

# **The Future of Penge**

## ***Prospects for People and the Environment***

**Submitted by:**  
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## **Project Report and Guidelines**

For the Asbestos Relief  
Trust

**Final Report, July 2008**

## **EXECUTIVE SUMMARY**

The Centre for Sustainability in Mining and Industry (CSMI) was approached by the Asbestos Relief Trust to conduct follow-up research and formulate policy options for Penge, a former asbestos mining village in which a community still lives.

The following themes are considered in this study:

### **The Socio-economic History of the Penge Community**

In this section, the concerns, aspirations and livelihoods of the Penge community are described. Most of the present inhabitants moved into the former mining village in 1993, when the asbestos mining came to an end. Local administration was handed over to the Lebowa government. In the transition from apartheid to democracy and the formation of new provinces, the former mine found itself in an administrative limbo. In 2007 the Provincial Administration gave permission to the French mining company, Emorys, to develop a housing scheme in Penge. This drew strong criticism from the Head of the Department of Community Health at Limpopo University, Dr Steven Donohue. His investigation into conditions of health and safety in the area provided evidence of heavy asbestos contamination. There are virtually no economic activities in Penge itself and there appear to be high levels of unemployment among inhabitants. The village infrastructure has fallen into disrepair with derelict buildings, roads and bridges.

A CSMI site visit in January 2008 provided evidence of visible asbestos fibres all over the paths, side-walks and dirt roads. Schools have closed down and the hospital has been downgraded to a clinic. Most children have to walk five kilometres to and from school, as taxis are too expensive. There appear to be few prospects for the development of a local economy that might bring employment. The idea of making the village into a tourist attraction was mooted by the Province, but this should not be encouraged, as the area remains a source of danger to health. While the people who live in the area wish to continue to do so, many expressed discontent at the lack of services, including water reticulation and sanitation. There is a police station and a local ANC Proportional Representation Councillor lives in the village.

### **Public Health Risks to the Penge Community**

Current public health risks are assessed on the basis of public and occupational health records of asbestos-related deaths and diseases, the characteristics of the asbestos fibres found at Penge, and exposure pathways – past and present – which are associated with occupational exposures, residential exposures, outdoor exposures and ambient air.

### **Rehabilitation of the Biophysical Environment**

Prospects for environmental rehabilitation of the Penge district are assessed on the basis of information on the extent of contamination. Sampling of soils, vegetation and fauna were conducted in 2007 by REDCO (a firm of Environmental Consultants). Data from the samples analysed were kindly made available to the authors of this report. The data were interpreted by Professor Mary Scholes. The lack of baseline

data from the time the initial rehabilitation took place in 1994 makes it very difficult to evaluate the success of the rehabilitation measures. Four different re-vegetation treatments were used during the rehabilitation process and the data indicate that there are no significant differences across the dumps that can be related to these different treatments. The woody vegetation cover is adequate to provide shade as well as fodder for some livestock. The grass cover is low and careful management of the dumps would be required to prevent this cover being trampled if livestock continue to roam on the dumps. There is the potential for erosion.

### **Conclusions and Recommendations**

- It is recommended that the dumps should be used for no or very limited livestock grazing or browsing.
- It appears that the overall contamination of the Penge site with asbestos is of much greater concern than the current soil and vegetation status of the dumps.
- There are very limited efforts by DEAT and DWAF to address the environmental issues related to asbestos contamination.
- It is strongly recommended that these government departments initiate a programme, together with the DME, in order to address the pollution of the environment, including specifically air and water quality.
- It is strongly recommended that the whole of the Penge site, including the former mining village and the mine dumps, be closed to human habitation.

## INTRODUCTION

Penge falls within the cross border District Municipality of Greater Sekhukhuneland which was established in 2000. The district comprises of about a million people, and despite the growing mining industry in the Tubatse area (within which Penge is located), unemployment is very high. In 2004/5, the district's Integrated Development Plan suggested a 69% unemployment rate. In Tubatse alone, with a population of nearly 196 185 people, only 12 195 were employed, 26 038 were unemployed and 84 251 not economically active.<sup>1</sup> Penge consists of about 3000 people. While no statistics exist for the village itself, our research suggested high levels of unemployment were combined with migrant absenteeism. This study seeks to understand the current socio-economic, health and environmental conditions in Penge to ascertain the status of the health and well-being of the inhabitants in the former mining village and its environs.

In 2007 an investigation<sup>2</sup> conducted by Dr. Steven Donohue, formerly the Principal Specialist/Acting Head of the Department of Community Health at the University of Limpopo found the Penge area to be heavily contaminated by asbestos. Dr. Donohue concluded that the area was unfit for human habitation in its present state. He rejected as flawed the results of a health risk assessment commissioned by the local authorities in 2002. This Scoping Report was undertaken by Eco Rehab, based in Potchefstroom.<sup>3</sup> Donohue's findings were supported by the results of both earlier and subsequent studies undertaken by J. McCulloch, A. Davies and D. Kielkowski et al, as well as studies by Orenstein and Scheker, and Metintas and Metintas, among others.<sup>4</sup>

Dr Donohue observed that approximately 250 houses in and around the Penge mine sites were occupied by local people and the families of former mineworkers (numbering approximately 3000 people in total).

A provincial plan to establish a formal township at Penge and develop the old town as a tourist attraction, with the possible further development of a new housing estate, prompted the Asbestos Relief Trust to commission this report. The plan seems recently to have been reconsidered in the light of widespread concern by the public, among them ART, the National Union of Mine Workers and other experts. These related especially to the fears for the public health of those people living at Penge from ongoing contamination of the environment by asbestos.

Asbestos fibres are very stable in the environment and resist chemical and biological degradation. Furthermore different types of fibre have different levels of carcinogenic potency. Amosite asbestos was mined at Penge for more than sixty years for which the following health effects have been documented:

- Malignant mesothelioma, which is a cancer of the lining of the lung (pleura) and other internal organs
- Pleural disease

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<sup>1</sup> Greater Sekhukhuneland District Municipality, Integrated Development Plan, 2004/5.

<sup>2</sup> Donohue, S. (2007) 'Site Visit and Assessment – Penge Asbestos Hazard'. University of Limpopo. January 2007.

<sup>3</sup> EcoHab (2002), Penge Scoping Report,

<sup>4</sup> Mc Culloch, 2003; Kielkowski, Nelson and Rees, 2000; Davies, Kielkowski et al 2004; Metintas and Metintas et al, 2002; Orenstein and Schenker, 2000

The assessment of exposures in the Penge area suggests that a life-time spent in this area could result in a lung burden able to induce mesothelioma and pleural disease.

## **Scope of Work**

The CSMI undertook the following:

- To review
  1. The history and socio-economic conditions in the area and undertake a case study of the relationship between the communities, the mine and mine-dumps. To what extent does the community continue to use these sites for recreation and play?
  2. Existing work on public health and environmental exposure in the area.
  3. The work undertaken to rehabilitate the existing asbestos mine sites and mine-dumps in the area and associated maintenance.
  4. Case studies on the rehabilitation of asbestos contaminated areas in other regions of the world.
  
- To assess whether
  1. The current public policy legislation provides a framework for addressing the Penge situation
  2. Further measurement and research should be undertaken to assess current exposure risks
  3. To draw conclusions, based on available data and information, on the future of the Penge community and the environment.

## **Methodology**

The review draws mainly on studies that have been undertaken over the last twenty years. However short site visits were also undertaken to explore both the social and environmental conditions in the area and to assess the validity of issues emerging from the literature review. Five focus groups and key informant interviews were undertaken with the assistance of Fieldworker's Onsite, who had previously undertaken research in the area with Paul Stewart, to elicit the views of members of the Penge community about the socio-economic living conditions in Penge.

## **Research Outputs**

The CMSI agreed to deliver the following:

1. A project report covering the issues addressed in the scope.
2. Provide preliminary recommendations on whether Penge is suitable for human habitation and the prospects for cleaning up asbestos contamination drawing on the results of the review.
3. A short guideline for deciding on the future of heavily polluted areas with reference to existing public policy and environmental legislation.

## HISTORY OF PENGE AND SOCIO ECONOMIC CONDITIONS

The goal of the literature review and the field research conducted in Penge, an old asbestos mine north of Burgersfort in the Greater Tobaatse Municipality, which is part of the cross-border Greater Sekhukhune District Municipality in the Mpumalanga and Limpopo Provinces, in early January 2008 was to contextualize the socio-economic future of Penge in the general context of the mine closure in 1993 and its attendant problems. There is a growing literature on the Asbestos Mining industry in South Africa which deals with a broad range of issues spanning geology, science, the environment, occupational health and most importantly, the intersection of the economic and the social. We begin with the latter first.

Jock McCulloch's *Asbestos Blues: Labour, Capital, Physicians & the State in South Africa*, published in 2002, documents the history of the South African asbestos industry. He highlights the collusion between the state and industry in hiding medical findings of the relationship between asbestos and mesothelioma during the 1960s. Suppression of scientific and medical evidence occurred in 1960<sup>5</sup>. However, it was not until the 1980s, that members of the South African medical profession focused on the strong evidence and effects of asbestosis.

Maria Anne Felix's detailed doctoral thesis on Mafefe, in the heart of the Pietersburg Asbestos Fields, was an important stepping stone towards fuller appreciation of the health as well as the socio-economic hazards that asbestos posed. The hazards remain even after the production and the factories have ceased to exist.

Felix's study shows the consequences for community health of environmental pollution in areas where asbestos mines have closed. Felix overturns popular perceptions of asbestos as a problem of the past to be addressed solely through compensation of sick ex-employees of the mines. Her study shows the extent of ongoing secondary pollution in the communities along the Olifants River where the Pietersburg Asbestos seam runs.

Scholars worldwide, in particular Joseph Ladou, Michael Huncharek and Thomas H. Murray emphasize what they term a 'global asbestos epidemic' and the fact that there is no known acceptable level of asbestos exposure. They argue that the burden of risk related to asbestos exposure should not fall upon the public. Donohue's risk assessment corroborates this global position.

Paul Stewart's<sup>6</sup> assessment of asbestos compensation payouts undertaken for the ART described how recipients used their money. His study alarmingly highlights the misconceptions and, in too many instances, the blatant ignorance or disregard of the risks from asbestos pollution by those people living in the vicinity of former mines

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<sup>5</sup> Beresford, David. 'Death from the Rock Exposes British Firms to South African Asbestos Claims', Guardian Unlimited Archives, January 31, 1999, Accessed December 26, 2007:<http://www.guardian.co.uk/Archive/Article/0,4273,3815070,00.html>

<sup>6</sup> Wits Enterprise, "'Great Expectations' Expenditure patterns and assessment of Asbestos Relief Trust compensation awards' June 2007

and who remain most at risk. This was corroborated by the focus group research undertaken at Penge in January 2008.

The site visit that CSMI researchers undertook in early January 2008 indicated a high level of pollution in Penge accompanied by attitudes that ranged from complete ignorance about the dangers of asbestos to uncertainty about the effects, with some people evincing an alarming insouciance and disregard for the dangers to health posed by the evidence of asbestos and the consequences of continuing to live at Penge.

## **Historical Background to Penge**

Penge is situated in the mountains of Sekhukhuneland, approximately 55 kilometres north of Burgersfort. Penge developed in two phases. The first was as an asbestos mining community from the 1910s until the early 1990s, which included its establishment, the local economy, community relations and eventual closure, when most of the mine personnel left the village and environs. A review of an earlier phase of the area's historical settlement will not be undertaken here, except to mention that the use of asbestos in earlier times is evident from oral traditions among the people living in the area.

In 1993, a second phase in its history began with the influx of new inhabitants who settled in the infrastructure of the old. The second phase opened at a time of marked political change in the region, particularly with the re-integration of Lebowa into South Africa's new provincial structures. The Lebowa government was replaced by a new provincial structure which took over administrative responsibility for the area. Initially known as the Northern Province, the new province was renamed Limpopo Province in 2001. Penge now falls within the cross-border Greater Sekhukhune District Municipality which was formed in 2000. However, its municipal status has remained unresolved, despite efforts in 2002 by a Limpopo Province-initiated Project Steering Committee to formalise its status.<sup>7</sup> It is clear from the minutes of the 2002 consultations that an attempt was made to further expand the numbers of erven and develop Penge as a township. At the same time, there was discussion about formalising the ownership of the houses by those who were living in them. However, nothing appears to have come of these discussions.

This report considers both the history of mining at Penge, and the subsequent history of the village once the mine closed down in 1992. It presents an analysis of the significance of these two historical periods in explaining present concerns surrounding land tenure, public health and environmental pollution in Penge.

With few medical records to ascertain the numbers of people affected by asbestos, it remains difficult to accurately grasp the burden of disease that arose from the mining activities at Penge. However, from the late 1980s and early 1990s diagnosis, reporting and recording of asbestos related disease began to improve.<sup>8</sup>

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<sup>7</sup> Minutes, Project formalization of Penge, April, June, August and September 2002.

<sup>8</sup> Roberts, J. (2005) 'The Historical Failure of the Surveillance of Asbestos Related Diseases in South Africa: Epidemiological Problems and Recent Advances in Detection.', p. 2

### **Medical Surveillance in the 1980s – National Centre for Occupational Health.**

The most significant step in tackling the challenge of asbestos-related disease was made by the National Centre for Occupational Health (NCOH) in the 1980s, and continued into the new millennium. Medical practitioners, including Drs Tony Davies and Maria Anne Felix, both recognized the need for systematic medical testing of residents throughout the asbestos fields, including Mafefe and Penge. They implemented both medical surveillance and community awareness and participation programmes in tackling the existing problems. They also began a process of seeking compensation for affected former workers of the asbestos mines.

### **Company Asbestos Mining**

Cape plc operated the Penge mine until 1978 when it was briefly taken over by Rand Mines. At the end of 1981 the Griqualand Exploration and Finance Company Ltd. (GEFCO) took over and ran the mine until the industry closed in the early 1990s when the market for asbestos dried up. By 1991, Penge had one last remaining market in Japan which closed in 1991, at which point the amosite industry collapsed. The mine was closed and within a short time mining personnel, both white and black, left the village. This had significant implications for local economic activity, as the mines had provided one of the sole means of livelihood for more than 3500 living in the locality and elsewhere.<sup>9</sup>

### **Mine closure and Administrative Transfer of Penge to Lebowa and Limpopo Province.**

When the mine closed and mining personnel moved out, the Lebowa government orchestrated the release and lease of the housing to local applicants, many of whom had been associated with the mine in the past. We were unable to locate the documentation that dealt with this process. We did, however, come across minutes of meetings held in 2002 with a town planner, Mr T. Kotze, based in Polokwane as part of a project to extend the housing at Penge. This does not appear to have proceeded. Further research needs to be undertaken to discover the location of the relevant documents and clarify the process of resettlement of new inhabitants during the early 1990s. The evidence for resettlement presented in this report comes from key informant interviews.

In the democratic transition it is clear that the administrative status of Penge was never officially concluded. Those who had moved into the village with the official consent of the Lebowa administration were left without formal ownership of their houses and without a formal local authority. At present, a ward councillor and a PR councillor appear to take some responsibility for Penge, but this appears to be informal. A PR councillor does in fact live at Penge. She argued that Burgersfort municipality should be responsible for local government. However, no rent was paid to any official body and no municipal authority took responsibility for the maintenance of the infrastructure in the village such as roads, rubbish collection sewerage, water reticulation and street lighting. All of these are in a state of decay.

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<sup>9</sup> McCulloch, Jock. *Asbestos Blues*, p. 41

The houses do have pre-paid electricity metres. While water is piped to houses, these are in a state of disrepair.

In common with many other homeland districts throughout South Africa, the transition to democracy left some confusion over issues of traditional leadership, land tenure and the legitimacy of homeland legal processes that had occurred up to that point.

### **Foundations and Discovery of Asbestos at Penge: Marvellous Asbestos Country.**

Asbestos, a substance historically used by local peoples, was only positively identified when it was ‘discovered’ by a local trader on the banks of the Olifants River in 1907. The discovery was attributed to Thomas Ward, a local shop-keeper, who later confirmed an earlier finding by ‘Charlie the Reefer’. By 1910 a road had been built from the farm Mooihoek and mining began on a small scale.

The ore was taken by ox-wagon to the nearest railway station at Belfast, approximately 320 km away. In 1912 J.P.D. Winter, a neighbouring German farmer at Kromellenboog, joined Ward and together they secured a number of claims in the area. Other prospectors arrived, securing options for the mineral rights.

Two companies were formed, Amosa Ltd and Egnep Ltd (Penge written backwards), in which the surface freehold rights to Penge and Holfontein were established. By 1918 the name ‘amosite’ was given to the unique amphibole fibre found only on these properties.

In 1925 British-owned Cape Asbestos purchased Egnep and Amosa. By the 1930s, the asbestos industry was acknowledged as having considerable economic potential. A newspaper article in 1937 described the area that passed in a line from the Transvaal to the sea as the ‘most marvellous asbestos country...all varieties (were) obtainable, from the coarse long blue fibre, to the shorter, silkier expensive kind.’<sup>10</sup>

### **The Labour Process on the Mine**

Two mine shafts were established which employed male workers on the mines and mills who worked fixed hours under a white supervisor. Until mechanization in the 1960s, processes were rudimentary and the distinctive dry milling of asbestos created an enormous health risk that was little understood at the time by all involved.

### ***Tributary System in Mafefe – Family Labour***

A parallel form of asbestos mining comprised of a tributary system developed further to the north west of Penge. Blasting licenses were granted to white tributors, who blasted for black ‘contract’ boys who comprised at least half of the workforce.<sup>11</sup> They would blast adits, or horizontal shafts, into the mountainside, where banded asbestos-bearing ironstone was hauled out. The ore was too heavy to bring down the mountain

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<sup>10</sup> ‘Witbank – A District of Growing Possibilities’, *Witbank News*, August 6, 1937, p. 4

<sup>11</sup> McCulloch, Jock, *Asbestos Blues: Labour, Capital, Physicians & the State in South Africa*, African Issues: James Currey, Oxford, p. 32

so it was generally easier to remove the softer and lighter asbestos from the ironstone on site. This was done by family groups, including women and children.

Groups of women would sit hammering the asbestos out of the rock in a process known as ‘cobbing’. These family units included children, including babies, who accompanied their parents to the work sites, where they were exposed to the dust in some of the highest recorded approximated quantities of human exposure to the carcinogenic fibre.

### ***Child labour***

X-rays conducted in the late 1940s revealed asbestosis in children younger than twelve. First-hand accounts include seeing children ‘covered from head to foot in large shipping bags, trampling down deadly asbestos for their British bosses.’ If they slackened, they would be whipped by their supervisor. Interviews with former child-workers have corroborated the earlier reports of these conditions, where no warnings were issued. Employment of women and children continued throughout the existence of the mine, despite the fact that the terms of their employment were heavily restricted from 1911.<sup>12</sup>

By the 1940s, at least 25 percent of male asbestos mineworkers were under sixteen years old and often conducted the most difficult work.<sup>13</sup> Cape Asbestos tried to waive the Native Labour Regulations, arguing that juveniles were ‘cheaper to employ and they did the work adult males would not do.’<sup>14</sup> McCulloch argues that the underlying reason was the need for supplementary income by worker families because of the low rates of pay.<sup>15</sup>

### ***Working Conditions***

On the amosite mines conditions were hard, but there were some advantages over the gold mines. While exploiting the family unit, at least the tributary system allowed families to stay together. McCulloch argues that while asbestos mining was ‘safer’ than gold mining in terms of the rate of rock-falls and fatalities, the long term environmental and health costs were unacknowledged by the companies or by the workers themselves.<sup>16</sup>

### **Integration of Migrants into the Local Communities.**

The Penge asbestos mine offered employment close to the rural homes of many of the labourers. In addition, the workforce was supplemented by a steady stream of migrant male workers from as far afield as Port Shepstone in Natal, the Transkei, Mozambique and even Ghana. Many of these men married local women and were thus absorbed into the growing BaPedi communities living within the radius of Penge.

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<sup>12</sup> From 1911, the underground employment of women and children was prohibited by law in South Africa, but employment and exploitative working conditions persisted in Penge. Cobbing was prohibited from 1973, in accordance with legal recognition of the health hazards this practice caused, but this too continued in Penge to some extent until 1992.

<sup>13</sup> McCulloch, Jock, *Asbestos Blues*, p. 33

<sup>14</sup> *Ibid.*

<sup>15</sup> *Ibid.*

<sup>16</sup> *Ibid.* p. 40

Migrant labour and ethnic intermarriage had a strong influence on the nature of the Penge community and the villages in the vicinity of the mine. Locals were not only affected by the imposition of British industrial exploitation but also by a process of acculturation that would slowly change a previously homogeneous ethnic community. Moreover, the low wage economy also meant that the communities were poor.

### **Social Conditions**

Conditions barely changed in the decades that followed. The Inspector of Native Labour described conditions in the 1950s as being ‘wretched, unhygienic and conducive to the outbreak of disease’. By 1953, the African workforce had grown beyond five thousand.<sup>17</sup> Visitors also observed that drinking water was collected from the same streams where clothing was washed; these were also likely to be contaminated with asbestos. The rudimentary kitchens of tributors were close to the mines and mills. Compounds were small and conditions were cramped.

Post-Second World War economic growth in the asbestos industry meant that growth centred on Penge. Cape plc built most of the infrastructure of the town, including bricking the streets which were lined with trees planted earlier by Ward. White miners and their families lived in white square single-storey houses with gardens and street lighting. Other amenities included a recreation centre, a golf course and club house, a mining hospital and several trading stores.

### **Present Socio-Economic Conditions : Findings**

A site visit to Penge in early 2008 showed that the mine is still flanked by fencing. The once grand entrance has fallen into a state of decay, the roads were not maintained and were encroached by vegetation, both indigenous and alien. The old golf club and recreation centre in the precincts of the old mine were in ruins and a squatter had appropriated part of the property as a make-shift cattle farm. Animals grazed on surrounding tail dumps and throughout the village itself. The whole village had visible asbestos fibres on the sidewalks, paths and the tracks on the old golf course, now overtaken by vegetation, were strewn with asbestos fibres.

#### ***Local Conceptions of Asbestos Pollution***

Central to the site research was an investigation of local conceptions of environmental asbestos pollution. The results from focus groups and individual interviews showed that while the young adults and elders of Penge had some sense of the dangers of asbestos exposure, their concerns were rooted in the relationship between exposure to asbestos and concomitant compensation. After the establishment of the Asbestos Relief Trust in 2003, and the rollout of compensation began, there was a clear incentive to get tested for lung disease. One resident even expressed dismay at not testing positive for asbestosis, as this denied her the possibility of applying for compensation.

The findings from the interviews and focus groups also indicated that while residents wanted formalisation of the town so that improvements could take place, they were

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<sup>17</sup> Ibid. p. 48

ambivalent about the issue of paying rents, rates and taxes, as most people were generally relatively poor.

Most of the breadwinners in Penge commuted to work in nearby Burgersfort, Steelpoort, or worked on the neighbouring andalusite mine. Unofficial statistics and anecdotal evidence presented by respondents revealed that less than 50% of residents were employed. Many were dependent on social grants and pensions. Food parcels were distributed on a monthly basis by the clinic sister. Opportunities for local development were minimal – so near-free or rent-free housing was welcome in a region of latent poverty and underdevelopment.

The public buildings were either abandoned or taken apart, brick by brick. The petrol station was empty and most of the buildings had painted signs advertising local economic activity from both before and after the demise of the asbestos industry. In many cases, these signs were painted on the walls of buildings that were derelict with tin roof panels having been removed. The previous existence of buildings of different sizes and purported uses was only visible from remaining cement bases. The centre of the village where shops once thrived and small industries appeared to have existed, was in decay.

### ***Trading Activity***

There were two or three spaza shops in the town. These provided the sole public space for social interaction. These spaza shops sold cool drinks, cooked meals and some toiletries and household appliances. According to one resident, products were sold at ‘black market’ prices, considering the lack of availability. There was clearly a lack of sustainable economic activity in the town. Some households were able to sell avocado, mango, watermelon, paw-paw and sugarcane grown in the vicinity. But most supplies came from Burgersfort.

### ***Water Supply***

Piped water was sporadic, although there was some piped water from mountain springs. Only one of fourteen boreholes remained operational. These had been set up by GEFCO, but they had either been removed or were in a state of disrepair. There was clearly a shortage of reticulated water in the village. People said that at times when water was scarce, big containers would be transported by donkey cart and sold for R20 per 100 litres.

### ***Sanitation***

Without running water, sanitation in the Penge houses was perforce rudimentary. The sewerage system was broken, with differing opinions amongst locals about the extent to which this posed a health threat. Pit toilets were dug in individual houses, and while this posed no distinct health threat for residents, it did reveal a degraded quality of life in a context of amenities where there had once existed the capacity for a higher standard of living.

### ***Education Facilities***

While a crèche did function within the village run by one of the local women, the Penge Primary school had been shut down, and school-children spent two hours daily walking back and forth to the neighbouring Rotole primary school.

### ***Recreation***

Children and teenagers played ball games in Penge, often in the dirt where once there was grass. Teenage pregnancy and marriage was common-place in the town. Those who wanted to study at both secondary and/or tertiary level were sent to live with family members in Polokwane or in Johannesburg.

### ***Decline in infrastructural upkeep***

The slow decay of infrastructure in Penge reflected the lack of an official civic body to take responsibility for the upkeep of public spaces and amenities. One elderly respondent (one of three white families living in Penge) expressed frustration with the despondence of younger residents; he resigned himself to the decay in the face of a general milieu of demoralization. External developments or initiatives were regarded with disdain and mistrust by residents who perceived themselves to be swindled by contractors, who had seemed to either overcharge or abandon projects altogether. While some upgrading of roads had taken place, costing millions, it seemed that locals were not consulted and did not understand the reasons for the development. Ultimately, a series of top-down development initiatives had eroded community cohesion in a context of neglect. While some consultation had taken place, the lack of follow-up was cause for frustration.

### ***Health Facility***

Penge Hospital originally served as a mine hospital, and was renovated in the late 1990s by the provincial health department. With eighty beds, and spacious, well-equipped rooms, the hospital stood half-empty. In fact, it barely functioned as a hospital. With no doctor, and a shortage of nurses, it was downgraded to the status of a community health clinic in January 2008. Critical cases were transported to Burgersfort for more intensive medical attention.

### ***Public Health Awareness***

From observation of the public health notices on the walls of the Health Clinic, these warned against diarrhoea, HIV/AIDS and tuberculosis, but there was no asbestos warning. According to the 2007 Donohue report, large quantities of asbestos waste were found on top of a building construction site next to the hospital grounds. Rudimentary attempts had been made by local residents to flatten these piles of dirt, but the efficacy of pushing the dirt around, to flatten it, were uncertain and would have dislodged asbestos fibres.

Local perceptions ranged from complete ignorance to uncertainty about the implications of previous irresponsible mining practices that had led to the environmental hazard in their village. The lack of urgency in the village was exemplified by the asbestos-bearing ironstone boulder that sat approximately six metres from the entrance to the Police Station Hall, obviously a monument to its previous history. The boulder lay on a dusty sidewalk in front of the old mine official parking bays, with asbestos fibres peeling off. People wanting to make telephone calls from the local public phone had to walk past the boulder. Children playing with tennis balls invariably kicked up the dust. Asbestos is visible in the sandy foot paths, starkly emphasized by its pale brown fibrous appearance.

According to Business Report journalist the late Ronnie Morris, ‘Penge is an ongoing environmental health disaster and should be deemed permanently uninhabitable.’<sup>18</sup> This was corroborated by the levels of asbestos in the dust, atmosphere and water sources monitored by REDCO on behalf of the Department of Minerals and Energy and reported on below.

## **Recommendations from the Socio-Economic Survey**

### ***Need for a Household Survey:***

A household survey would provide invaluable information about Penge. Random sample studies have been conducted by researchers affiliated with the ART, but the community is highly heterogeneous, comprised of families who have settled in the town from the surrounding villages and many other towns. It would also be beneficial in providing the information necessary for systematic and ongoing assessment of residents, as in the case of Felix’s work in Mafefe, where medical assessment was conducted only after surveillance tests had been done.<sup>19</sup>

### ***Local Initiatives & Health Committees:***

Several respondents in the focus groups suggested that testing should take place every year. In previous experiences of development by external sources, the community was despondent, but it became clear that local development organized from within could yield a more positive outcome.

There is the potential for local residents to organize into a health committee, which could focus on health education about the ongoing risks of asbestos. More urgently, there was a need for demystification of asbestos and its role as an environmental pollutant. The committee would need to take on a proactive stance in combating risk.

### ***Employment***

With little economic activity in the town, most families are reliant on some or other form of migrant labour or social grants. Labour patterns would only be fully understood with more intensive demographic research and analysis. There exists a need for downstream opportunities from the nearby mining activities.

### ***Moving the Inhabitants from Penge***

Questions directed at the prospect of moving people into Penge brought the issue of the long-term health and safety of residents to the fore. This has raised questions about the continued viability of residence in Penge. Quantifying the hazardous effects of asbestos pollution in the town is difficult when the latency period between exposure and diagnosis can be up to forty years. It is also difficult to convince residents that there is a danger.

The outcome of tests reveals dangerous levels of asbestos in the town. Relevant authorities will have to secure the health and safety of residents. In the context of

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<sup>18</sup> Morris, Ronnie. ‘Firm wants to move families to asbestos wasteland’, March 19, 2007, quoted by Kazan-Allen, Laurie, in ‘Environmental Asbestos Fallout in Asia and Africa’. International Ban Asbestos Secretariat, April 6, 2007, [http://www.btinternet.com/ibas/lka\\_env\\_asb\\_fallout\\_asia\\_africa.htm](http://www.btinternet.com/ibas/lka_env_asb_fallout_asia_africa.htm).

<sup>19</sup> See Felix, Marianne, ‘Environmental Asbestos and Respiratory Disease in South Africa’, PhD Thesis, University of the Witwatersrand, Johannesburg, 1997

studies undertaken elsewhere in the world, the outcome and prognosis is bleak, and our recommendation is that the Provincial Government of Limpopo, in collaboration with the Greater Sekhukhune District Municipality and the local Penge community represented by the ward and PR councillors as well as SANCO, as a matter of urgency begin making plans for the closing down of the village and removal of the people elsewhere.

## **PUBLIC HEALTH RISKS TO THE PENGE COMMUNITY.**

### **Asbestos and Health – an Historical Account**

In the past, the mineral asbestos was valued for its properties of heat resistance and tensile strength. It was once regarded as a 'wonder' material. It has been used in thermal, electrical acoustic insulation, fire-resistant insulation, textiles, asbestos-cement production for building and construction such as piping, roofing and partition boards. Today asbestos has been substituted by safer materials.

### **ASBESTOS AND ITS EFFECTS ON HEALTH**

#### **The Nature and Characteristics of Asbestos**

The word asbestos refers to a family of chemical compounds which consist of slender hydrated silica chains and have the appearance of fibres. These fibres are very durable and are not easily degraded by chemical or biological agents. The fibrous form of asbestos gives it a high surface area-to-weight ratio, making it more likely to be airborne than other, more spherical substances of the same weight. The durability of asbestos causes it to remain unchanged in the body. Because the fibres are long, they are often too large to be engulfed by microphages in the body and removed.

Asbestos compounds are classified into two main groups, the serpentine group and the amphibole group. The amphibole group is further divided into sub-groups including amosite and crocidolite.

#### **The Serpentine Group of asbestos**

Chrysotile is the most common of asbestos fibres in the serpentine group, representing up to 90% of the asbestos which has been mined in the world. It is tough and curly, and can withstand a great deal of mechanical handling. It is softer than amphibole asbestos fibres and has been used widely to weave cloth or tape.

#### **The Amphibole Group of Asbestos**

This group of asbestos fibres are long, straight, stiff and brittle. They break easily, readily becoming a dust hazard. Amphibole asbestos includes amosite (greyish brown in colour), crocidolite (blue), anthophyllite (white) and tremolite (white) and actinolite (green). Tremolite and actinolite have not been used in commercial applications.

#### **Exposure Pathways**

Asbestos fibres enter the body through inhalation. To be inhaled into the lungs, fibres should be light enough to become airborne and small enough in diameter to be drawn down the throat and into the lungs. Fibres with these characteristics are said to be respirable and are typically less than 3 micrometres ( $\mu\text{m}$ ) in diameter. Most inhaled

fibres are expelled in mucous from the lung and swallowed, but some become embedded in lung tissue and remain there for life.

Most evidence on asbestos related health risks originate from occupational health related studies. There is less data on non-occupational exposures and this data is less quantitative.

### **Health Effects**

The amphibole group appears to have more potential to cause mesothelioma than the serpentine group. Mesothelioma's are particularly associated with crocidolite exposures, with amosite regarded as being less potent. Accumulation of asbestos in the lungs causes scarring and inflammation. It is this scarring and inflammation which can affect breathing and lead to disease.

All types of asbestos are known to cause asbestosis, other pleural disorders and cancer. All disorders are progressive and can continue after exposure has stopped. Asbestos related disorders usually progress slowly as there normally is a long latency period between exposure and the onset of disease. This observation does not hold when exposure levels are extreme.

According to the Agency for Toxic Substances and Disease Registry in the USA, asbestos exposure is very widespread because of extensive use of asbestos in construction and everyday products. However, most people do not become ill from the low levels of exposure arising from the normal wear and tear of construction products and materials.

In contrast, at high levels of exposure, usually found in occupational settings and environmental settings in old mining areas, the risk of developing asbestos related-diseases is high, and health effects can be severe.

Asbestos most commonly causes plaques in the lung tissue which appear to have minimal health effects, and asymptomatic localised pleural thickening. Fluid around the lungs (pleural effusion) is also associated with asbestos exposure. When pleural thickening becomes widespread and the pleura pucker with raised folds, lung functioning is impaired. The effects of pleural thickening on lung function were not well-appreciated in the past.

Exposure to asbestos places individuals at risk for the following diseases, which can have severe health impacts and can even lead to death.

- **Malignant mesothelioma.** This is a cancer of the lining of the lungs (pleural mesothelioma) and other abdominal organs (peritoneal mesothelioma). It is a rare condition and most documented cases are associated with occupational exposure to asbestos, crocidolite in particular, but it has also been found in family members and residents who live close to asbestos mines. It is distinctive by its diffusiveness i.e. its spread over the surface of the lungs and other organs. Increased exposure increases the risk of disease, but does not affect the induction period which may be 30 years or longer (longer than for other lung cancers). If untreated, the mesothelioma can lead to death within two years. The incidence and progress of the disease is not affected by smoking.

- **Asbestosis** is a serious progressive long-term disease. It involves local or diffuse thickening or scarring of the lung tissue usually in the basal (lower) region of the lung, but the whole lung may be involved. Areas of thickened tissue (plaques) may be present in the outer lining of the lung (parietal region) at the same time. As asbestosis advances it restricts lung functioning causing shortness of breath and causes crackling of the lung tissue during breathing. Advanced asbestosis can lead to heart or respiratory failure. The development of asbestosis is usually slow, usually about 15 years after first exposure in asbestos workers, but gross exposures can lead to death within a decade. Reducing exposure slows the progression of the condition.
- **Lung cancer** is a tumour that invades and obstructs the bronchial tubes (air passages) and affects the lung tissue. It tends to occur more readily when there is existing fibrosis. The condition usually develops several years after exposure (from 5 to 9 years, or even as long as 20 years later) Smoking tobacco multiplies the risk of developing lung cancer in individuals exposed to asbestos. The effect has been described as being synergistic and even multiplicative. The lung cancer attributable to asbestos exposure is indistinguishable from the cancers caused by other environmental agents. It is diagnosed when the cancer is present and there is evidence of a history of exposure to asbestos.

There is less clear evidence that other types of cancers of a non-respiratory nature, such as gastro-intestinal cancer, laryngeal cancer, are associated with asbestos exposures.

### **Factors which increase the risk of asbestos-related disease**

**Exposure Concentration** – Exposure to respirable asbestos increases the risk for developing all asbestos-related diseases. However for lung cancer and mesothelioma, there appears to be no threshold dose and therefore there is no known safe level of exposure.

**Duration of exposure** – Continued exposure increases the amount of asbestos which accumulates in the lungs. The amount of respirable asbestos inhaled and the length of time since first exposure determines the severity of asbestosis.

**Size of the asbestos fibre** – According Doll and Julian, there is evidence that the fibres which present the greatest health risk are between 5 and 100µm in length, have diameters of less than 1 or 2µm, and ratios of length to diameter of more the 5 to 1. Asbestos fibres can be very slender, as low as 0.02µm but fibres with diameters below 0.2µm cannot be detected by optical microscopes, a common tool in air quality monitoring. Long fibres reach the lower airways and alveolar of the lungs. Wide particles are not expected to reach the lungs and pleura and very short fibres may not be carcinogenic.

**Type of fibre** - The greater potency of amphibole asbestos has been ascribed to its greater propensity to break into respirable dust fractions which can be very small in diameter yet long in length. Curly serpentine fibres (chrysotile) are more likely to be

cleared from the lungs and are possibly more readily trapped in the upper air passages.

**Age of exposure** – the earlier individuals are exposed to asbestos the more likely that that disease will develop at an early age.

### **Safety Precautions**

Safety precautions to prevent exposure to asbestos fibres were developed to protect workers in occupational settings. However the principles which typically involve the following, can be extrapolated to environments in which the risk of exposure is widespread:

- Avoiding activities or situations which release asbestos fibres from asbestos products
- Avoiding activities which generate asbestos dust
- Using methods of which minimise dust generation
- Wearing respiratory protection
- Containing and sealing debris
- Removing asbestos from contaminated clothing by thorough washing
- Keeping people out of area in which they may be exposed asbestos

### **Discovery of the Carcinogenic Quality of Asbestos**

After World War Two amosite and crocidolite had become major international commodities, and most asbestos produced in South Africa was geared towards an export market. Growth expanded between the 1960s and 1970s, with the industry reaching its peak around 1973. By this time, growing concern had emerged over the carcinogenic qualities of asbestos. While asbestos-related legal claims date back to the 1930s in the United Kingdom and resulted in workplace regulations being implemented in British factories, these cautionary measures were not extended to the South African mines and mills.

In fact, companies like Cape Asbestos operating in Penge took advantage of the isolation of South African black workers within a context of racial segregation. No appropriate health and safety measures to protect workers were implemented.

### **Establishment of the Pneumoconiosis Research Unit.**

When South African medical doctors recognized the link between asbestos and mesothelioma, the incurable disease that attacks the pleura (or lining of the lung), the Pneumoconiosis Research Unit was set up. The asbestos industry partially funded research into the problem, but when findings revealed how dangerous and far-reaching the problem was, further research was stifled.

While South African labour vulnerability to the full effects of occupational exposure to asbestos became increasingly manifest, similar suppression of findings were taking place worldwide. Suppressed medical findings were surfacing in line with the growing recognition of the dangers of working with asbestos. Because of the long latency period, it was only in the mid twentieth century that the signs of an epidemic became clear and unavoidable.

### Health Impacts in Mafefe

In Mafefe, Felix concluded in 1997 that 34% of the environmentally exposed adults had asbestos-related pleural disease, 52% of adults who had also been occupationally exposed had the same disease, and the numbers of people with pleural disease increased with age. In addition, 10% of all adults had extensive bilateral disease (pleural thickening), and associated shortness of breath.

The National Health Laboratory Services have data on the prevalence of mesothelioma in South Africa up to 1999. These mesotheliomas recorded are of exposure that occurred at least 20 years previously, as a result of occupational and environmental exposure in the Northern Cape mines, Penge and industry using asbestos. It is difficult to establish how many of those mesotheliomas are from the exposure in Penge but without a doubt some are the consequence of such exposure. During the Mafefe study, one worker, who had only worked for two years in Mafefe, was diagnosed with mesothelioma.

Table 1: Mesothelioma rates for South Africa based on Cancer Registry data

Year	Total	Male	Female	Northern Cape, Eastern Cape, Free State, Western Cape, North West Province	Gauteng, Mpumalanga, Northern Province, Kwa-Zulu Natal
1988	152	109	43	Not available	Not available
1989	191	126	65	77	86
1990	164	120	44	Combined with 1991	Combined with 1991
1991	184	132	52	167	173

## REHABILITATION OF THE BIOPHYSICAL ENVIRONMENT

### Asbestos Pollution of the Environment

Amosite (brown) asbestos was mined in the Penge area and Pietersburg Asbestos Fields. Mining started in Penge in 1914, after the difficulties of marketing a new fibre had been overcome.

Amosite production peaked at 100 000 tons in 1970 when 7000 workers were employed. Penge consisted of three shafts, Penge, Weltevreden and Kromellenboog. Outcrop mining was done by Penge in the Pietersburg asbestos fields at Egnep in Bewaarkloof until the late 1970s. All three shafts are associated with large asbestos waste dumps. The mining village was situated next to the Penge shaft where the new mill was built in the late 1970s.

Even though the dumps around Penge have been covered, they cannot withstand development around them as any earthworks would uncover the asbestos and create a health risk.

The Donohue report referred to above, does not unfortunately provide information on the concentration of air-borne fibres. Research undertaken by Felix and more recently by REDCO which is summarised below suggests that this remains a dangerous factor in the area.

### **Similarity between Penge and Mafefe**

Just north of Penge is Mafefe where asbestos was mined between 1917 and the early 1980s. Exposures at Penge can be expected to be of the same order of that recorded in Mafefe during an atmospheric sampling survey in 1989.

The average concentration of atmospheric fibres was 12f/l. High concentrations of fibres (23f/l), were recorded where there was visible asbestos in the yards of public buildings, schools and road verges. The average exposure for children was 20f/l.

Exposure is certain for all residents. Therefore a lifetime in Penge could result in a lung burden able to induce mesothelioma and pleural disease.

### **STATUS OF REHABILITATION AT PENGE: RESULTS**

The rehabilitation of the dumps started in 1986, with the nursery being established in 1987. The rehabilitation of all the old dumps was completed in 1991. All dumps were graded to 18°, with the earthworks completed in 1994. Re-vegetation only began to be effective once rainfall occurred in February 1995 and by December 1996, re-vegetation had occurred. Details of the rehabilitation are sketchy. The annual rainfall of the site is 650mm.

The database kept by REDCO indicates that detailed design data for the rehabilitation had been documented but these documents were not available. There are no records of what volume of soil was moved to the area or the thickness of the soil layer. There are also no data on the chemical, physical and microbiological properties of the soil used in the rehabilitation of the dumps. No initial samples were collected from the rehabilitated dumps in 1996 (to act as the baseline data), therefore it makes it very difficult to discuss the impacts over the last 12 years.

After extensive discussion with REDCO it was established that four different treatments were applied with respect to re-vegetation: 1) Dumps 1 and 2 were planted with *Dichrostachys cinerea*, and *Acacia karoo*; 2) Numbers 3 and 4 were borrow pits and dumps 5, 7 and 11 all appear to have received no treatments; 3) Dumps 6, 9 and 10 were planted with *Dichrostachys cinerea* and *Euphorbia tirucali*; 4) Dump 8 was planted with *Euphorbia tirucali*. All other details about the re-vegetation e.g. whether fertilizers were used, are unclear but may be in the DME guidelines. No mention is made of whether grasses or forbs were included in the re-vegetation treatments.

Sampling of soils, fauna and vegetation was conducted by REDCO Services on behalf of the DME in September and October 2007. A total of 66 samples were collected from the Penge mine dumps. Soil samples were collected from eleven dumps and at each mine dump, three sampling points were selected and two soil samples were collected at each sampling point. One surface sample was collected at a depth of 100mm for microbiological testing and a second sample was collected at 300mm for chemical analysis. The soil samples were analysed using standard chemical

procedures. An assay of microbial activity was conducted on the surface samples using a standard dehydrogenase assay. All dumps have livestock grazing on them.

The tables which follow summarise the results from the research and measurements undertaken by REDCO.<sup>20</sup>

Table 1: Results of the capture of small mammals on the dumps

<b>Treatment</b>	<b>Location</b>	<b>Species</b>	<b>Number</b>	<b>Sex</b>	<b>Mass (g)</b>
Planted with <i>Dichrostachys</i> and <i>Acacia</i>	Penge 1	-	-	-	-
	Penge 2	<i>Aethomys crysophilus</i> (Red veld rat)	1	Female	52
Borrow pits (3 and 4: no treatments) and no treatments on 5, 7 and 11)	Penge 3	<i>Aethomys crysophilus</i>	1	Male	54
	Penge 4	-	-	-	-
	Penge 5	-	-	-	-
	Penge 7	<i>Aethomys crysophilus</i>	1	Male	56
Planted with <i>Dichrostachys</i> and <i>Euphorbia</i>	Penge 11	-	-	-	-
	Penge 6	-	-	-	-
	Penge 9	<i>Aethomys crysophilus</i>	1	Male	55
Planted with <i>Euphorbia</i>	Penge 10	<i>Aethomys crysophilus</i>	1	Female	84
	Penge 8	-	-	-	-

Very few mice were caught during the exercise as the study was limited both in time and extent however it is encouraging that 5 mice were present on the dumps. The occurrence of mice was not linked to the treatments on the dumps.

<sup>20</sup> All the data presented in the section which follows were kindly made available by DP van der Merwe from REDCO Environmental Consultants. The sampling was conducted by REDCO and interpretation of the data was undertaken by Prof Mary Scholes.

Table 2: Dominant vegetation measured on the dumps at Penge

Treatment	Location	Dominant tree	Dominant shrub	Dominant grass	Dominant forbs
Planted with <i>Dichrostachys</i> and <i>Acacia</i>	Penge 1	<i>Acacia tortilis</i>	<i>Acacia tortilis</i>	<i>Cenchrus ciliaris</i>	<i>Achyranthes aspera</i>
	Penge 2	<i>Acacia tortilis</i>	<i>Acacia tortilis</i>	<i>Enneapogon cenchroides</i>	<i>Achyranthes aspera</i>
Borrow pits (3 and 4: no treatments) and no treatments on 5, 7 and 11)	Penge 3	<i>Dichrostachys cinerea</i>	<i>Acacia tortilis</i>	<i>Aristida congesta</i>	<i>Corchoris kirkii</i>
	Penge 4	<i>Acacia tortilis</i>	<i>Acacia tortilis</i>	<i>Enneapogon cenchroides</i>	<i>Sida cordifolia</i>
	Penge 5	<i>Acacia tortilis</i>	<i>Acacia tortilis</i>	<i>Enneapogon cenchroides</i>	<i>Corchoris kirkii</i>
	Penge 7	<i>Acacia grandicornuta</i>	<i>Acacia tortilis</i>	<i>Enneapogon cenchroides</i>	<i>Hibiscus micranthus</i>
	Penge 11	<i>Acacia tortilis</i>	<i>Dichrostachys cinerea</i>	<i>Aristida congesta</i>	<i>Hibiscus micranthus</i>
Planted with <i>Dichrostachys</i> and <i>Euphorbia</i>	Penge 6	<i>Euphorbia tirucali</i>	<i>Euphorbia tirucali</i>	<i>Aristida congesta</i>	<i>Tephrosia rhodesica</i>
	Penge 9	<i>Dichrostachys cinerea</i>	<i>Dichrostachys cinerea</i>	<i>Aristida congesta</i>	<i>Abutilon angulatum</i>
	Penge 10	<i>Acacia tortilis</i>	<i>Acacia tortilis</i>	<i>Urochloa mosambicensis</i>	<i>Achyranthes aspera</i>
Planted with <i>Euphorbia</i>	Penge 8	<i>Euphorbia tirucali</i>	<i>Euphorbia tirucali</i>	<i>Cenchrus ciliaris</i>	<i>Rhynchosia minima</i>

There are no apparent trends in the dominant vegetation on the dumps as a function of treatment. It is interesting that the dominant *Acacia* is *Acacia tortilis* when it was stated that *Acacia karoo* was used for the initial re-vegetation. I think a mistake may have been made at planting. It is also interesting that *Dichrostachys* has become dominant, this is an invasive species but causes no harm to the ecological functioning of the system. All the species are indigenous. *Dichrostachys* and *Acacia* are both palatable, having high protein content in the leaves and the seeds. They are also prolific seeders and are mostly animal dispersed. The dumps do have domestic livestock on them and are probably responsible for the transfer of seeds. The two dominant woody species exist for about 40-60 years and during this period sufficient seeds are introduced into the seedbed to make it a functional, sustainable system. Some of the grasses are highly palatable and others less so, some of the grasses are also well adapted to dry conditions.

**Table 3: Mean (n=3) percentage cover of vegetation types and vegetation density on each mine dump**

Treatment	Location	Herbaceous crown cover (%)	Wood crown cover (%)	Basal cover (%)	Vegetation density (number of plants/m <sup>2</sup> )
Planted with <i>Dichrostachys</i> and <i>Acacia</i>	Penge 1	10.1±4.4	11.9±15.7	4.5±1.8	15.3±6.0
	Penge 2	9.3±4.5	24.6±20.6	5.7±1.0	23.9±5.6
Borrow pits (3 and 4: no treatments) and no treatments on 5, 7 and 11)	Penge 3	18.5±4.7	12.5±5.4	7.3±1.5	24.0±7.8
	Penge 4	5.9±1.7	12.1±11.2	3.0±0.7	19.0±0.6
	Penge 5	11.7±9.5	10.9±8.2	3.6±1.3	18.5±3.4
	Penge 7	18.5±3.6	11.3±9.9	4.9±0.1	24.9±5.6
Planted with <i>Dichrostachys</i> and <i>Euphorbia</i>	Penge 11	16.7±16.2	13.4±19.9	3.7±1.9	22.2±0.5
	Penge 6	15.8±10.8	27.9±11.6	3.9±0.4	20.4±15.7
	Penge 9	8.1±3.6	15.9±9.7	3.5±0.6	20.0±2.2
Planted with <i>Euphorbia</i>	Penge 10	3.6±2.3	8.3±2.9	2.4±1.0	14.8±6.1
	Penge 8	6.6±6.3	40.4±26.7	3.5±0.3	12.4±11.4

There are no apparent trends in the dominant vegetation on the dumps as a function of treatment. There is high variability across sites, with the herbaceous cover ranging from 3-17%, the woody crown cover from 8-40% and the basal cover from 2-7%. The quadrant size for sampling was 4 m<sup>2</sup>, which may have influenced the results but this is difficult to assess. The woody cover would be adequate to provide shade if livestock were to continue to use the dumps as a food resource, however the livestock numbers would need to be very carefully controlled. The basal cover is very low which indicates that the site is prone to erosion and would be more suited to goats than cattle.

**Table 4: Mean value (n=3) of soil analysis (Macro-elements) sampled from eleven dumps in the Penge Area. Soil was sampled at 30 cm depth. All units are in millimol per litre**

Treatment	Location	Ca	Mg	K	Na	PO <sub>4</sub>	SO <sub>4</sub>	NO <sub>3</sub>	NH <sub>4</sub>	Cl	HCO <sub>3</sub>
Planted with <i>Dichrostachys</i> and <i>Acacia</i>	Penge 1	0.82±0.54	0.29±0.18	1.13±0.78	0.08±0.06	<0.01	0.13±0.15	1.15±1.59	0.05±0.02	0.32±0.46	0.90±0.65
	Penge 2	0.76±0.66	0.33±0.22	0.17±0.14	0.19±0.19	<0.01	0.13±0.16	0.90±1.40	0.04±0.03	0.14±0.12	1.28±0.23
Borrow pits (3 and 4: no treatments) and no treatments on 5, 7 and 11)	Penge 3	0.49±0.50	0.22±0.18	0.24±0.22	0.06±0.01	<0.01	0.16±0.18	0.32±0.32	0.05±0.01	0.3±0.38	0.85±0.56
	Penge 4	0.45±0.08	0.17±0.20	0.35±0.23	0.07±0.03	<0.01	0.07±0.05	0.41±0.20	0.06±0.01	0.14±0.01	1.08±0.32
	Penge 5	0.59±0.09	0.23±0.06	0.50±0.59	0.07±0.02	<0.01	0.08±0.06	0.46±0.38	0.05±0.01	0.09±0.04	1.60±0.33
	Penge 7	0.28±0.10	0.10±0.05	0.66±0.10	0.11±0.06	<0.01	0.04±0.01	0.32±0.09	0.02±0.01	0.06±0.01	1.17±0.24
Planted with <i>Dichrostachys</i> and <i>Euphorbia</i>	Penge 11	0.39±0.23	0.21±0.16	0.12±0.05	0.09±0.08	<0.01	0.05±0.04	0.20±0.06	0.04±0.01	0.09±0.05	0.98±0.82
	Penge 6	0.71±0.58	0.23±0.23	0.77±0.93	0.05±0.02	<0.01	0.10±0.14	0.93±1.48	0.02±0.02	0.23±0.34	1.40±0.46
	Penge 9	0.51±0.04	0.13±0.02	0.50±0.72	0.06±0.02	0.01±<0.01	0.04±0.04	0.32±0.19	0.03±0.01	0.06±0.04	1.40±0.44
Planted with <i>Euphorbia</i>	Penge 10	1.01±0.50	0.27±0.18	0.80±0.82	0.21±0.18	<0.01	0.21±0.19	1.51±1.97	0.03±0.01	0.19±0.12	1.48±0.19
	Penge 8	0.63±0.15	0.19±0.10	0.64±0.47	0.06±0.01	0.03±0.01	0.10±0.05	0.12±0.05	0.03±0.01	0.21±0.54	1.87±0.63

There is no pattern across the four treatments with respect to all the macro-elements. The

soils are not sodic as the sodium levels are in correct proportion to the calcium and magnesium levels. On the whole the levels of nutrients are low, with the amounts of phosphorus being extremely low. It is unclear what form of phosphate was measured. Nitrate is the dominant nitrogen ion which usually indicates that microbial activity is taking place and that the system is ecologically functional. However, it must be borne in mind that the nitrate measured may be from residual inorganic fertilizer applied at planting.

**Table 5: Mean value (n=3) of soil analysis (Micro-elements) sampled from eleven dumps in the Penge Area. Soil sampled at 30 cm depth. All units are in millimol per litre except for pH, P, EC and C.**

Treatment	Location	Fe	Mn	Cu	Zn	B	pH	EC (mS/cm)	P-bray 1 (ppm)	% C
Planted with <i>Dichrostachys</i> and <i>Acacia</i>	Penge 1	19.31±13.50	0.54±0.26	0.52±0.07	0.08±0.07	1.50±0.71	6.89±0.36	0.32±0.21	7.32±5.10	0.47±0.15
	Penge 2	12.38±12.60	0.56±0.46	0.71±0.56	0.12±0.13	1.50±0.71	7.45±0.16	0.26±0.18	7.56±3.53	0.41±0.31
Borrow pits (3 and 4: no treatments) and no treatments on 5, 7 and 11)	Penge 3	17.70±11.77	1.71±1.14	0.80±0.68	0.21±0.15	1.50±0.71	6.87±0.52	0.18±0.16	1.57±0.36	0.73±0.08
	Penge 4	21.39±5.08	0.44±0.23	0.65±0.67	0.06±0.07	2.00±1.00	7.03±0.13	0.18±0.03	2.89±0.91	0.72±0.12
	Penge 5	13.65±12.79	0.25±0.26	0.61±0.33	0.05±0.03	3.00±<1.00	7.13±0.14	0.23±0.09	2.67±1.38	0.74±0.15
	Penge 7	34.52±4.07	3.39±4.02	0.53±0.24	0.32±0.28	1.50±<1.00	7.25±0.12	0.16±0.02	4.79±0.95	0.52±0.04
	Penge 11	16.95±13.59	1.77±2.48	0.50±0.12	0.19±0.22	1.00±<1.00	7.05±0.32	0.15±0.08	1.88±0.15	0.47±0.07
Planted with <i>Dichrostachys</i> and <i>Euphorbia</i>	Penge 6	17.71±14.43	0.99±0.28	0.38±0.34	0.09±0.06	1.00±<1.00	7.26±0.12	0.28±0.25	3.69±1.76	0.58±0.18
	Penge 9	18.68±9.73	0.50±0.24	0.43±0.09	0.02±0.01	1.33±<1.00	7.18±0.15	0.19±0.07	7.42±8.36	0.46±0.02
	Penge 10	9.66±11.19	0.24±0.10	0.62±0.075	0.10±0.08	2.00±0	7.45±0.09	0.36±0.23	2.83±1.30	0.70±0.26
Planted with <i>Euphorbia</i>	Penge 8	20.18±3.00	1.16±2.26	0.59±0.30	0.13±0.08	1.64±0	7.33±0.01	0.23±0.10	4.26±0.22	0.59±0.18

There is no pattern across the four treatments with respect to all the micro-elements. The pH is neutral making the soils very favourable for plant growth. The phosphorus levels measured using Bray 1 show that there are significant amounts of phosphorus available for plant growth which can only have come from inorganic fertilizer application. The data variability is no higher than normal. Soil carbon levels are low which indicate that organic matter should be added to the system for long term sustainability.

**Table 6: Presentation of results for the microbial dehydrogenase activity. Mean value (n=3) of soils sampled from eleven dumps in the Penge Area. Soil sampled at 10 cm**

Treatment	Location	Dehydrogenase activity (INF $\mu\text{g/g/2h}$ )
Planted with <i>Dichrostachys</i> and <i>Acacia</i>	Penge 1	196.15 $\pm$ 6.59
	Penge 2	168.35 $\pm$ 9.29
Borrow pits (3 and 4: no treatments) and no treatments on 5, 7 and 11)	Penge 3	241.32 $\pm$ 39.88
	Penge 4	206.45 $\pm$ 21.22
	Penge 5	295.44 $\pm$ 29.34
	Penge 7	188.72 $\pm$ 60.49
	Penge 11	177.38 $\pm$ 14.01
Planted with <i>Dichrostachys</i> and <i>Euphorbia</i>	Penge 6	280.31 $\pm$ 31.92
	Penge 9	276.85 $\pm$ 109.77
	Penge 10	355.39 $\pm$ 24.99
Planted with <i>Euphorbia</i>	Penge 8	144.30 $\pm$ 48.77

There is no pattern across the four treatments with respect to the dehydrogenase activity. The higher the dehydrogenase activity the higher the microbial activity and one would assume the microbial functionality of the system

#### Comments with respect to rehabilitation.

Rehabilitated asbestos dumps are being exposed due to over-grazing and other activities on these sites (cf. health risk assessment). Poorly rehabilitated waste dumps<sup>21</sup> and asbestos waste has contaminated the whole village, while Donohue concluded that ‘no management plan for the dumps can change this fact.’<sup>22</sup>

It was extremely difficult to get precise details of the rehabilitation and re-vegetation that was conducted on the dumps. It is claimed by REDCO that the dumps were rehabilitated according to the DME guidelines, however, a number of parties were involved and it proved difficult to obtain information. Some of the information may be kept with the DME but some remains with the various contractors. Much of the information is only in hard copy and has not been captured electronically. This makes access to the documents even more difficult.

From the nine case studies detailed below, the processes involved in rehabilitation all involve a series of similar steps: a survey to assess the severity of the exposure and associated risks; a plan to deal with the impacts; the removal of the contaminated material or the capping of material *in situ*; the diversion of rivers and the building of devices to prevent erosion; the grading of the dumps; the covering of the dumps with topsoil; fertilization of the sites; plant selection, planting and establishment of vegetation; limited access; and a monitoring plan. All

<sup>21</sup> Donohue, S. Site “Visit and Assessment – Penge Asbestos Hazard”. University of Limpopo. January 2007, p.9

<sup>22</sup> Donohue, S. Site “Visit and Assessment – Penge Asbestos Hazard”. University of Limpopo. January 2007, p.12

of these steps occur in all of the case studies, however details are often missing. In the Penge situation, there does not seem to have been a systematic process associated with the documentation of all the steps taken during the rehabilitation.

### **Some specific comments about the soil and vegetation data**

The woody cover would be adequate to provide shade if livestock were to continue to use the dumps as a food resource, however the livestock numbers would need to be very carefully controlled. The basal cover is very low which indicates that the site is prone to erosion and would be more suited to goats than cattle.

There is no pattern across the four treatments with respect to all the soil chemical and microbiological properties. There are no imbalances in the macro and micronutrients and no indications of toxicity of any element. The pH is neutral making the soils very favourable for plant growth. The phosphorus levels measured using Bray 1 show that there are significant amounts of phosphorus available for plant growth which can only have come from inorganic fertilizer application. The data variability is no higher than normal. Soil carbon levels are low which indicate that organic matter should be added to the system for long term sustainability.

The overall conclusion from this section does not allow one to evaluate the success of the rehabilitation measures. Professor Scholes recommends that a rigorous monitoring programme be put in place and that the data presented here could be used as baseline data for comparison in the future.

It appears that the overall contamination of the site with asbestos is of a much greater concern than the soil status on the dumps. From the case studies reviewed one could recommend that the dumps could be used only for limited livestock fodder.

## **LEGISLATIVE IMPLICATIONS FOR PENGE**

### **The Effects of Class Action Litigation on the Industry**

Litigation worldwide created a tide of class action suits, with the result that the asbestos industry began to feel the burden. Legal claims often centred on global asbestos industry attempts to ‘conceal known adverse health effects of asbestos from the scientific community and the public.’<sup>23</sup>

While global lawsuits led to the eventual banning of crocidolite, or blue asbestos, the market for amosite continued. However public relations attempts mainly led by Canadian asbestos companies, producers of the more commonly used serpentine chrysotile, or white asbestos, resulted in a declining market for amosite.

In the past decade, South Africa has put into place rigorous environmental management and mine closure legislation. However, many of the closed or abandoned mines, including asbestos mines, have been closed without dealing with residual environmental impacts<sup>24</sup>, thus leaving to government the responsibility to close and rehabilitate ownerless mines in the

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<sup>23</sup> Huncharek, Michael, ‘Exporting Asbestos: Disease and Policy in the Developing World’, *Journal of Public Health Policy*, Vol. 14, No. 1., Spring 1993, p. 53

<sup>24</sup> Ndaba D, ‘Derelict mine rehabilitation strategy set for march 2008 implementation’, *Mining Weekly*, 30 Nov. 2007

interest of neighbouring communities. The Constitution provides a clear prescription that a public policy framework ‘ensuring an environment that is not harmful to the health and well-being of anyone’.

The evidence for rehabilitation of the mine dumps in Penge is uneven, and here is clearly a problem of exposure due to erosion, grazing and other activities on the dumps. The Department of Mineral and Energy Affairs initiated a rehabilitation programme for derelict and ownerless mines like Penge (see ‘Status of Rehabilitation at Penge’).

Asbestos contamination in Penge is not confined to the mine dumps, the entire village is contaminated with asbestos fibres and rehabilitation measures should encompass the whole area.

In relation to mining, the Minerals and Petroleum Resources Development Act (MPRDA, 2002) has provisions that allow competent authorities to take the necessary measures to make the area safe, prevent further damage to the environment, or rehabilitate dangerous occurrences in the event of pollution or environmental degradation caused by mining.<sup>25</sup> In accordance with the amended MPRDA (section 43), if a mine has closed, but has not obtained a closure certificate, it is deemed operational and the owner is still liable for closure and any pollution or environmental degradation. While the status of Penge as a closed mine is not in question, there is still a major question as to its official status in local government terms.

### **Asbestos and the Law in South Africa**

The current South African legislation prescribes strict environmental management and mine closure strategies, thus breaking with a tradition of environmental neglect characteristic of the previous regime. However, since mining and processing activities largely precede the development of current legislation, most of the closed or abandoned mines in South Africa, including asbestos mines, have been closed without dealing with residual environmental impacts<sup>26</sup>. In the case of Penge, this has resulted in an environmental hazard that has spread to the entire settlement.<sup>27</sup>

Although mining and use of asbestos are now banned in South Africa, laws to prevent exposure to asbestos, dispose of asbestos waste, and deal with derelict and ownerless asbestos mines remain in force and are detailed in the following sections.

### **Prohibition on mining, import and use of asbestos in South Africa**

Asbestos mining was banned in South Africa in 2001; in addition, the Department of Environmental Affairs and Tourism issued Regulations for the prohibition of use, manufacturing, import and export of asbestos and asbestos containing materials in early 2008.<sup>28</sup>

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<sup>25</sup> Section 46 Amended MPRDA

<sup>26</sup> Ndaba D, ‘Derelict mine rehabilitation strategy set for march 2008 implementation’, Mining Weekly, 30 Nov. 2007

<sup>27</sup> As a group A carcinogen, asbestos is classified as HG1, an extreme hazard, in terms of the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste. DWAf, ‘Policy On The Handling And Disposal Of Asbestos And Asbestos Containing Waste In Terms Of Section 20 Of The Environment Conservation Act, 1989 (Act 73 Of 1989)’, p.3

<sup>28</sup> Section 24B of the Environment Conservation Act 73 of 1989

## **Regulations to prevent exposure to asbestos**

Because asbestos mining and use was so widespread, health and safety and environmental laws remain in force to prevent asbestos exposure. Relevant laws include the Occupational Health and Safety Act, no 85 of 1993 (OHSA), the Mine Health and Safety Act, no 29 of 1996 (MHSA), the Atmospheric Pollution Prevention Act, no 45 of 1965, the Environment Conservation Act, no 73 of 1989, The National Water Act, no 36 of 1998, and the National Environmental Management Act, no 107 of 1998.

### *Occupational exposure*

Exposure to asbestos in workplace settings is controlled in terms of the Asbestos Regulations, 2001 (promulgated under section 43 of the OHSA), issued by the department of Labour. Duties in these regulations pertain mainly to employers. Workers also have specific responsibilities. The exposure limits for airborne asbestos is 0.1f.ml of air.

The Asbestos regulations include provisions for:

- Controlling exposure to asbestos
- Informing workers about the effects of asbestos exposure and training workers on the precautions to be taken to protect their health when working with asbestos
- Precautions to be taken when transporting, processing, packaging, and disposing of asbestos and in construction work in which asbestos containing materials are present
- Precautions to be taken to prevent asbestos from entering the wider environment and water.
- Workers duties to prevent asbestos from becoming airborne by following work procedures
- Monitoring of exposures
- Medical surveillance of people who are at risk of exposure

## **Mine Closure and Rehabilitation**

Activities associated with mining impact widely on the environment and for mine land to be useable, effective rehabilitation must be carried out. ‘Unrehabilitated land is frequently not fit for use and may degrade surrounding land through water and air pollution.’<sup>29</sup> In terms of the MPRDA mine owners are responsible for the rehabilitation of areas affected by mining.

### *Responsibility to remedy (section 38 of the MPRDA)*

Holders of mining rights and permits ‘must as far as it is reasonably practicable, rehabilitate the environment [...] to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development; and [are] responsible for any environmental damage, pollution or ecological degradation [...] which may occur inside or outside the boundaries of the area’<sup>30</sup> associated with mining activities. In addition, “the directors of a company or members of a close corporation are jointly and severally liable for any unacceptable negative impact on the environment [...]”<sup>31</sup>

According to section 43 of the amended Mineral and Petroleum Resources Development Act, until a closure certificate has been issued, the holder of a mining right or permit ‘remains responsible for any environmental liability, pollution [or] ecological degradation, and the management thereof’. However, if he or she is deceased, or cannot be traced, or, in the case of

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<sup>29</sup> MMSD Southern Africa, The Report of the Regional MMSD Process, Volume 1, 2002, p.59

<sup>30</sup> Section 38 (1) MPRDA

<sup>31</sup> Section 38 (2) MPRDA

a juristic person, has ceased to exist, and such pollution or degradation may be harmful to the health or well-being of anyone, then the competent authorities may take the necessary measures to make the area safe, prevent further damage to the environment, or rehabilitate dangerous occurrences.<sup>32</sup>

### **Disposal of asbestos containing waste (ACW)**

Asbestos containing waste (ACW) is divided into four hazard classes, A to D (table 1). The potential hazard or risk associated with the release of fibres is highest in class A, and decreases to class D, where the risk posed by the waste is extremely small.<sup>33</sup>

The carcinogenic risk of asbestos is linked to the air pathway; ingestion of the fibres when swallowed in water does not carry any associated cancer risks. “Asbestos shows a slight solubility in water and the natural fibres tend to become blunted on a molecular scale thus greatly reducing the associated cancer risk. Water therefore serves as a natural route for the removal of fibres from the air and as a mechanism to suppress the emission of fibres into the air”<sup>34</sup>.

Approved treatment and disposal methods listed in the DWAF’s policy on the Handling and Disposal of Asbestos and Asbestos Containing Waste include wetting, solidification, and land-filling.

In consultation with researchers from the Department of Environmental Affairs and Tourism (DEAT) as well as the Department of Water Affairs and Forestry (DWAF) it was confirmed that the interactions between the two Departments and the DME occurred, but only at the Ministerial levels. A number of different divisions at DEAT could be involved in asbestos related environmental issues but to date the only division that is active is the Authorization and Permitting Division, which has the responsibility for regulating and monitoring import, export and transport of asbestos into and out of South Africa. Colleagues at DWAF were not aware of any activities related to asbestos. It was also confirmed that only national policies were applied and there did not seem to be any provincial policies.

## **REHABILITATION OF ASBESTOS WASTES: THE INTERNATIONAL RECORD**

### **Asbestos Rehabilitation Guidelines and Criteria outside of South Africa**

Information and Guidelines on the rehabilitation of asbestos-contaminated mining wastes is very limited and overshadowed by the focus of the principal user countries on the safe handling, disposal and rehabilitation of asbestos-contaminated construction wastes. This section will seek to highlight some of the international approaches to the rehabilitation of asbestos contaminated wastes and point out their limitations.

The guidelines that exist are not specific when it comes to the rehabilitation of sites into which asbestos-contaminated waste has been placed, and by contrast, focus their attention and

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<sup>32</sup> Section 46 Amended MPRDA

<sup>33</sup> DWAF, ‘Policy On The Handling And Disposal Of Asbestos And Asbestos Containing Waste In Terms Of Section 20 Of The Environment Conservation Act, 1989 (Act 73 Of 1989)’, p.2

<sup>34</sup> DWAF, ‘Policy On The Handling And Disposal Of Asbestos And Asbestos Containing Waste In Terms Of Section 20 Of The Environment Conservation Act, 1989 (Act 73 Of 1989)’

detail on the safe handling and placement for disposal of the material into landfill.<sup>35</sup> Any landfill receiving asbestos-contaminated material must be a hazardous materials landfill.

The guidelines and information governing the handling and placement of asbestos-contaminated material are extensive and all focus on managing / minimizing the airborne mobilization of the asbestos fibres / dust in a manner that could bring it into contact with humans or animals (directly or indirectly). Almost none of them deal with the requirements of the disposal sites for asbestos since in both the European Union (EU) and North America, landfill sites are generally managed by public, as opposed to private sector organizations.<sup>36</sup>

In the EU the disposal of asbestos-contaminated waste is treated almost exclusively as a landfill issue where

In a landfill with separate quarters asbestos-containing waste should be stored separately from other waste and the quarter should bear warning signs and should be marked on the landfill map. Such waste should be stored in landfill sites located far from residential buildings and separated from them with a green strip... A layer of waste packages thus stored should be covered with plastic or with 5 cm ground layer in order to prevent damage of the packaging.<sup>37</sup>

In the United States the main concern is around the risk that faulty asbestos removal poses to potential additional exposure. The five main treatment categories are<sup>38</sup>:

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<sup>35</sup> A Cameron *Neues Magnesium-Schmelzverfahren vereinfacht die Entsorgung gefährlicher Abfälle Metall* 1995 vol 49 No 11 pp.710-712.

<sup>36</sup> ASTM International, the world's largest producer of voluntary consensus standards. *Standard E2394: The ASTM Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products* suggests procedures for:

working with asbestos-cement products – roofing, siding, ducts, pipes and other construction materials – that have already been installed in and between buildings... Control of dust and fiber release using wet methods – soapy water, shaving cream and similar substances – is stressed. Four appendices cover underground pipes, buried ducts, drilling holes and removing panels, and additional appendices will be prepared to cover other operations and materials. Installation of new asbestos-cement products is not encouraged by the standard. Large-scale abatement is not the intended purpose, although some of the procedures may apply to such operations.

E2394, which is intended for use by supervisors, managers, government agencies and NGOs, is applicable to conditions in developing and developed countries; the need for worker training and hands-on experience with non-asbestos products is indicated as is the hazard of using power tools. The emphasis of the standard is on the protection of those workers most at-risk of exposure to airborne asbestos. No asbestos regulations are cited in the protocol which can therefore be used as a guideline for national asbestos control regulations where needed.

<sup>37</sup> Paper presented at *The Management of Asbestos Waste in Poland* was the subject of the presentation by Ewa Mieczkowska, an expert from the Ministry of Environment: Asbestos Conference in Poland held on May 11, 2004 in Lodz,

<sup>38</sup> Jim Fite (White Lung Association USA) *The Technical Aspects of Asbestos Abatement* / Andy Oberta *A New Standard for Repair and Maintenance of Installed Asbestos-Cement Materials* both; Proceedings of the Asbestos Conference held in Lodz Poland, May 11, 2004.

Repair	<p>Purpose: to make the asbestos containing material (acm) non-friable.</p> <p>Process: use of glue, plaster or other products to seal a broken floor tile, a cracked transite board, etc.</p>
Encapsulation	<p>Purpose: to bond asbestos onto a surface or into a material thereby preventing fiber liberation.</p> <p>Process: application of a liquid sealer over acm.</p>
Enclosure	<p>Purpose: to prevent liberation of fibers.</p> <p>Process: use of an airtight and watertight barrier to prevent human exposure to asbestos dust.</p> <p>Examples: used where asbestos cannot be removed such as in abandoned mines, factories, crawl spaces, boilers.</p>
Operations/ Maintenance	<p>Purpose: recognition of damaged acms and hazardous conditions, minimization of risks for small jobs.</p> <p>Process: training.</p>
Removal	<p>Purpose: final solution to asbestos contamination.</p> <p>Process: location of and evaluation of asbestos, state-of-the-art removal and decontamination techniques (negative pressure, HEPA filtered equipment, etc.), constant monitoring, clearance with phase contrast microscopy or transmission electron microscopy.</p>

Neither the US EPA nor any of the major European Environmental Protection Agencies have published guidelines on the rehabilitation of former asbestos mining sites and it appears that where the challenge of rehabilitating asbestos-contaminated material does exist at a former mine site, the default is to rely on the handling and landfill disposal guidelines.<sup>39</sup>

Asbestos ore is found in material which after treatment is very prone to erosion and thus rehabilitation of asbestos-contaminated mine wastes is subject to a range of criteria, including but not limited to: climatic conditions, erodibility of capping material and impact of human and animal movement across the surface of the rehabilitated area. In one way or another all of the rehabilitation methods are aimed at covering/ encapsulating the asbestos-contaminated material with an inert layer of material that can resist erosion for some time. Due to the threat of litigation most developed world countries have been very reluctant to settle on an accepted thickness for the capping layer or its composition.<sup>40</sup>

From the information gained from the examples of asbestos mine site rehabilitation outside of South Africa a common theme emerges: beginning with some form of capping or encapsulation as the only accepted way of rehabilitating such sites. However, in more

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<sup>39</sup> Kaliampakos D., Menegaki M., 'Transforming and Old Asbestos Mine into a Hazardous Waste Repository: Pros and Cons', *Apré-mine 2003*, International Symposium, Post – Mining, Impacts and Risk Management, Nancy, France, February 5-7, 2003

<sup>40</sup> Personal Communications Prof Ron Cohen Colorado School of Mines May 2008.

developed and litigious societies, the default is often strict access control and administration by public sector agency pending some consultative process for an acceptable decision regarding the rehabilitation methodology employed. This process has also become more difficult as new technologies for the extraction of the magnesium associated with asbestos ore / wastes are coming on line which may lead to the treatment of at least high-grade wastes by smelting.

With respect to evaluating the success of rehabilitation/ vegetation work on capped asbestos dump sites, no guideline spells out criteria for formally determining ‘success’. In part this is due to the recent nature of much of the rehabilitation work, but it is also a function of uncertainty among rehabilitation practitioners more generally as to what constitutes long-term sustainable vegetation on dumps. While the general trend would be to argue that success is defined as ‘self-sustaining vegetation’ this is not necessarily a condition that can be achieved permanently for asbestos dumps where there is the ever present danger that the ingress of deeper rooting plants could lead to asbestos ore exposure in future. In the absence of success criteria for asbestos-specific rehabilitation, the definition of rehabilitation success and self-sustaining vegetation can only be based upon the conditions of the ecosystem surrounding the asbestos contaminated area. If the rates for erosion, water ingress and vegetation cover of the surrounding natural ecosystem (provided this is not degraded) can be achieved on the capped asbestos dump over a period of time sufficiently long to demonstrate sustainable succession of a locally representative diversity of plants, then the site can be deemed successfully rehabilitated. It is submitted that few rehabilitated sites have been monitored sufficiently long for such a determination to be made.

## **CASE STUDIES - REHABILITATION OF CONTAMINATED AREAS**

### **Introduction**

Asbestos has been mined and processed for more than 2000 years<sup>41</sup>. The largest production of asbestos came from the USSR and Canada. Other known asbestos producers include South Africa, Brazil, Zimbabwe, Italy, China, Greece, the USA, Swaziland, Cyprus, Turkey, Colombia, Japan, North Korea, Bulgaria, Australia and Egypt. Impacts of asbestos mining have affected not only the employees of the mining companies but also residents living in close proximity to mining areas. In the United States of America tens of millions of dollars have been paid in compensation of which a large number of the claimants had not worked in asbestos mining environments or handled asbestos products. This was further proved by a study conducted by the Pneumoconiosis Research Unit (PRU)<sup>42</sup> on residents from Prieska, Koegas, Kuruman and Penge in 1963 which concluded that people who lived in the close proximity to these mining areas were in danger of contracting asbestosis although they had no exposure to industrial asbestos exposure inhalation. Contracting asbestos related health impacts such as mesothelioma is relative easy and requires minimal exposure. The impacts will take some time before evidence of the disease is evident. The latency period of mesothelioma can be up to 40 years.<sup>43</sup>

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<sup>41</sup>H.Hart. ‘Asbestos in South Africa’. *Journal of the South African Institute of Mining and Metallurgy*. June 1988, Vol 88, No 6, pp 185-198

<sup>42</sup>P Otness et al. ‘Asbestos-Recent Developments and Implications for the Health Policy’. *Proceedings of the fifth national workshop on the assessment of site contamination*. 2003. p 243 – 252.

<sup>43</sup>McCulloch, J 2007 ‘Surviving blue asbestos: mining and occupational disease in South Africa and Australia.’ *Transformation* 65, pp 68-92.

An investigation conducted by in the mining area of the Chaibasa Region in India<sup>44</sup> revealed that asbestos mining activities left a legacy of abandoned mine sites and dumps in the Roro which pose a serious threat to the health of the local community and environment. The extent of the asbestos impacts has been increased beyond the mining area sites by monsoons and winds which transport asbestos material down slopes to new areas. Vegetation growth in the hills is characterised by limited flora and fauna species.

Rehabilitation of mine dumps should aim to ensure that contaminated soil is covered to prevent exposure of asbestos dust fibres to the environment. Such rehabilitation measures should include permanent land cover in the form of buildings, roads and car parks which gives the land beneficial alternative land use. Asbestos can not completely degrade in the environment and thus will remain in the disposal area for a long time until asbestos fibres are lifted by anthropogenic activities. An experiment to examine asbestos in the air resulting from wind erosion conducted Van Der Walt and De Villiers<sup>45</sup> revealed that the concentration of asbestos fibres in the atmosphere was proportional to the wind speed at a point in time. However, calculations of this nature are fraught with errors due to the difficulty of quantifying the variables. Asbestos dust will not be completely eradicated, it is advisable that future land uses should be inspected periodically to monitor and ensure that buried asbestos is not exposed.

Experiments have been conducted to rehabilitate asbestos contamination. Different methods have been implemented in different parts of the world to rehabilitate asbestos wastes. A number of rehabilitation approaches, case studies and procedures are given below.

## **Rehabilitation of Asbestos Contaminated Areas**

### ***1. Pano Aminantos Asbestos Mine***

Pano Aminantos is located on the Island of Cyprus which is located approximately 75 km south of Turkey.<sup>46</sup> Cyprus covers an area of 9 251 km<sup>2</sup>, Pano Aminantos is located east of Olympus in the mountain range of Troodos.<sup>47</sup> The mine site is located between the Livadhi and Loumata Valleys.

The asbestos mining operation started small but by the time the mine was closed, an area of approximately 220 hectares had been mined of asbestos.<sup>48</sup> Asbestos mining in Cyprus was conducted between 1904 – 1988. Chrysotile (white) asbestos was mined over an area of 6.5 km<sup>2</sup> and was mined using the open cast mining method.<sup>49</sup> In 1947, asbestos produced from the mine had reached 35 000 tones per year, resulting in approximately 3 to 5 million tones of waste production per year. The mining operations gave rise to the development of Pano Aminantos Village. During the early stages of the mining operations, in the 1930's, the mine employed more than 10 000 people. When the mine was closed it had a population of approximately 650 people and the number declined further as the years passed. In 2001, the village had only 61 people.

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<sup>44</sup> Madhumita et al. 'The Blight Hills of Roro' B.I.R.S.A. Mines Monitoring Centre. 2003.

<sup>45</sup> I.J Van der Walt and A.B De Villiers. 'Model to determine airborne environmental pollution from asbestos mine dumps'. *Geomorph* N.F. Vol 30 No3. Page 339 - 347

<sup>46</sup> C. Dimokratia. Cyprus. Country overview. [www. Nations Encyclopedia.com/economies/asia and the pacific/Cyprus.html](http://www.Nations Encyclopedia.com/economies/asia and the pacific/Cyprus.html).

<sup>47</sup> Pano Amniantos. [www.panoamniantos.org/english/general.shtm](http://www.panoamniantos.org/english/general.shtm)

<sup>48</sup> A Pearce et al. Mines and Caves of Cyprus. [www.shropshiremines.org](http://www.shropshiremines.org)

<sup>49</sup> K Kyrou and George Petrides. 'The rehabilitation of the asbestos mine in Cyprus'. 2005. pp 1 - 9

Operation of the mine boosted the economy of Cyprus extensively, providing employment to the local people and attracting workers from neighbouring villages. The mining operations in the area also had negative impacts. The major environmental impacts that were identified with the closure of the mine were the open pit, waste tips and contamination of soil and surface water which posed a health risk to people. Large tracts of flora and fauna were destroyed during the operations. The waste material from the mine was scattered across the mining area. The presence of the exposed mine dumps posed a health and environmental risk.

The council and ministers decided that rehabilitation work had to be undertaken. Rehabilitation of the mine started in 1995. The highest priority was given to the stabilization of the waste tip slopes which posed a safety risk to properties below the mine and pit area. Washing away of asbestos material by surface water was also a concern and so were the angles of the slopes. The final outcome was expected to be a reforested area which would be as close as possible to pristine.

Liquefaction which would result in the waste sliding to a nearby village was a possibility which was taken into consideration during the rehabilitation of the slopes. Liquefaction is a condition whereby material becomes fully saturated and is mobilized due to events such as during earthquakes. Tsuchida (1970)<sup>50</sup> noted that uniformly graded fine sands and silts have a high potential to become liquefiable. Observations were made by Seed et al.<sup>51</sup> that according to empirical correlations based on standard penetration resistance liquefaction is not possible in these soils by earthquakes of magnitude below 7.5.

A slope stability analysis was conducted for static loading and earthquake loading. The first step of rehabilitation was to ensure that the slopes were stabilized. Slopes on the mine dumps were re-profiled with the objective of ensuring the slopes did not differ significantly from the slopes of the area and to ensure that the slopes would be safe. The mine dumps were graded to create slopes of 2:1. The design of the mine dump profiles ensured that the surface water was intercepted to prevent erosion of the dumps. More than 3.6 million m<sup>3</sup> were handled during reshaping of the dumps.

Following reshaping of the slopes, reforestation efforts were implemented. The initial preparations were the construction of 0.8 meter (m) deep trenches at 5 m apart in the flat area, to allow trucks access to the dumps for the delivery of top soil. The top soil was also used to fill up the trenches. On the slopes, two secondary terraces 1.2 m wide were constructed. The mine dumps were then capped with approximately 30 cm fertile top soil. Monitoring systems were installed to measure surface and groundwater movements in the waste and results indicated that movements were more pronounced during wet winter months.

Planting was then carried out on the terraces and trenches. Seed sowing was applied in the other areas of the prepared dump using different species. Species used for planting along the trenches and terraces are *Pinus brutia*, *Cedrus breuifolia*, *Rhus coriaria*, *Rabinia pseudoacacia*, *Cupressus sempervirens*, *Quercus alnifolia*, *Arbutus andrache*, *Sorbus aria*, *Juniperus foetidissima*, *Clematis vitalba*, *Pistacia terebinthus*. Other areas of the dumps were sown with *Pinus brutia*, *Robina pseudoacacia*, *Rhus coriaria*, *Allanthus altissima*, *Alyssum cypricum*, *Eschscholzia californica*, *Alcea roses*, *Solvia willeana*, *Pterocephalus multiflorus*, *Helichrysum italicum*, *Cistus creticus*, *Cistus*

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<sup>50</sup> H Tsuchida. 'Predictions and counter measures against the liquefaction in sand deposits' - *Abstract of the seminar in the Port and Harbour Research Institute*. 1970. pp 3.1 – 3.33

<sup>51</sup> H.B Seed et al. 'The influence of SPT procedures in soil liquefaction resistance evaluations.' 1984. Report NoUBC/EERC-84/15

*salivifollus*, *Phytolacea pruirosa*, *Vicia tenuifolia*.<sup>52</sup> Species used for planting and sowing were collected from plants growing in the area. The capping of the dumps and reforestation proved to be successful. Vegetation established in the supplied top soil and most areas have limited vegetation growth.

From this case study is noted that, it is important to ensure that the slopes of the mine dumps are reshaped where required to limit soil erosion and to allow establishment of vegetation. Since asbestos contaminated soil inhibits plant growth, it is imperative that a suitable substratum is provided for the vegetation. The soil used for capping the dumps should preferably be planted with indigenous species. This will ensure that the vegetation will adapt to the local environment.

## **2. Millington Asbestos Processing Plant, New Jersey, USA.**

Millington is located in New Jersey, in eastern United States of America. The Millington site is located at 50 Division Avenue in Millington.

The site consists of 4.4 hectares of land which was used as an asbestos processing plant and for the disposal of asbestos and asbestos containing material.<sup>53</sup> Millington has a population of 7 800 people.

Chrysotile asbestos processing operations at the site started in 1927 and stopped in 1978.<sup>54</sup> Water from the plant was impounded at the site by dams. Sediments containing asbestos material were removed from the pond and disposed of on site. Waste generated from the processing plant was also dumped at the site in a two hectare area. Over time waste production at the site exceeded the waste storage capacity and additional waste was transported off site for disposal. Approximately 68 400 million m<sup>3</sup> of asbestos material were dumped at the site.

The asbestos dumps were identified to pose a health risk through inhalation and ingestion of asbestos fibres. Asbestos dumps were also found to be too close to the rivers in the area posing potential contamination. Soil assessments conducted at the site also revealed elevated concentrations of mercury and nickel at the site.

In rehabilitation of the site a retaining wall was constructed at the foot of the mine dump close to the river. The retaining wall was constructed using a pre-cast concrete mat. Water diversion channels were constructed around the dumps to prevent washing away of the asbestos dumps. A 0.60 m soil cover was constructed over the mine dumps. The area was fenced off and warning signs placed at the site. Access to the site was restricted. The rehabilitated area was vegetated with native species. Monitoring of rehabilitation efforts was to be conducted over a 30 year period and is currently underway. Over the monitoring period, some areas had to be rehabilitated due to exposure of fibres by erosion while in other areas, re-vegetation had to be implemented as vegetation failed to establish.

Rehabilitation efforts are predominately undermined by erosion of the cap material which results in the exposure of the underlying fibres. From the case study, it was noted that rehabilitation efforts should be implemented on an on-going basis to ensure success. In addition, for satisfactory results, a rehabilitated area may be required to be fenced off limiting disturbance to rehabilitation efforts.

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<sup>52</sup> K Kyrou and George Petrides. 'The rehabilitation of the asbestos mine in Cyprus'. 2005. pp 1 - 9

<sup>53</sup> EPA report. 2007. 'Asbestos mine dump, New Jersey'.

[www.epa.gov/region2/superfund/npl/02007969c.pdf](http://www.epa.gov/region2/superfund/npl/02007969c.pdf)

<sup>54</sup> EPA. Record of decision. Asbestos dump. OU01 Millington, NJ, 1988

### **3. Coalinga Asbestos Mine.**

The City of Coalinga is located in Fresno County, California. It is located west of Central San Joaquin Valley. The asbestos mine site is located approximately 27 km from Coalinga in Fresno county.<sup>55</sup>

The Coalinga asbestos site covers an area of approximately 300 hectares. A chrysotile asbestos mine and milling plant was operated at the site starting from 1963 and the last operations were conducted in 1974. The operations resulted in the formation of asbestos mine dumps that covered 50 hectares and two open pits. Asbestos from the milling site was transported to the city of Coalinga for storage and shipping, resulting in contamination of an area of 268 hectares in the city.

The Coalinga asbestos mine is located within a rural area. The asbestos tailings created at the site posed a health risk to residents in the former mining area and to people visiting the area. Asbestos fibres were also found to be washed away during rainy periods. The waste washed into water courses posed an environmental and health risk.

Rehabilitation efforts started in 1993 after the potential impacts were identified to be significant. Asbestos tailings were graded to stabilize the dump slopes. Diversion of rivers that ran close to the asbestos dumps was implemented to prevent washing away of asbestos fibres. The existing sediment trapping dam was improved to further limit washing away of tailings into rivers. The graded asbestos tailings were capped with clean fertile soil. A pilot project for re-vegetation of the mine dumps with indigenous species was conducted at the site. The project was identified to be a success and all the mine dumps were re-vegetated with indigenous species. Following completion of the rehabilitation, the area was fenced off and access restricted.

Monitoring investigations conducted in 2007 following rehabilitation, indicated that the rehabilitation measures implemented at the site were successful and there is no change to the land-use<sup>56</sup>

From the case study it was noted that asbestos fibres in waste dumps could be transported over a long distance by running water. To limit the spread of asbestos fibres by water, a settlement pond can be constructed to ensure that limited asbestos fibres find their way into water ways.

### **4. The City of Coalinga**

The City of Coalinga is located within the Fresno County in California. The city is located approximately 27 km south of the Coalinga asbestos mine. The San Joaquin Valley is located to the east of the city. The city had a population of approximately 1700 people in 2007.

Mining activities of asbestos and chrome ore in the vicinity of the city resulted in the development of an industrial area within the city, where these materials were milled, manufactured, stored and transported out of the city. This industrial area is located along the Highway 198 on the south-western end of the city.<sup>57</sup>

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<sup>55</sup> EPA. 'Coalinga Asbestos Mine EPA region 9, superfund report'. [www.yosemite.epa.gov/r9/sfund](http://www.yosemite.epa.gov/r9/sfund)

<sup>56</sup> Envirostos. Coalinga Asbestos Mine. [www.envirostor.dtsc.ca.gov/public/profile\\_report.asp](http://www.envirostor.dtsc.ca.gov/public/profile_report.asp)

<sup>57</sup> EPA. Final Second five year review report for Coalinga asbestos mine superfund site. Coalinga Fresno County, California. 2001

The operations of the area as well as the handling and storage sites resulted in the accumulation of asbestos waste and ore material. The contamination covered an area of approximately 268 hectares between the intersection of Lucille Avenue and Highway 198. The area was covered by approximately 15 200 m<sup>3</sup> of asbestos, chrome and nickel contaminated soil. Health impacts associated with the inhalation of asbestos dust and contamination of soil was identified at the site and rehabilitation measures formulated.

As a temporary measure, in response to the identified potential environmental and health risk, the contaminated area was closed off allowing restricted access. Dust emissions were suppressed using a biodegradable sealant and by covering waste ore with plastic sheeting. Permanent rehabilitation measures were implemented in 1989. A waste disposal unit was constructed at the site by excavating a portion of the site. Asbestos contaminated materials were removed and consolidated. Buildings in the area were also decontaminated. The consolidated waste material was disposed of in the waste disposal unit. Following disposal, the surface of the waste disposal unit was capped. The capping process was conducted by compacting soil over the waste and then an impermeable clay mat was compacted over the base soil. An additional soil layer was finally added. Indigenous vegetation was planted over the rehabilitated area.

Monitoring of the rehabilitation efforts indicated that the soil and air in the area was clean. The area of the waste unit was fenced off and access restricted. Additional monitoring conducted at the waste unit area identified damages to the unit. The damage was caused by burrowing animals. Re-vegetation was found to be successful and self-sustaining. No irrigation was required and significant erosion impacts were noted on the rehabilitated area. Maintenance on the site was conducted monthly whereby vegetation growth was monitored, fertilizer added where required, deep rooted vegetation removed and burrow holes filled. After five years the site was declared fully self sustaining and requiring only periodic monitoring.

The City of Coalinga asbestos rehabilitation project highlighted that asbestos mining and its associated impacts is not only limited to the mining and milling areas. Asbestos dumps are also generated at the manufacturing and storage plants located away from the mine area. The case study highlights variations in the application of the capping method. At this site asbestos waste was found to pose significant health impacts and a short term solution, which was the implementation of dust suppression techniques to limit asbestos exposure during rehabilitation, was provided. Permanent rehabilitation of asbestos material at the site was undertaken by excavating an area where the asbestos was disposed and a soil layer added. For increased protection, three layers of soil were added with two layers being compacted forming an impermeable layer. This limits potential impacts of erosion and increases the stability of the capping layer. In addition, it was noted that vegetation can also pose a threat to the success of a rehabilitation plan. Vegetation with deep roots had to be monitored and removed if suspected of posing a risk to the capping surface.

### ***5. Atlas Asbestos Mine***

Atlas asbestos mine is located approximately 20 miles north west of the City of Coalinga in Fresno County, California. The mine site is located 4.8 km west of the Coalinga Asbestos mine.<sup>58</sup>

Chrysotile asbestos mining was conducted from a 350 hectare site. Asbestos operations were conducted from three open pit mines. Asbestos was milled on site before being moved to the City of Coalinga for further transportation. The mining operations started in 1967 and the operations were

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<sup>58</sup> Five year review report for Atlas Asbestos Mine Superfund Site and Coalinga Asbestos mine (Johns-Manvine Mill) superfund sites Fresno County, California', 2006, prepared by CH2MHill

closed down in 1979. The result of the mining and milling operations was the development of 2.3 million m<sup>3</sup> of asbestos tailings.

Elevated levels of asbestos fibres were detected in 1980 in water samples collected from the California aqueduct. Water analysis from rivers in the area and from the air revealed elevated asbestos concentrations. The source of the asbestos fibres was identified as the Atlas Mine. It was decided that remedial action was to be implemented at the site.

Rehabilitation efforts were directed at eliminating release of asbestos fibres into the air and into local rivers. Rehabilitation activities started in 1994.<sup>59</sup>

Rehabilitation measures implemented at the site, included stream diversions, sediment trapping, grading of asbestos tailings and re-vegetation. Several sediment ponds were constructed at the site to retain sediments from storm water runoff. Sediments storage areas were also constructed close to the settlement ponds. The mine dumps were graded to stabilize the slopes. Water diversion channels were constructed around the graded mine dumps diverting water into impoundment ponds. The main access road to the site was paved with a double bituminous cap and a soil stabilizer was applied to the access roads to the ponds, to limit dust emissions. The rehabilitated area was then re-vegetated with indigenous species. The area of the site was fenced off to allow limited restriction.

For the regeneration efforts of the area, trails were conducted to assess the plant species and soil to be used for the treatment of the site. Approximately 2 356 m<sup>3</sup> of soil was added to an area of 7.4 hectares and 10 000 individual plants were planted. Hydro seeding was applied to approximately 3.7 hectares of the rehabilitated land. During the treatment and planting process, the soil applied to the area was mixed with organic compost, slow releasing fertilizer and gypsum. Planting was conducted in contours of live shrubs and grass seeds applied as a hydro-seeded slurry.

Follow-up monitoring investigations conducted in 2005 at the site, revealed that soil erosion was taking place in some areas of the site and these areas were attended to by recapping the exposed soils. Vegetation monitoring revealed that, vegetation was growing in a satisfactory manner. Vegetation efforts were deemed successful as new vegetation had established in the rehabilitation area and outside the vegetation area. Self dispersal of vegetation was taking place at the site.

From the Atlas case study it is important to ensure that rivers in the asbestos contaminated areas be diverted away from the dumps to limit erosion of the dumps and contamination of the rivers. It is also key, that in areas where rivers are located close to the mine dumps and where the erosion potential is high, to create impoundment ponds which will capture material eroded from the dumps. This rehabilitation technique will require continuous monitoring as the ponds have to be drenched. Asbestos contamination is not limited to the dumps of the mine, the roads are also contaminated and movement of vehicles can release asbestos fibres into the air. Roads in asbestos contaminated areas should be capped with a hard surface to prevent release of asbestos fibres.

## **6. Southern Quebec, Canada.**

Quebec is located within Canada to the north of Montreal. Quebec is located along the river Becanour in the Appalachians.<sup>60</sup> The asbestos mining area is located on the southern parts of Quebec.

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<sup>59</sup> EPA. 'Remedial Action Implementation, Atlas Asbestos Mine Superfund Site'. 2004

<sup>60</sup> J Dubois and P Mailhot. Thetford mines. The Canadian Encyclopaedia. 2008.

Chrysotile asbestos was mined in the area from 1877. The largest open pit asbestos mine in the world is found in Southern Quebec.<sup>61</sup> More than 125 000 tons of asbestos were produced in the area since 2002. The mines in the area produced almost 40% of world's asbestos.<sup>62</sup> Asbestos mining in the area resulted in the formation of large volumes of asbestos tailings and in some areas houses had to be relocated to make space for the mining operations. Asbestos waste (in south eastern Quebec) of approximately 5.5 km<sup>2</sup> has been in existence for up to 60 years, yet no vegetation or limited vegetation grows on these dumps.

The asbestos mining activities in the area resulted in the deterioration of health conditions of the local community. Asbestos mining is still continuing in the area. Recent air and soil sampling conducted at the site indicated that there were high concentration levels of asbestos fibres in the area.<sup>63</sup> The government of the area is benefiting significantly from asbestos operations in the area and as such health and environmental impacts are not publicized. Limited rehabilitation efforts have been implemented in the area.

A study was conducted by Moore and Zimmermann<sup>64</sup> on flat topped and sloping asbestos mine dumps to assess factors that inhibited plant growth in these areas and to find solutions that can be used to improve plant growth. The study aimed to specifically study the effects on plant growth of adding inorganic and organic fertilizer to the contaminated soil.

Nine 4 x 4 m plots, divided into two subplots of 2 x 4 m, were established on the asbestos dumps. A mixture of agricultural fertilizer containing ammonium nitrate, potassium sulphate and super phosphate were added to the mine waste at 0, 0.1, 0.25, 0.5 and 1 kg/m<sup>2</sup>. Farmyard cow manure was applied at 1 and 4 kg/m<sup>2</sup>. The mixture was added to the upper 5 to 10 cm layer of the mine dumps and seeded with a mixture of common agricultural grasses and legumes at an amount of 20 g/m<sup>2</sup>.

The results of the study revealed that the most successful treatment was that of the addition of 1 kg/m<sup>2</sup> of fertiliser and 4 kg/m<sup>2</sup> of manure which resulted in more than 90% plant cover. Plant growth and health was more pronounced on the flat tops than on the slopes. Predominate grass species were perennial rye-grass (*Lolium perenne*), *Poa pratensis*, *Elymus junceus*, *Bromus inermis*, *Poa palustris* and *Hordeum jubatum*. The most successful legumes were *Trifolium hybridum* and *Melilotus alba*. The most suitable species was *Elymus junceus*, which was the only species that produced roots extending more than 10 cm into the untreated asbestos waste.

The southern Quebec case study highlights the fact that asbestos tailings inhibit growth and if not treated, the mine dumps will remain exposed. Some mine dumps in the case study have existed for more than 60 years and have limited vegetation. The study conducted by Moore and Zimmermann showed that treatment of asbestos tailings improves vegetation growth. In addition, certain vegetation species may require treated soil during the early development stages and once established they can grow on asbestos tailings. This can be observed with *Elymus junceus* which at establishment, extended its roots more than 10 cm into the untreated asbestos waste. Such species are likely to require limited maintenance.

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<sup>61</sup> J. Kuyek. Asbestos Mining Activities in Canada. 2003

<sup>62</sup> W. Ross. 'Encroachment of the Jeffrey Mine on the town of Asbestos, Quebec'. *Geographical Review*, vol 57, No 4, 1967, pp 523-537

<sup>63</sup> W. Charney. 'Quebec Asbestos Mining Town Severely Contaminated.' Last updated, November 2007.

<sup>64</sup> T.R Moore & R.C Zimmermann. 1977. 'Establishment of vegetation on serpentine asbestos mine waste'. *Journal of Applied Ecology*, Vol 14 pp 589 - 599

## **7. Libby Montana, United States of America**

Libby is a small town located on the north-western corner of Montana, 56 km east of Idaho and 105 km south of Canada in the Lincoln County. To the east of Libby are the Zolite mountains. The town sits on the bed of the Kootenai River which flows from Canada towards the Columbia River. The Libby area boasts a population of less than 3000<sup>65</sup> with approximately 12000 people living within a 16 km radius of Libby.

Vermiculite was mined and processed in Libby employing more than 1900 people from 1919 to 1990.<sup>66</sup> During its operation, Libby mine produced 80% of the world's supply of vermiculite. The vermiculite was heated at high temperatures until it popped in order to create pockets of air in the material, making it suitable for use as insulation material and for soil amendments. Vermiculite was also processed to create Zonolite.<sup>67</sup> The vermiculite mined in Libby was contaminated with tremolite-actinolite series asbestos, a type of asbestos which is relatively uncommon and often referred to as tremolite, libby asbestos or libby amphibole. The waste rock and waste from the mills was stockpiled in the vicinity of the different operations. Asbestos dust from the waste dumps was blown to other areas of Libby where it settled covering buildings and other infrastructure. The asbestos contaminated vermiculite is estimated to have affected more than 350 000 properties.

Several residents and former employees of the vermiculite mine and processing plant died and others were ill. The health effects on the communities were blamed on the presence of asbestos in the vermiculite mine and processing areas.

The United States Environmental Protection Agency (EPA) began investing in asbestos decontamination of properties in 2002. The major source of libby asbestos was determined to be the mine, the screening and exporting plants. Investigations were conducted by visual observation of vermiculite material on buildings and plots. Visual identification of libby asbestos is more difficult than identification of vermiculite material. Vermiculite sampling in Libby had indicated the presence of 70 % of libby asbestos in each sample. Based on these observations, it was concluded that cleaning up of vermiculite greatly assisted with the removal of libby asbestos. Libby asbestos dust was found to pose environmental and health risk. EPA initiated emergency remediation work to eliminate the risk to human health.

Soil sampling commenced in 2002 and contaminated areas were identified. All sources of contaminated waste were safely removed from the major sources in August 2002.<sup>68</sup> Contaminated soil was excavated from each property and removed for safe disposal off-site at a mine shaft. Dust and other contaminated materials found in buildings were removed for disposal. During the cleanup period residents were temporarily relocated until the rehabilitation was completed. Contaminated waste was disposed at a mine site. Excavations were then filled with top soil subsequent to removal of asbestos contaminated soil. Following the cleaning of the area, asbestos contamination was found to be within acceptable levels. Asbestos contamination in the town is still being monitored closely.

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<sup>65</sup> United States Environmental Protection Agency. 'Libby Asbestos Site Residential/Commercial Cleanup Action Level and Clearance Criteria'. Technical memorandum. December 2003

<sup>66</sup> EPA. 'Asbestos and Vermiculite'. Region 8. Mountains and Plains. Last updated 1 November 2007. [www.epa.gov/region8/superfund/libby/asbestos.html](http://www.epa.gov/region8/superfund/libby/asbestos.html)

<sup>67</sup> T Walker et al. Division of Health Assessment and Consultation. 'Asbestos Contaminated Vermiculite'. A National Issue. Hazardous Substance and Public Health. Vol 12, #1, 2002

<sup>68</sup> EPA. 'Asbestos Cleanup Activities'. Region 8: Mountains and Plains. [www.epa.gov/region8/superfund/libby/cleanup.html](http://www.epa.gov/region8/superfund/libby/cleanup.html)

The Libby vermiculite mine case study highlights that rehabilitation of asbestos impacts should not only focus on the dumps as dust fibers can be transported by air and water to other area in the vicinity of the dumps. Rehabilitation efforts should also include decontamination of properties in the vicinity of the mine dumps. The waste removed from the Libby residential area was disposed of at a mine site. As an alternative, asbestos tailings can be disposed of in the mining area and used for closing the pits created.

### **8. Wittenoom, Australia**

The town of Wittenoom is located in Pilbara, Australia.<sup>69</sup> The town developed in 1947 due to asbestos mining activities in the area. The area was developed for the mine employees and by the late 1940s, it was the largest town in north-west Western Australia. Wittenoom was the main source of blue asbestos in Australia. The town was moved and already more than 40 people had died due to asbestos infections and others had asbestos related diseases. The air quality of the area had been determined not to be suitable for human occupation. The Australian government had been trying to close the area down since 1970 and managed to remove the last person in 2006.

Approximately 150 000 tons of blue asbestos was mined between 1937 and 1966. Asbestos was mined from three mines namely the Yampire, Wittenoom and Colonial asbestos mines which resulted in over three million tons of asbestos tailings.<sup>70</sup> Asbestos was blown across the mining area over a distance of approximately 10 km<sup>2</sup>.

In order to determine an intervention plan for the asbestos contamination, a risk assessment process was adopted to determine the asbestos concentrations, exposure of people and the level of risk posed to different people in the area. The results of the risk assessment revealed that the area was extremely contaminated. Based on the evaluation criteria a response plan was selected.

Rehabilitation efforts included capping of tailings with rock fragments, shaping of steep slopes to avoid erosion, diversion of surface water away from the dumps and establishment of vegetation on the prepared tailings. In river courses, asbestos contamination was removed and stream beds reshaped to limit erosion. Contaminated areas were fenced off and warning signs erected. The town area was evacuated and people permanently relocated. Access to the contaminated areas was limited to a few carefully planned roads.

In some areas where residential developments are located within close proximity to the asbestos dumps and where contamination levels are high, residents need to be relocated permanently to ensure that health impacts are reduced and to make rehabilitation successful. In Wittenoom, the residents were initially temporarily relocated for rehabilitation of the area, however, following resettlement of the communities it was determined that the rehabilitated fibres were exposed again. The solution was then to permanently relocate people due to the significant fibre concentrations in the environment. Permanent relocation and a closing down of the area were the best sustainable solutions. However, some residents have remained, risking the dangers of asbestos-related diseases and state that “we couldn’t imagine living in a place more peaceful and beautiful than this”.<sup>71</sup>

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<sup>69</sup> Asbestos and Mesothelioma News. ‘Australia shuts down asbestos town’. July 2006. [www.asbestos-post.com/australia-shuts-down-asbestos-town.html](http://www.asbestos-post.com/australia-shuts-down-asbestos-town.html)

<sup>70</sup> PB and GUD. ‘Management of Asbestos Contamination in Wittenoom’. Non-technical Summary. November 2006

<sup>71</sup> *Sunday Independent*, South Africa, June 8, 2008

## 9. Mountain View Mobile Home Estates, USA

The Mountain View mobile home estate site is located in the state of Arizona. Mountain View is located in Central Arizona in Globe, Gila County. The town was developed as a result of blue asbestos mining in the area.<sup>72</sup> Approximately 300 people lived in the town during the initial phases of mining.

Blue asbestos was mined in the area from 1953 to 1974, the operation was shut down in 1974 due to the poor air quality resulting from the mining and milling of asbestos. The poor air quality of the area was found to exceed the Gila-Pinal County's air quality standards. Following the closure of the mine the asbestos tailings were levelled and used as landfill material. The levelled area was then subdivided into 55 plots and 47 of the plots were eventually used as residential property for approximately 130 people. The state and local health officials discovered asbestos contamination of soil and air in 1979 in the subdivided portions.

The area was declared unfit for human occupation in 1980 and people were temporary relocated while their properties were decontaminated. Rehabilitation measures implemented at the properties were the demolishing of the mill buildings and the on-site burial of all contaminated material. The rehabilitated area was then capped with a 1.5 m protective soil cover to eliminate migration of asbestos fibres.

In 1981, asbestos fibres were by erosion and human activities, posing a health and environmental risk. The Arizona Department of Health Services concluded that a more permanent remedy was considered to be the best solution for the Mountain View area. EPA started temporary replacement of people in 1983, in order to carryout remedial investigations/feasibility studies. Remedial investigations commenced in April 1983 and were conducted over a four week period. The final draft report was completed in May 1983. The investigation was undertaken with the aim of determining a more permanent remedy and the most suitable final land use, in consultation with the local community. The options included the abandonment of the site, removal of asbestos contamination from the area and the construction of a cap over the contaminated tailings and soil.

Three alternatives for the permanent remediation of the asbestos contamination were identified namely: abandonment of the site through permanent relocation; site rehabilitation with asbestos removal and site rehabilitation with deep capping of asbestos contamination. The investigation determined that the best permanent solution for the Mountain View estates was site abandonment by permanent relocation in terms of cost effective considerations, best protection of public health and environment and in terms of feasibility.

Temporary relocation of residences pending finalisation of permanent relocations commenced in May 1983. Permanent relocation included the purchasing of the affected properties, burial of the contaminated mobile homes on site and capping of the contaminated areas. Residents of Mountain View Mobile homes were permanently relocated in 1985.<sup>73</sup> Homes and other infrastructure at the site were subsequently demolished and buried on-site. To limit erosion impacts which had previously negatively impacted the rehabilitation measures implemented at the site, drainage channels were constructed at the site. The whole site was covered with a filter fabric to further limit erosion. A clean soil cap was placed over the fabric and compacted. The soil was then overlain with crushed

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<sup>72</sup> EPA. 'EPA Superfund Record of Decision'. Mountain View Mobile Home Estates. February 1983

<sup>73</sup> EPA. Mountain View Mobile Home Estates EPA NPL Site. 2007

rock and the area fenced off.

A twenty year monitoring plan was recommended. Monitoring investigations conducted in 1988, 1991 and in 2005 revealed that the rehabilitation measures were successful as vegetation was establishing itself and cap integrity was still intact. The cap provided adequate protection to human health and the environment.

The mobile homes case study indicates that rehabilitation of asbestos contaminated area requires constant monitoring. Following rehabilitation, the site was determined to be clean. However, with time, erosion due to water run-off and human activities exposed asbestos fibres buried at the site. Surface water is a major problem to rehabilitation of asbestos dump rehabilitation as it destroys the cap placed to limit dust emissions. The restriction of access to the site is also key to the success of asbestos dump rehabilitation.

### **Recommendations and Concerns for Further Research arising from literature reviews, both social and scientific, site visit and interviews:**

- 1.** The site visit clarified that the municipal responsibility and official status of Penge needs to be formalised as a matter of urgency.
- 2.** The findings of this report should be shared with the DME, DEAT, DWAF and the community in order that a participative planning process be initiated.
- 3.** Mine Health and Safety records need to be located to enable a proper assessment of the effect of environmental pollution by asbestos on the population.
- 4.** More appropriate and rigorous record keeping and documentation of who does what, and when needs to take place.
- 5.** More effective co-ordination between government departments and consultants needs to take place.
- 6.** As a first step, a household survey should be undertaken to assess the ongoing dangers in each inhabited structure in the village. The survey could inform planning and consultations with the community over their future.
- 7.** While the community of Penge is anxious to remain in the village, due to the ongoing dangers of asbestos pollution, CSMI recommends that a plan to remove the present community to another vicinity be made as a matter of urgency.

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## Appendix 1

### Questionnaire Prepared for Interviews and Focus Groups in Penge January 2008

#### *Penge – Scope of Socio-Economic Study* *The future of Penge: Prospects for People and the Environment*

This study is being undertaken for the Asbestos Relief Trust by the Centre for Sustainability in Mining and Industry – CSMI. The reason for the study is to explore the prospects for the people and the environment, to assess the ongoing risks of asbestos contamination of the human population and the environment and to formulate policy options for Penge. There appears to be a plan by the Limpopo Provincial government Department of Local Government and Housing to establish townships in the vicinity and to develop Penge as a tourist attraction. This plan involved a risk assessment commissioned by the local authorities that pointed to asbestos contamination, dolomite land with sinkhole potential and flooding. The Department of Mineral and Energy Affairs commissioned a detailed rehabilitation process that is at present being evaluated by D.P.van der Merwe.

The study will develop three aspects: a socio-economic history of the area, public health exposure, and the environment and rehabilitation. The socio-economic history will include the concerns and aspirations of the existing community and will draw on past studies and current interviews of leaders in the community including the chief, headman, priests, local councillor representative, head teachers in the school(s), health workers at the local clinic, older persons, women's groups and youth representatives living in the community, as well as researchers who have had dealings with the area – among whom are Dr Steven Donohue, Dr Marianne Felix and Dr Tony Davies as well as the Potchefstroom Reclamation Ecology Unit.

The socio-economic study will consider the following themes:

1. A case study of the relationship between the communities, the mine and mine-dumps and the local authority structures over time.
2. The extent to which the local community has been integrated into a rehabilitation process. Do they understand the health hazards? Are there public education programmes and information leaflets in the clinics, schools and churches that educate and discuss the risks of asbestos contamination in the present?
3. Understand the nature of the health and safety hazards and implications of the environmental instability of the areas surrounding the mine. In this regard, it will ask what the local authorities have done to rehabilitate the environment e.g. provided vegetation on and cordoned off the tailings dumps so that children cannot play on them, whether they have grassed or paved open recreation spaces (in the school grounds, around shops, along the verges) and macadamized the roads. Have the local authorities tested the air/wind factors for asbestos contamination?

4. Engage the community about their social needs and their relationship with various tiers of government, including traditional authorities, local government and provincial government.

## Questions

### *Local Politics.*

How are decisions made about settling new independently mobile migrant families into the area?

Kgosi?

Local Headmen?

Local Councillor?

Local officials?

Are there many strangers living in the area?

Who are they?

Do they become part of the community or do they remain outsiders?

How are decisions made about creating new settlements/townships in the area?

Kgosi

District representatives

Local Government (municipality)

Provincial government

Have you heard about the new plan to settle 240 families from Segorong Annesley Andalusite Mine (owned by the French Company Emerys ) in a township nearby?

Were you consulted about this township?

Do you know about the rules that require a public participation process in establishing houses for the mineworkers. (The Minerals and Petroleum Resources Development Act (MPRDA) 2002)

What is the opinion of people living here about this?

### Health Issues

Do people living in Penge and villages nearby the old asbestos mines know about the dangers of asbestos dust in the environment?

Do the schools and the churches talk and educate people about this?

Do you think there is any difference between the living conditions of people in Penge and Mafeke and other villages? If so, in what ways are they different?

Is everybody including the children told about asbestos? Is it still an issue today?

What are the main health issues that are spoken about in the community?

### Rehabilitation

Were people involved in covering the asbestos tailing dumps with vegetation or soil after the mines closed in 1992?

There were committees in the 1990s – do they still exist?

Are people involved in protecting and maintaining the work done in the 1980s and 1990s?

Social and Economic Conditions in the Pietersburg Asbestos Fields – Penge Risk Assessment.  
Employment and Social grants

- Pensions

What possibilities are there for employment in the area?

What do most people do in the area?

Observe whether people keep chickens, goats, sheep, donkeys, cattle – and perhaps follow up question?

#### Agriculture and land use

Do you have land for gardens?

Where do the animals roam and graze?

Do families have enough food to eat?

Do they grow vegetables?

What kind of vegetables and fruit do people grow?

Do people here understand about preventing soil erosion and damping down the dust? (please elaborate)

#### Water

When does it rain? How often does it rain?

Is it very dusty? How do you manage the dust?

How do you get water to your homes? (water carriers, pipes).

Do you have taps and running water in your homes? Is there a flush toilet?

What do people use water for? (kinds of things we want to get at are domestic use of washing – where does the water come from for washing clothes, for gardening, for drinking water, for dampening down the dust).

#### Electricity

Has electricity come to the villages?

Is it in the form of pre-paid meters?

#### Household – quality of life

Cooking – what fuel do you use to cook food?

How do you store food?

Do families share food when there are shortages – who feeds the children who are hungry?

Does the church help?

Do people still use asbestos for scrubbing and fixing pots, for using on their walls, for making bricks, for filling in holes on the roads?

Are there any other uses that people use asbestos for?

#### Health

Where is the nearest Clinic?

Where is the nearest hospital?

What kinds of sicknesses do people get? [cholera, bilharzia, hypertension, malnutrition, chest problems, TB, lung cancer, asbestosis, HIV]

What causes these sicknesses?

What can people do about them?

Where do people go for their medicine? What medication do people get?

#### Housing and Land

Is there adequate housing here?

Does everyone have some land on which to grow vegetables, keep small live-stock?

Community Relations:

Is there a Community Environmental Health Committee in the area?

What other committees are there in the community?

Who belongs to the committees?

Do the Committees link with other Committees in Mafefe and other areas?

What are the social issues that are of concern to the people? [Health, education, housing, compensation, government grants?]

What do people think the government should be doing for the people living in this area?

Have there been external groups - NGOs or Health Workers - working with the people?

What were they doing?

Where were they working, and how did they decide to work there?

Are they still here?

Burial Societies

Does everyone in the village belong to the same burial society?

Is there an undertaker in the area?

Where is the graveyard, and do strangers also use it?

Children

Who looks after the babies and little children?

What do the older children do to help the household?

Do all the children go to school?

What games do children play?

Where do children play?

Do children swim in the river?

Do children play on the old mine dumps?

Are the old mines fenced off so that children do not go into them?

Marriage and Family Life

Do you have lots of celebrations for young people who are growing up – like Xhosa do for circumcision? Do you have circumcision for boys and girls?

When is the age of marriage?

Are marriages arranged between families, and how much is the lobola?

Do families educate their children about asbestos – environmental, occupational, about the history and time of the mine and what happened afterwards. Can you tell us about that? What stories and memories do you have?

What would the community like the local authorities to do in terms of education and action about asbestos or any other problems facing the community?

How do families educate their children about sex and sexuality in this day and age of HIV?

Infrastructure - Observation

Paved roads

School playing fields – are they grassed?

Facilities in Schools

Clinic,

Hospital,

Chief's Office.

Post Office

Telephone

Transport – bus, taxi, carts, cars...

Soil erosion

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