scale where 1 is very likely, and 5 is very unlikely, how likely is it that you would make an offer on this home?

Likely **Unlikely**

Would

1 2 3 4 5

What is the **most** you would be willing to pay for the home?_____

Scenario B. The home is located within a kilometer of Main Reef Road, between Soweto and the Johannesburg Central Business District. The travel time to the CBD by taxi is 10 minutes. The house is new, and has other new homes around it. Schools and shopping areas are nearby. A vegetable garden on the ground is not possible, and the 4-room unit is on the second floor of a 3-storey building. Except for this, the home and neighborhood are just like the one you are looking for.

Using the 1-5 scale where 1 is very likely, and 5 is very unlikely, how likely is it that you would make an offer on this home?

Likely ***Unlikely***

Would

1 2 3 4 5

What is the **most** you would be willing to pay for the home?_____

Scenario C . The home is located on former mining land, close to the Johannesburg Central Business District. Schools and shopping areas are nearby. The travel time to the CBD by taxi is 10 minutes. The mine tailings have been taken away, but the land has a small amount of leftover chemicals under it, including radon****. The site has been cleaned to where the levels are the same as property elsewhere. The government is satisfied that the property is suitable for housing. There is a small***** risk of having health problems in 20 years. Vegetable gardening on the ground is not possible, and the 4-room unit is on the second floor of a 3-storey building. Except for this, the home and neighborhood are just like the one you are looking for.

Using the 1-5 scale where 1 is very likely, and 5 is very unlikely, how likely is it that you would make an offer on this home?

Likely ***Unlikely***

Would

1 2 3 4 5

What is the **most** you would be willing to pay for the home?_____

Scenario D. The home is located on former mining land close to the Johannesburg Central Business District. The travel time to the CBD by taxi is 10 minutes. Schools and shopping are nearby. The house is located next to an existing mine dump that is 30 meters high. Sometimes the wind blows the dust onto the neighborhood where the house is located. There is a risk of having health problems. Vegetable gardening on the ground is not possible, and the 4-room unit is on the second floor of a 3-storey building. Except for this, the home and neighborhood are just like the one you are looking for.

Using the 1-5 scale where 1 is very likely, and 5 is very unlikely, how likely is it that you would make an offer on this home?

Likely **Unlikely**

Would

1 2 3 4 5

What is the **most** you would be willing to pay for the home?_____

Demographics of household composition. ***We are almost done, now we have just a few final questions about you:***

Which best describes your current house: (check one) informal house___

RDP house __ , Formal private sector house____, Other (what)_____

Your Age: (tick one) 20-29___ 30-39___ 40-49___ 50-59___ 60-69___ 70+___

Education: (tick one) Less than grade 8___, Some High school (standard 8)___

High School grad Matric)___ some college____ college grad____ post grad_____

Did you attend secondary school in a rural area (Y/N)_____

How many persons lived full time in your house last week: (number) __

Of these, how many children under 18 years_____

How many employed (full and part time) people were living in your household? ____

Recent monthly income (for entire household, tick one)

Less than Rand 2500 ____

2501-3500 ____

3501-4500 ____

4501-5500 ____

5501-6500 ____

6501-7500 ____

More than Rand 7500 ____

(If own) Value of your present house _____, (or) Monthly Rental paid _____

Thank you very much for your time!

<u>If asked, elaborate as follows</u>:

*** CBD means town***

**** Extended family means relatives, family***

***** Flat means a one storey home in an apartment building, not on ground***

****** Radon means a radioactive gas formed by the decay of uranium***

*******small risk means one cancer death out of 1,000 persons, in 20 years***

******** If respondent cannot provide an answer in Rands, then review prior answers from the first part, and restate their housing situation. Refer to their response to where they would be living in 5 years, and ask about how much they could afford, in a range.*